MONTSERRAT ENERGY POLICY, 2008 – 2027

FOR:
DEPARTMENT OF PUBLIC WORKS
MINISTRY OF COMMUNICATIONS AND WORKS
MONTSERRAT

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OVERVIEW/EXECUTIVE SUMMARY:

MONTSERRAT ENERGY POLICY, 2008 – 2027

OVERVIEW: As we, *The People and Government of Montserrat*, work to rebuild and redevelop in the wake of the volcanic crisis, it has become more and more clear that our energy sources and energy-based services have to be changed towards more sustainable alternatives.

This is readily apparent in light of our dependence on fossil fuels -- which are subject to sudden, large, disruptive jumps in price. As those prices begin to trend towards US$ 200/barrel for crude oil, they are plainly potentially ruinous for Montserrat. In short, we face a "survival" challenge. Also, there are increasing global, regional and local concerns that heavy fossil fuel use is linked to potentially dangerous and destructive climate trends. Thus, global initiatives such as the Kyoto Protocol have provided opportunities for us to move away from excessive dependence on such fuels.

Through these opportunities, Montserrat has the ability to develop its energy sources and technologies away from fossil fuels and move to a more sustainable energy path that emphasises (1) *renewable energy* (e.g. geothermal, wind, solar energy, bio-fuels) and (2) *enhanced efficiency* of energy use. Also, since they dominate our energy use patterns, *the electricity and transportation sectors* will be the main focal points for our efforts to move towards such alternative energy technologies.

To successfully explore, develop and exploit green energy opportunities, we will need to build up our own national capacities through transparent, credible partnerships. Steps must be taken to see that such partnerships will be transparent, so that they will not compromise our democratic right to control the key strategic national assets that are the foundation of our hopes for long-term development. We also seek to become a regional centre of excellence for sustainable energy, through which we can demonstrate by our example, develop training programmes in, and consult with others about, practical ways in which our region and the wider world may be able to find a more sustainable energy path.

The Montserrat energy policy, as envisioned, declared and explained below, therefore provides a credible, broadly-supported and feasible strategic approach to make the most of these opportunities, over the period 2008 to 2027, starting with plans for the implementation of an initial programme of action over the period 2008 - 2012.

SCHEDULE 1:

A framework of Goals for Renewable/ Sustainable Energy, 2008 – 2027

<table>
<tr><th rowspan="2">Waves of Advance & Themes</th><th colspan="5">Goals for Lines of Action</th></tr>
<tr><th>LOA 1: Renewable Energy</th><th>LOA 2: Energy Efficiency</th><th>LOA 3: Fossil Fuels & Alternatives</th><th>LOA 4: Transportation Sector transformation</th><th>LOA 5: Capacity Development</th></tr>
<tr><td>W I: 2008 – 2012:

Geothermal, Wind and core capacity</td><td>• Geothermal [3 – 5 MW plant], if feasible
• Wind electricity, 300 kW+ ; associated generating plant, power distribution grid and grid control upgrades
• Systematic, daily and ongoing monitoring of wind and insolation resources
• Affordable solar water heaters through a financing mechanism
• Research and pilot projects on RE air conditioning systems and other novel technologies</td><td>• Energy audits: MUL and/or ESCOs
• Provision of affordable, efficient replacement lighting systems, appliances, office equipment and PCs, etc. through an audits-linked financing mechanism
• ESCO inputs into major new building projects, towards harvesting efficiency gains and integration of renewables
• Associated promotion of high efficiency, renewables-compatible building designs through upgraded building regulations</td><td>• Exploratory use of ethanol, butanol and bio-diesel, etc. as fuels in their own right, including the possible use of alcohol(s) in fuel cells
• Exploration of hydrogen generation, storage and use as an energy carrier
• Possible recovery of one or more of the Plymouth-based diesel generation sets (and of associated plant etc).
• Monitoring of global developments on other alternative energy, e.g. PBMR reactors (S. Africa, China)</td><td>• Use of ethanol as an additive for vehicle fuel
• Initial, demonstration use of butanol and biodiesel as fuel additives
• Demonstration of hybrid, fuel cell and/or plug-in recharge vehicles, esp. flexible-fuel plug-in hybrids
• Pilot, green energy demonstrator bus-based public transport: e.g. bio-fuels, flexible fuels, hybrids, electric vehicles, fuel cells, hydrogen</td><td>• Creation of an Energy Office, with Board, and technical Advisory Panel
• BOAT partnerships for geothermal
• Technical training and capacity building [Comm Coll, UWI, etc.],
• Data, statistics and analysis capacity upgrade
• ESCO capacity
• Legislation & regulations
• Utilities Commission
• If geothermal, industries to use “extra” electricity
• TiO_2, other solar pv, & fuel cells tech. capacity building</td></tr>
<tr><td>W II: 2013 – 2017,

Transportation Sector transformation</td><td>• If feasible, expansion of Geothermal energy and export to Guadeloupe, etc.
• Pilot projects for TiO_2 and other novel solar PV techs
• Pilot projects for fuel cells</td><td>• Introduction of LED, solid state lighting as the next generation on lighting efficiency
• Beginning of global replacement of incandescent lighting</td><td>• Initial distribution network for bio-fuels “compatible” with current generation vehicles: e.g. biodiesel, biobutanol
• Local fleet-level demonstration of hydrogen (and/or alcohols) as an energy carrier</td><td>• Butanol and biodiesel initial production and distribution, M’rat and wider region
• Fleet-scale demonstration use of fuel cell vehicles (alcohol and/or hydrogen)
• Deployment of “affordable” hybrids etc</td><td>• If large geothermal resources, export of electricity to Guadeloupe, etc.
• Initial offers of training and external consultancies as energy transformation experts</td></tr>
<tr><td>W III: 2018 – 2022:

Future Energy</td><td>• Solar-hydrogen economy demonstration, if the technology is available and cost effective</td><td>• Global phasing out of incandescent lighting
• Initial use of small, efficient fuel cells to replace chemical primary batteries</td><td>• Gradual phasing out of gasoline and fossil fuel derived diesel</td><td>• Bio-fuels for conventional vehicles,
• Fuel cells for new generation vehicles and for remote sites or mobile equipment</td><td>• Modularisation of energy delivery using solar, fuel cells
• Full-scale training and consultancy capacity</td></tr>
<tr><td>W IV: 2023 – 2027:

Green Energy Economy</td><td>• Transition to Solar energy and bio-fuels for the long term, and introduction of hydrogen</td><td>• Transition to a high-efficiency energy equipment economy</td><td>• Transition to hydrogen and bio-fuels, and to fuel cell vehicles
• Monitoring of global developments on fusion</td><td>• Gradual phasing out of fossil fuel based, internal combustion engine powered vehicles
• Transition: fuel cell vehicles</td><td>• Green economy consolidation
• Initial capacity development towards fusion</td></tr>
</table>

TABLE P.F 1

Chart of initial Five-year Implementation Plan, 2008 – 2013

The relevant timelines and milestones for major initiatives under the energy implementation plan 2008 - 2012 may be shown through a *Gantt chart*:

Ref.	*Initiatives*	*Actors*	*Timelines* 2008 2009 2010 2011 2012	*Current Status*
1	Energy Policy & implementation plan [Q1, 08]	GOM, UN ECLAC, GEM/TKI		This: work in progress.
2	Energy Office [EO] initiation [Q2, 08]	GOM, DFID	**(operational)**	Pending policy approval
3	Wind Energy & utility viability enhancement [Q 2 08 – Q2 09]	GOM, MUL, DFID, UN ECLAC	**(operational)**	Proposal and initial consultations
4	Geothermal, pre-commercial exploration [Q1 08 – Q4 09]	GOM, DFID, UN		Phase 1: scoping study, in progress
5	Geothermal development [pending success of exploration] [Q1 09 – Q2 10]	GOM, Tenders Board, EO, Developers	**(operational)**	Tenders Board bid process, pending successful exploration
6	Affordable Energy Efficiency & DSM initiation [Q3 08 – Q4 09]	GOM, EO, MUL, DFID, ESCOs*	**(operational)**	Opportunity identification in progress
7	Initial setting up of a Public Utilities Commission) [Q3 – 4 08]	GOM, MCW, EO		Pending completion of Law and associated policy
8	Establish ongoing wind, solar monitoring [Q2 – 4 08]	GOM, EO, Met Office		Early steps taken
9	Improving statistics collection and analysis on energy [Q3 – 4 08]	GOM, EO, Stats Dept, Customs		Opportunity/need identified
10	Developing workshops & courses on sustainable energy [Q3 08 – Q2 10]	GOM, EO, DFID, M'rat Comm Coll, UWI, Caricom		Opportunity/need identified
11	Small, capacity-building, community-based energy projects grants scheme [Q1 09 – Q4 12]	GOM, EO, Aid Agencies, community based partners		Opportunity/need identified
12	Advanced energy technologies exploratory projects [Q3 09 – Q2 12]	GOM, EO, MUL, DFID, partners		Opportunities to be identified
13	Public GOM forums on sustainable energy [July, Dec, in years 08 – 12]	GOM, EO, NETF/ Energy Advisory Board, Tech & Sci Advisory Panel, [TSAP], PUC*	* * * * * * * * * *	Pending EO set-up
14	Evaluation, revision, policy rollover and new plan [Q1 09, Q1 – 4 12]	GOM, EO, NETF/ Energy Advisory Board, TSAP, Dev't Unit: SDP*, DFID		Pending policy approval

* NB: **ESCO:** Energy Services Company, **SDP:** Sustainable Development Plan; **PUC:** Public Utilities Commission

Table PF.1: *Suggested timeline for major initiatives under the implementation plan 2008 - 2012*

MONTSERRAT ENERGY POLICY, 2008 – 2027:

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PART A:

Policy Vision and Declaration/Statement

MONTSERRAT ENERGY POLICY, 2008 – 2027, I:

THE MONTSERRAT SUSTAINABLE ENERGY VISION

Our generation has a mission to rebuild our nation.

While doing that, we have more and more come to see that our present over-dependence on fossil fuels is economically and environmentally unsound. At the same time, Montserrat's existing and potential *renewable energy resources* (e.g. geothermal energy, wind, solar energy and bio-fuels) and prospects for *enhanced energy efficiency* give us an opportunity for us to move to more sustainable energy sources and technologies.

Therefore, we commit ourselves as a nation, to investigate and – where it is technologically, financially and economically sound – adopt such green energy alternatives. In so doing, we will need to build up our own national capacities through transparent, credible partnerships.

As a part of that capacity-building, we will also work to become a regional centre of excellence for sustainable energy. Thus, we can demonstrate by example and propagate by training and consultancies, practical ways in which our region and the wider world may be able to find a more sustainable energy path.

MONTSERRAT ENERGY POLICY, 2008 – 2027, II:

POLICY DECLARATION

I. POLICY VISION -- *TOWARDS A SUSTAINABLE ENERGY FUTURE*:

Our generation has a mission to rebuild our nation. While doing that, we have more and more come to see that our present over-dependence on fossil fuels is economically and environmentally unsound. At the same time, Montserrat's existing and potential *renewable energy resources* (e.g. geothermal energy, wind, solar energy and bio-fuels) and prospects for *enhanced energy efficiency* give us an opportunity for us to move to more sustainable energy sources and technologies. Therefore, we commit ourselves as a nation, to investigate and – where it is technologically, financially and economically sound – adopt such green energy alternatives. In so doing, we will need to build up our own national capacities through transparent, credible partnerships. As a part of that capacity-building, we will also work to become a regional centre of excellence for sustainable energy. Thus, we can demonstrate by example and propagate by training and consultancies, practical ways in which our region and the wider world may be able to find a more sustainable energy path.

II. POLICY OVERVIEW – *RISING TO MEET THE CHALLENGE OF SUSTAINABLE ENERGY*:

As we, *The People and Government of Montserrat*, work to rebuild and redevelop in the wake of the volcanic crisis, it has become more and more clear that our energy sources and energy-based services have to be changed towards more sustainable alternatives.

This is readily apparent in light of our dependence on fossil fuels -- which are subject to sudden, large, disruptive jumps in price. As those prices begin to trend towards US$ 200/barrel for crude oil, they are plainly potentially ruinous for Montserrat. In short, we face a "survival" challenge. Also, there are increasing global, regional and local concerns that heavy fossil fuel use is linked to potentially dangerous and destructive climate trends. Thus, global initiatives such as the Kyoto Protocol have provided opportunities for us to move away from excessive dependence on such fuels.

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To successfully explore, develop and exploit green energy opportunities, we will need to build up our own national capacities through transparent, credible partnerships. Steps must be taken to see that such partnerships will be transparent, so that they will not compromise our democratic right to control the key strategic national assets that are the foundation of our hopes for long-term development. We also seek to become a regional centre of excellence for sustainable energy, through which we can demonstrate by our example, develop training programmes in, and consult with others about, practical ways in which our region and the wider world may be able to find a more sustainable energy path.

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III. DECLARATION OF POLICY INTENT:

The Montserrat 2008 – 2027 Sustainable Energy Policy, is based on **the intent** that:

> *across time, and in light of identified opportunities, challenges, strengths and weaknesses we shall more adequately and more fairly meet our energy needs in our own generation, but at the same time we commit ourselves to not compromise the ability of future Montserratians to meet their own energy needs.*

In so declaring that the policy is based on the concept of *sustainability*, we mean by that, that over the next twenty years, The People and Government of Montserrat therefore will adopt **priority strategic initiatives** that jointly and cumulatively undertake . . .

> *a* ***course of action*** *for our community in Montserrat, that will help our nation to identify and fulfill a desirable and achievable* ***vision****:*
>
> > *(1) of how we will obtain energy from technically and economically feasible, environmentally sound sources; and*
> >
> > *(2) of how we will then use it effectively and efficiently to contribute to an ever more wholesome, prosperous and earth-friendly lifestyle.*

We will do so based on our **commitment** to certain vital and valued underlying God-fearing ethical principles (such as *The Golden Rule*[i]) and associated sustainable development goals (as adopted from time to time).

Thus, we define our **principal policy goal** as . . .

> *the reliable, cost-effective, affordable, economically, socially and environmentally sustainable provision of adequate energy services matched to Montserrat's needs across time; based on robust, diverse energy sources and distribution systems, using appropriate technologies, and equitably provided to all sectors of the society.*

This overarching goal will be achieved through the fulfillment of the following targetted **objectives**:

IV. INDICATIVE POLICY TARGETS: FIVE, TEN, FIFTEEN & TWENTY YEARS:

The energy policy's targets fall along five mutually supportive *lines of action*, in four *waves of advance*:

WAVE 1: *2008 - 2012: geothermal, wind, efficiency and core capacity*

W1.1 In the *first five-year sustainable energy policy implementation plan*, the main line of advance will be to exploit available opportunities for relatively mature renewable energy technologies, especially geothermal energy and wind, while improving efficiency of energy use and building basic capacity.

W1.2 Energy efficiency will be enhanced through energy audits and related changes in equipment and energy-use patterns. This will be backed up by affordability-enhancing *demand side management* [DSM] initiatives by the electricity utility and partners in efficiency, multiplied by public education and moral suasion. The first such initiative will be at Government Headquarters, as a strategic demonstration project. As advanced, cost-effective renewable or efficient technologies (e.g., low-cost solar photovoltaic systems, solid state LED lighting) emerge in global markets, they will be introduced here as well.

W1.3 Monlec/the energy division of MUL will continue to be the designated sole electricity grid holder and manager of the mains power supply, in the interests of the people of Montserrat. As appropriate, electricity generation shall be in-house or on a power-purchase contractual basis with licensed independent power providers; especially if geothermal energy and/or wind are to be brought into the generation mix. Electricity tariffs, fuel surcharges, grid connexion fees and terms, grid extension and the like shall be regulated and managed under the relevant electricity and utilities legislation, with associated scrutiny by the designated regulatory authority. Pricing shall as far as reasonably possible target affordability. This, within the constraint of meeting costs and returns to investment to finance, provide and manage the mains electricity service and related support across time; while reckoning with the implications of the small scale of Montserrat. Given the strategic importance of a stable, adequate electricity grid and generation capacity for national development, if required investments are not feasible on a commercial basis, aid agency support will be sought. (Such support will especially be sought as options are explored to shift as large a fraction as feasible of generation away from ever more expensive and environmentally unfriendly fossil fuels, and towards renewable energy.) Also, as the main concentration of relevant technical expertise, the division will be required to undertake and support a portfolio of demand side management [DSM] initiatives and associated renewable energy, energy efficiency and alternative energy projects. In support of this, appropriate staff training and staff development projects will also be undertaken in collaboration with suitable regional and local partners.

W1.4 Since bio-fuel, hydrogen and hybrid electric vehicle technologies are not currently as technologically mature and/or cost competitive as those prioritised for the first five-year plan, it is in the *second five year plan* that the emphasis shifts to the second major area of energy use, transportation. However, in this period, initial explorations of fuel and transportation alternatives should be undertaken, towards identifying best green energy options. For instance, fuel cell-powered buses for public transportation, hybrid vehicles, alcohol fuels, bio-diesel and electric vehicles should all be investigated and where practicable, explored on at least a demonstration basis.

WAVE 2: *2013 - 2017: Transportation sector transformation*

W2.1 In this second period, cost-effective bio-fuels compatible with current engine technologies -- such as ethanol, butanol [a very close substitute for gasoline], bio-diesel and/or other emerging sustainable fuels -- will be introduced on a widespread commercial basis, as additives to existing fuels and/or as fuels in their own right. Similarly, hydrogen, fuel cells and plug-in hybrid electric vehicles, etc., will also continue to be explored and where feasible initially introduced.

WAVE 3: *2018 - 2022: Future Energy*

W3.1 For *the third five-year plan*, bio-fuels will be increasingly brought into general use for current generation type internal combustion engine and flexible fuel vehicles, fuel cell and hybrid vehicles and supportive infrastructure should be fully mainstreamed as they come into commercial availability.

W3.2 We will also re-brand Montserrat as an island where *the global green energy future* is happening; thus positioning ourselves in the education and consultancy markets to offer energy transformation training and associated technical and strategic consultancy services to the region and world.

WAVE 4: *2023 - 2027: Green Energy Economy*

W4.1 The objective here is consolidation and positioning for further advances in energy technology. The *fourth five year plan* will complete the green energy transformation, and will open the gateway for the probable ultimate "future energy" technologies: hydrogen, fuel cells, high efficiency low-cost photo-voltaic systems and fusion.

In each of these waves, even with shifting emphases, initiatives and activities will be clustered along five balanced, parallel, mutually supportive lines of action [LOA]:

LOA 1: *Renewable Energy*

A1.1 Montserrat's major opportunities for sustainable energy lie in modern renewable sources, augmented by efficiency measures. Projects will therefore be undertaken to identify, evaluate, prioritise and implement environmentally sound, technically and economically feasible initiatives on geothermal, wind, solar energy, bio-fuels and such other prospects as may emerge from time to time.

A1.2 In undertaking such projects, advantageous use will be made of global, regional and local technical and financial facilitation mechanisms accessible to Montserrat and Montserratians. This includes: carbon trading, clean development mechanisms, pioneering industry tax holidays, import duty relief, income tax credits, soft green-energy loan funds, technical assistance mechanisms, market penetration barrier overcoming projects [e.g. CREDP] and the like.

LOA 2: *Energy Efficiency*

A2.1 Through the collaboration with the electricity utility and partner agencies and local/ regional/ international *energy services companies* [ESCOs], a programme of energy audits and credit-assisted transitioning of firms and households to energy efficient appliances, processes and patterns of energy use, will be undertaken.

LOA 3: *Fossil Fuels and alternatives*

A3.1 To facilitate transitioning away from unsustainable levels of dependence on fossil fuels, potential bio-fuels will be identified, evaluated, and where sound and feasible, introduced as additives then as replacements for such fossil fuels.

A3.2 Novel energy harvesting technologies such as fuel cells and associated energy carriers such as hydrogen gas will be similarly evaluated and implemented where/when feasible. If and as nuclear fusion technology begins to emerge – probably towards the middle of the twenty-first century, it too will be evaluated.

LOA 4: *Transportation sector transformation*

A4.1 Bio-fuels that are more or less compatible with current internal combustion engines are an important bridging technology for motor vehicles. Thus, prospects for the introduction and use of ethanol, bio-butanol, bio-diesel, and other bio-fuels will be evaluated, towards local/regional production and distribution to augment then replace fossil fuels. This will be done in partnership with CARICOM, OECS and other relevant regional or international institutions and movements.

A4.2 Onward, the probable emergence of flexible fuel, hybrid, fuel cell based, hydrogen [or ethanol or the like] powered vehicles will require a further evaluation and introduction.

LOA 5: *Capacity Development*

A5.1 Montserrat will seek to develop a cadre of *capable people* to manage and implement the energy transformation process, which implies both a need for training (locally, regionally and overseas) and for organising and equipping institutions – public and private sector -- for them to work in.

A5.2 Such *institutions* may require appropriate application and/or amending of existing laws and regulations [e.g. Tenders Board process, industrial investment incentives, environmental law, utility regulation mechanisms], and/or if necessary creation of new ones – which should be compatible with related CARICOM and OECS initiatives insofar as possible. It will also require associated, stakeholder based oversight bodies [e.g. Public Utilities Commission, Energy Board based on the *National Energy Task Force* (NETF), etc] to ensure transparent, efficient management in the interests of the people of Montserrat.

A5.3 These institutions will need to be able to so work together that the whole will be greater than the sum of the individual parts, so that our *community* will have capacity to transition smoothly to the new sustainable energy era. This implies a need for a broadly participative, transparent, cooperative, consensus-building process for developing the energy policy and carrying forward its implementation.

Specific operational objectives derived from these targets are therefore identified and tabulated in Schedule 1 to this policy declaration. Schedules 2 and 3 specify requisites specific to the prospective development of geothermal energy, the principal identified renewable energy opportunity for Montserrat.

To effect the lines of action across the four envisioned waves of advance, the following *policy instruments* are adopted:

V. MAIN POLICY INSTRUMENTS:

I 1: Energy Office

The Government of Montserrat, acting through the Executive Council, undertakes the creation of an *Energy Office* (EO) attached to [an appropriate ministry] and working with relevant Government Departments, the private sector, community groups and project teams tackling priority projects under the policy's integrated implementation plan. This Office is intended to carry forward, facilitate and coordinate priority strategic initiatives under the energy policy:

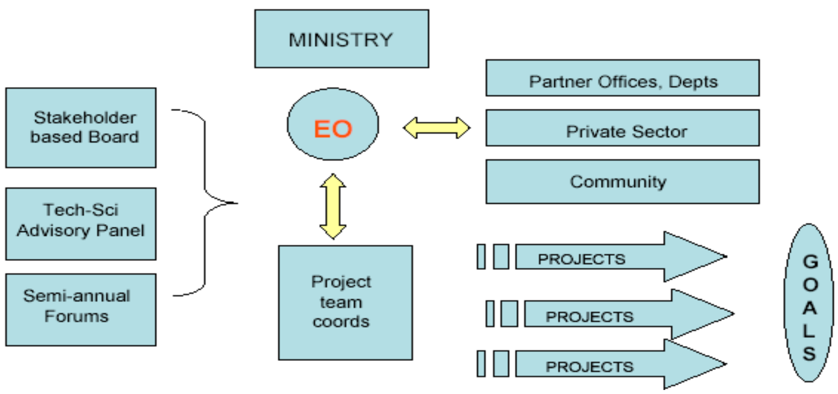


Fig. 1: *Energy Office*

The Energy Office, while principally accountable to [its Ministry], shall also use broader governance and transparency structures such as a stakeholder-based *Advisory Energy Board*, a *Technical and Scientific Advisory Panel*, and semi-annual *Public Forums*; to promote maximum participation by the community in the implementation and onward development of energy policy.

To mobilise and best coordinate available resources, it shall use a cross-functional project team organisational structure to support and oversee the carrying out of priority projects, through application of "best [or at least *effective*] practice" for project cycle management. Programme and project governance shall therefore be done jointly with designated project team leaders and representatives of resource-providing Government agencies, private sector groups and community-based organisations, as well as aid agencies. In such organisations, there shall be designated priority project facilitation officers reporting to the senior managers of the relevant bodies.

The office shall also cooperate with the Statistics Department and other relevant offices on coordinating the collecting, monitoring, analysing and reporting on energy and emissions statistics and information generally that are relevant to *Carbon Trading*, and to compliance with regional and international agreements.

I2: The First Five-year Energy Transformation Implementation Plan

Integral to the policy shall be a series of five-year implementation plans, the first of which shall be as described in outline in Declaration VI of this policy, below. The Energy Office's principal tasks and scope of action, in the first instance, shall be defined and managed through this initial plan. Onward, its further tasks and scope of action shall be further defined through successor plans and revisions to the policy framework as made from time to time.

I3: Regional and International Mechanisms relevant to energy policy

Regional and international mechanisms and agreements that Montserrat -- as [a] a United Kingdom Overseas Territory, [b] a member of the Caricom, and [c] a member of the Organisation of Eastern Caribbean States -- is a party to (and/or *is implicitly involved in, as an overseas territory of the UK)*, are hereby deemed to be an integral part of the Montserrat energy policy. This, within the constraints imposed by national capabilities and limitations that lead to such derogations as are necessary for a small island developing state in long-term recovery from a major natural disaster.

The Energy Office is the designated *Focal Point* for coordinating monitoring, compliance and application of such instrumentalities, including identifying, developing and coordinating projects to make advantageous use of opportunities opened to us through such mechanisms.

Since there is a recognised capacity challenge on associated statistics collection and analysis, in the first year of the Office's existence, it shall undertake a survey of the needs and develop one or more projects to improve this critical capacity required for successful carbon trading and for environmental reporting generally.

I4: Local Law, Regulations and Capacity

The energy policy and its implementing arm, the Energy Office, will as far as possible seek to be compliant with and make advantageous use of *existing* relevant local laws, policies, and regulations and shall seek to collaborate with other government agencies, with the private sector and community based organisations. This shall in particular apply to the current *Sustainable Development Plan* [SDP] and the *National Environmental Management Strategy* [NEMS]. (Where necessary, derogations shall apply, as per warrant from the relevant ministry on application by the Energy Office.)

As a capacity building project under the first five-year implementation plan, the Energy Office shall in its first year of existence, undertake a review of relevant laws, regulations and capacity. Based on its findings, it shall then recommend to the Government of Montserrat a prioritised agenda of such adjustments and upgrading as is reasonably achievable within the scope of available resources and priorities.

In promoting strategic energy initiatives, such as geothermal development, advantageous use shall be made of the upgraded *Tenders Board* process, and the entrenched legal principle that reserves mineral, treasure and water rights as public goods [i.e. as "Crown"]. As relevant, *tax holidays*[ii] for pioneering or vital industries, *duties exemption schemes* and the like should also apply; bearing in mind the well-known double taxation effects and financial/economic implications of (a) taxing a firm's profits and then also (b) taxing equity holders on their dividends and capital gains. *Royalties* shall be premised on the value of public resources used (inclusive of not only mineral wealth but also those for inspections and administration, etc.) and should be assessed at regionally competitive rates.[iii] These and other similar instrumentalities should be applied in accord with international and regional best – or at least effective – practice; with due consideration for the balance between investment incentives, cost savings and income effects for the State and members of the community

I5: Public Utilities Commission

As a Public Utilities Commission law is in draft, which will support enhanced and governance of public utilities, this commission will inter alia serve as a means of enhanced transparency of management of energy-related utilities. Thus, it is a policy instrument for the national energy strategy.

I6: Environmental Impact Analysis [EIA] and Environmental Management Systems [EMS]

Through the relevant clauses of the NEMS, and in accordance with international best (or at least acceptably effective) practices, EIA and EMS shall be integrated into projects and other initiatives undertaken under the energy policy. This shall be a key component of the sustainability aspect of the energy policy. Through EIA and EMS, energy-related projects shall -- without imposing excessive bureaucratic delay and/or entangling rules and regulations -- seek to minimise damaging stress on the biophysical, socio-cultural and economic environmental domains, as is consistent with the long-term interests and welfare of the current generation and our posterity.

Since certain key energy related technologies are "dirty," within the first two years of the energy policy coming into effect, the Energy Office will undertake an initial survey of waste management relating to energy sources and technologies in Montserrat, and shall develop and undertake relevant projects, e.g., on disposal/recycling of fluorescent lighting [Mercury hazard] and Lead-Acid Batteries [Lead hazard].

Similarly, in coordination with the Disaster Management Coordination Agency [DMCA], the Fire Department and other relevant partners, the Office will undertake projects to enhance capacity to prevent or manage energy related disasters such as oil spills or tank farm fires.

VI. FIVE-YEAR INITIAL PROGRAMME OF IMPLEMENTATION:

To achieve the aforementioned targets through judicious application of the above instruments, a series of *five-year programmes of action* and associated *implementation plans* shall be developed and executed, through the Energy Office and collaborating partners. At semi-annual intervals during the plans, under the auspices of the [appropriate ministry] regular public forums shall be held by the Advisory Energy Board, the Technical and Scientific Advisory Panel and the Energy Office, to publicly report on progress and challenges, and to take inputs from the public at large. If convenient, these forums shall be timed to coincide with the annual Christmas and Calabash festivals.

The first such plan, in indicative outline form, is attached as Section II of this energy policy, and its targets are those identified as those for the first wave of advance across the five lines of action discussed under Declaration IV above, and in Schedule 1 as attached below. The main areas of effort pursued through this initial plan are: *geothermal, wind, efficiency and capacity-building.*

VII. ORGANISATION, RESOURCING, OVERSIGHT, REVIEW:

In order to effectively and transparently implement the policy, as is discussed in Declaration V above, the principal practical instrument under the energy policy is the creation of an Energy Office integrated into a participative governance mechanism and with a project team based implementation structure for priority initiatives.

Such a framework creates institutional capacity and enhances community capacity to undertake energy transformation. However, such measures will have little or no effect without capable people and supportive financial and material resources. Accordingly, active training, recruiting and retention strategies for energy capacity will be integrated into the onward work of Government-level management of Montserrat's human resources. As opportunities arise, energy-related training programmes will be introduced into locally based education institutions, at technical and managerial levels, with an eye towards eventual offering of such courses and programmes across the region and beyond.

Further, since, energy transformation is now a global theme, many *financing mechanisms* have emerged and are continuing to emerge at regional and international levels; clustered on the theme Carbon Trading. The Energy Office will be tasked to monitor and make advantageous use of such opportunities in the national interests. And, through cost-savings on energy efficiency and moving to cost-effective alternative technologies, an agreed proportion of released or sourced funds (this last through a small but realistic coordination fee as appropriate) on a per project basis will be invested in the support of current and onward energy initiatives.

VIII. ONWARD LINES OF ACTION:

Given the dynamic nature of the energy sector and the initial imperative of risky exploration of geothermal, wind and solar energy prospects, there will be a major review at the end of the first year to year and a half of implementation under this policy.

Then, at the fifth year, there will be a further major review, leading to a policy rollover in time for Wave of Advance 2. (A similar review and rollover will occur at succeeding five-year intervals.)

SCHEDULE 1:

A framework of Goals for Renewable/ Sustainable Energy, 2008 – 2027

Waves of Advance & Themes	Goals for Lines of Action				
	LOA 1: Renewable Energy	**LOA 2: Energy Efficiency**	**LOA 3: Fossil Fuels & Alternatives**	**LOA 4: Transportation Sector transformation**	**LOA 5: Capacity Development**
W I: 2008 – 2012: **Geothermal, Wind and core capacity**	• Geothermal [3 – 5 MW plant], *if* feasible • Wind electricity, 300 kW+ ; associated generating plant, power distribution grid and grid control upgrades • Systematic, daily and ongoing monitoring of wind and insolation resources • Affordable solar water heaters through a financing mechanism • Research and pilot projects on RE air conditioning systems and other novel technologies	• Energy audits: MUL and/or ESCOs • Provision of affordable, efficient replacement lighting systems, appliances, office equipment and PCs, etc. through an audits-linked financing mechanism • ESCO inputs into major new building projects, towards harvesting efficiency gains and integration of renewables • Associated promotion of high efficiency, renewables-compatible building designs through upgraded building regulations	• Exploratory use of ethanol, butanol and bio-diesel, etc. as fuels in their own right, including the possible use of alcohol(s) in fuel cells • Exploration of hydrogen generation, storage and use as an energy carrier • Possible recovery of one or more of the Plymouth-based diesel generation sets (and of associated plant etc). • Monitoring of global developments on other alternative energy, e.g. PBMR reactors (S. Africa, China)	• Use of ethanol as an additive for vehicle fuel • Initial, demonstration use of butanol and biodiesel as fuel additives • Demonstration of hybrid, fuel cell and/or plug-in recharge vehicles, esp. *flexible-fuel plug-in hybrids* • Pilot, green energy demonstrator bus-based public transport: e.g. bio-fuels, flexible fuels, hybrids, electric vehicles, fuel cells, hydrogen	• Creation of an Energy Office, with Board, and technical Advisory Panel • BOAT partnerships for geothermal • Technical training and capacity building [Comm Coll, UWI, etc.], • Data, statistics and analysis capacity upgrade • ESCO capacity • Legislation & regulations • Utilities Commission • If geothermal, industries to use "extra" electricity • TiO_2, other solar pv, & fuel cells tech. capacity building
W II: 2013 – 2017, **Transportation Sector transformation**	• If feasible, expansion of Geothermal energy and export to Guadeloupe, etc. • Pilot projects for TiO_2 and other novel solar PV techs • Pilot projects for fuel cells	• Introduction of LED, solid state lighting as the next generation on lighting efficiency • Beginning of global replacement of incandescent lighting	• Initial distribution network for bio-fuels "compatible" with current generation vehicles: e.g. biodiesel, biobutanol • Local fleet-level demonstration of hydrogen (and/or alcohols) as an energy carrier	• Butanol and biodiesel initial production and distribution, M'rat and wider region • Fleet-scale demonstration use of fuel cell vehicles (alcohol and/or hydrogen) • Deployment of "affordable" hybrids etc	• If large geothermal resources, export of electricity to Guadeloupe, etc. • Initial offers of training and external consultancies as energy transformation experts
W III: 2018 – 2022: **Future Energy**	• Solar-hydrogen economy demonstration, if the technology is available and cost effective	• Global phasing out of incandescent lighting • Initial use of small, efficient fuel cells to replace chemical primary batteries	• Gradual phasing out of gasoline and fossil fuel derived diesel	• Bio-fuels for conventional vehicles, • Fuel cells for new generation vehicles and for remote sites or mobile equipment	• Modularisation of energy delivery using solar, fuel cells • Full-scale training and consultancy capacity
W IV: 2023 – 2027: **Green Energy Economy**	• Transition to Solar energy and bio-fuels for the long term, and introduction of hydrogen	• Transition to a high-efficiency energy equipment economy	• Transition to hydrogen and bio-fuels, and to fuel cell vehicles • Monitoring of global developments on fusion	• Gradual phasing out of fossil fuel based, internal combustion engine powered vehicles • Transition: fuel cell vehicles	• Green economy consolidation • Initial capacity development towards fusion

SCHEDULE 2:

A suggested, candidate "best practice," BOAT Geothermal energy development model

Adj 08:02:14 per suggestions UNECLAC, 03:14 per those of OAS, 09:10 per Energy Steering Group

PREAMBLE: *Geothermal resources development, per regional and international experience, requires initial scientific investigation and exploration, then development and finally operations, in a capital-intensive, significantly (but not necessarily exceptionally) risky and complex business environment. Further to this, Montserrat is looking to provision of electrical energy from such sources for local use and possibly for export. This requires careful consideration of legal and regulatory policy factors, and also some examination of "yardstick" options for best or at least effective practice. What follows in this schedule to the policy declaration, proper, is therefore indicative, and incorporates associated "yardstick" suggestions on best or at least effective practice that – while based on well known praxis and relevant considerations -- are not intended to be seen as exhausting our policy options.*

Geothermal resources can be identified as in the first instance being due to certain thermal characteristics of waters and rocks beneath the earth that give rise to economically valuable features, and also secondarily due to entrainment of dissolved minerals in such waters. These resources, *inter alia* include[iv]:

a) resources related to deep circulation of meteoric water along faults and fractures;

b) resources in high-porosity rocks at hydrostatic pressure;

c) resources in high-porosity rocks at pressures greatly in excess of hydrostatic pressure (i.e., "geo-pressured");

d) resources in hot but relatively dry (low-porosity) rock formations; and

e) resources related to the upward flow of heated water towards the surface along fractures and where there is permeability.

Accordingly, for the purposes of this policy, these resources may be viewed as being due to minerals and waters with an additional valuable thermal property. Thus, they immediately fall under the general legal principle that such resources are public ["Crown"], to be identified, developed and managed through transparent processes established under the Laws of Montserrat and under the regulatory oversight of accountable public authorities; in the interests of the people of Montserrat.

However, due to their peculiar thermal aspects and uses [such as the making of electricity or the direct use of thermal energy], from time to time, it will be appropriate to further specify how geothermal resources are to be managed. This could be done through amending existing Law and associated regulations, and/or through creating new Law and regulations; in consultation with relevant stakeholders and partners. (As Declaration V above, Instrument no. 4, indicates, during the first year of the energy policy, a review process will be initiated towards such upgrading or introduction of Laws and regulations as may seem advisable.)

Consequently, under existing and future Laws and regulations as appropriate,[v] the relevant authorities may (in light of scientific evidence) designate certain areas as potential or known geothermal resource zones.[vi] They may thereafter (upon due diligence regarding the technical capacity of potential suppliers of such exploratory services) issue permits for the safe, environmentally responsible exploration and identification of thermal and mineral resources associated with such geothermal zones. These authorities may also similarly issue licences for development and exploitation of proved resources, and are responsible to promote, oversee, and regulate the use of such resources; towards the sustainable development of Montserrat.

So, providing Montserrat's geothermal potential is confirmed through such initial investigations as are now in prospect, it may be feasible and desirable to develop a geothermal power plant at the first level, to supply Montserrat with up to perhaps 3 - 5 MW. (This is a typical size for an initial development of a geothermal field.)

Such a scale of plant would be big enough to provide for Montserrat's needs (with room for moderate growth), would provide an opportunity to develop capacity and would further prove the resource for possible onward developments.

On such a scenario, the development of a plant, its operation and the building up of local capacity to manage a geothermal electrical process and field would then be priority issues. This brings to the fore a possible variation on the now almost traditional **BOOT** and **BOT** "best" or at least known effective models for energy and similar high-capital cost developments of basic infrastructure facilities that directly serve the public interest.

The **BOOT** model – **B**uild, **O**perate, ***O**wn,* **T**ransfer – is based on the concept of creating a franchise for a contracted private entity to finance, design, implement and operate a facility for a set period, then ownership is transferred to the initiator of the process. During the operating period, the operator harvests fees, tolls, rentals and other reasonable charges as stipulated in the contract, covering investment and operations and maintenance and providing a reasonable profit matched to the relevant risk of the sort of operation undertaken.

As Mr. Albert Daley of the Development Unit has observed, a related alternative is the **BOT** model – **B**uild, **O**perate, **T**ransfer. That is, to retain ownership of the plant in the name of the people and Government of Montserrat (and, we add: if commercial development is not attractive, perhaps to fund the plant through "future-building" development investments through aid agencies acting in concert with qualified developers) – *Build, Operate* [without ownership] and *Transfer*:

(a) The private consortium designs, finances and constructs the plant/facility and then operates and maintains it over the contractual period on behalf of the government until investments are recouped along with an acceptable return for the risk taken.

(b) The government retains ownership & responsibility for the plant/facility

(c) The government is normally both the customer and regulator of the service/product.

(d) The Government usually agrees to purchase a minimum level of output (e.g. through MUL), to ensure that the private consortium or joint venture partnership has some guarantee of recouping their investment, operating and maintenance costs over time.

(e) The government ensures that the private operator/consortium operates the plant according to performance standards agreed.

It should be noted that at the time of transfer the plant would still belong to the government, who may choose to sell the majority of the shares to the local company in the consortium that operated the plant/facility and retain minority shareholding; it may choose to sell majority of the shares to the local partner in the consortium, some of the ownership to the foreign company and retain minority shareholding in the plant/facility; or it may chose to divest or privatize the plant/facility by selling it to the local partner in the consortium whose capacity would have been developed as agreed in the contract for the operation of the plant/facility. It should be noted however that there may be some benefit in selling the foreign based company (with access to funding and technology) a minority shareholding in the plant/facility after the initial investors have recouped their investment.

The obvious advantage of this approach is that ownership is vested in the GOM throughout the period of the investment, and in the case that commercial development is unattractive, this would fit with a development-funded approach. However, where commercial funding is sought, it is possible that by having ownership in hands other than the financing partner, financing costs – due to a higher risk to the banker-- may be significantly higher. Also, retaining the plant on the financing partner's books, with transfer by in effect a balloon payment at the end of the period when the GOM is better able to afford it, may be a countervailing advantage. *Some flexibility on the matter of ownership of plant and land is therefore advisable.* Especially since, in either case, per relevant law, the control of mineral, water and treasure rights is not open to transfer.

Either model allows for a due spreading out of financial risks for both parties. For, the initiating entity is not forced to enter into a new field of operations that it may lack expertise in, and the operator can leverage his expertise and spread his risks across several similar projects in diverse situations. The BOOT/BOT process also provides opportunity for *technology transfer and capacity building.* That opportunity leads to a variant of the basic model which emphasises the transfer component: *a* **BOAT** *development and capacity-building oriented variant for the Montserrat case:*

B – *BUILD:*	The contract operator undertakes specific relevant technical pre engineering studies, financing, full technical design, construction and commissioning of the plant and related infrastructure.
O – *OPERATE:*	The operator manages the plant and harvests appropriate returns for this effort. (*Ownership* of assets is left to the terms of the particular agreement entered into with local and/or regional and/or international partners in light of where financing advantages etc. may lie.)
A – *AND:*	Simultaneous with the development and operation of the plant, a capacity-building and technology transfer process is carried through as a part of Montserrat's ongoing rebuilding and redevelopment.
T - *TRANSFER:*	The capacity-building and technology transfer lead up to a scheduled transfer of management (and, where relevant, ownership) of relevant assets at the close of the franchise period. In the final five years of the contract, management of the plant

would be progressively handed over to a successor Montserratian entity, in agreed stages. At the end of this period, any relevant assets owned by the international partner are sold to the emerging Montserratian entity at a price negotiated based on their audited residual value.

This variant would allow the spreading out of risks and technology transfer, also laying a base for further cooperative developments. (Such further developments would be a credible prospect if the field is suitable for expansion and especially if there is a credible opportunity for power transfer to other islands through undersea cables.)

SCHEDULE 3:

On Pre-Qualification for Geothermal Energy Development

Adj. 08:02:14 per suggestions UNECLAC, 09:10 per Energy Steering Group

PREAMBLE: *Geothermal Energy development for utility electricity generation is a "yardstick" exemplar of modern renewable energy development; with implications for other similar developments such as wind, OTEC, solar thermal or large-scale solar PV. Further to this, as Schedule 2 supra discusses, there are not only various candidate best practice pathways to such energy developments, but also there are several regulatory/legislative effective/best practices that bear on such developments, one of which is the use of a transparent bid process. In that context, a main candidate for best practice, given the highly technical, capital-intensive and significantly risky nature of geothermal development, is that a pre-qualified sealed bid process be undertaken. The following therefore outlines a suggested "yardstick" pathway for that to be initiated for Montserrat. (As "yardstick" implies, such a pathway is not intended to exhaust the list of possible options, but to lay out a comparison standard based on known effective practice.)*

The BOAT energy development process, as outlined in Schedule 2 above, emphasises the need for capacity development and technology transfer to equip a Montserratian partner to take over management and technical functions of the envisioned geothermal power plant, across time. This would be carried out through a structured development, operation and hand-over process that also properly reflects the highly technical and specialised nature of geothermal energy development. The process should also reflect the associated needs to cover financing costs, risk premiums, design, construction, commissioning, operating and managing, reasonable profit-making by the successful firm or partnership that actually develops the power plant, etc.

The highly specialised, highly technical, high-risk, capital-intensive nature of geothermal energy development further leads to the need for ***pre-qualification*** so that GOM may confidently enter into partnership with a firm or joint venture that credibly has the requisite financial and technical capacity as well as local involvement implied in the just above, as an integral part of the Tendering process. Also, *since the underlying energy resource is a public resource under applicable Montserrat Law on mineral, water and treasure rights, it is appropriate that the bidding process for commercial geothermal development should go through the designated Tenders Board.* (It is anticipated that the initial, relatively risky exploration phases will be in large part undertaken through a development aid process funded through development aid partners; that is, following the successful aid-assisted geothermal development model exemplified by the plants at Bouillante, Guadeloupe. Thus, anticipated bidding for commercial development and operation would be relative to a reasonably demonstrated resource.)

Further to this, it is suggested by the logic of the energy development process, that there are three *core criteria for pre-qualification*[vii] of bidders to develop geothermal energy in Montserrat:

I. *Financial capacity* to undertake a venture that (on credible preliminary technical reports) may cost up to ~ US$ 12.5 – 15 millions at the initial 3 – 5 MW level, and would require perhaps up to three or more years of initial investment in exploration and development before commissioning of a plant and associated income-generation.[viii]

II. *Proven technical capacity* to credibly undertake geothermal development in a new and hitherto largely unexplored geothermal field.

III. *Involvement of a Montserratian entity in any proposed partnership* involving external components, in a context of capacity-building through technology, management [and if applicable, ownership] transfer under the modified BOOT or BOT development model identified in Schedule 2 as BOAT.

(Implicit in all of this, is the premise that *since property rights in general in Montserrat do not normally enfold mineral and treasure rights, such minerals and treasures as may be discovered are to be considered a patrimony of the people of Montserrat as a whole, to be transparently managed by elected Governments and their agents across time, in the people's interest.* As an incentive, due consideration should be made to the effort of finders of said minerals and treasures, <u>and</u> to the reasonable expectations of the owners of the land where they were found. For, *"one should not muzzle the ox that treads the grain."*)

In this light, firms and/or partnerships bidding on *commercial development* should demonstrate:

1] The requisite **<u>financial capacity</u>**. This will be identified by substantiation through a combination of audited financial statements, supporting documents, possible interviews and the like evidence, that the firm or partnership in question has adequate internal capital to sustain the combination of equity, debt and possible development assistance and/or "environment" funding that would be used to develop and operate the plant under the terms of the version of a BOAT agreement they propose.

2] The requisite **<u>technical capacity</u>.** The successful bidder should:

(a) have successfully developed at least one Geothermal field;

(b) have thus built and operated at least a 3 – 5 MW plant for something like five years;

(c) have produced electricity at reasonably competitive cost relative to alternatives in their local market;

(d) have done so at a production costs reasonably comparable to the global "benchmark" of about 4 ¢ [US] per kWh of electricity at levellised cost; also,

(e) in the case of <u>consortia</u>, or <u>partnerships</u>, or other forms of <u>joint ventures</u> *at least one member should meet points (a) through (d) of this criterion.*

One possible framework for identifying the relevant levellised electricity costs would be through the following expression [Adapted: Ampere Commission, Belgium, c. 2000]:

Cost in ¢/kWh = Fuel cost in ¢/BTU multiplied by the plant's heat rate in BTU/kWh

+ Other variable costs (e.g. operations and maintenance), in ¢/kWh

+ Capital costs and other fixed costs expressed as an annuity in ¢/kW of capacity, divided by the expected maximum operating hours per year, in ¢/kWh

[+ External costs, in ¢/kWh (if significant and relevant)] . . . *Eqn. S3.1*

Finally, the prospective joint venture development is in a *small island developing state* [SIDS], with a relevant history of colonial oppression and exploitation, and the intended plant would exploit a natural resource in a context that is at once high-science, high-technology, high-risk and highly capital intensive. Thus, from the tendering stage, bidders should show the Tenders Board that their corporate decision-making and governance structures, mechanisms and instruments are balanced, robust and reflective of the underlying sensitivities. In particular, the members of the executive structure and the Board should balance interests reflecting the three core criteria and should include individuals representing the required capacities.

PART B:

First Five-year Energy Policy Implementation Plan

MONTSERRAT ENERGY POLICY, 2008 – 2027, III:

OUTLINE INDICATIVE PLAN OF ACTION, 2008 - 2012

INTRODUCTION: *The Montserrat Sustainable Energy Policy 2008 – 2027*, as declared, and explained above, is based on transformation from a current unsustainable over-dependence on fossil fuels, to a sustainable energy economy -- one that will increasingly rely on efficient use of energy, and on renewable sources and technologies.

Such a transformation will not succeed by chance or accident.

Therefore, it must be carefully planned and effectively carried out under a framework set by a long-term energy policy accompanied by feasible and adequately resourced implementation plans, with associated priority strategic projects and with institutional capacity to carry forward implementation. The following indicative plan of action 2008 – 2012 is intended to serve as the first of these, corresponding to the first wave of advance in the policy.

A] BACKGROUND AND RATIONALE:

As stated in *Declaration IV* above, the first wave of advance (2008 – 2012) for the Montserrat Sustainable Energy Policy 2008 – 2027, principally targets:

. . . *geothermal, wind, efficiency and core capacity*

W1.1 In the *first five-year sustainable energy policy implementation plan*, the main line of advance will be to exploit available opportunities for relatively mature renewable energy technologies, especially geothermal energy and wind, while improving efficiency of energy use and building basic capacity.

W1.2 Energy efficiency will be enhanced through energy audits and related changes in equipment and energy-use patterns. This will be backed up by affordability-enhancing *demand side management* [DSM] initiatives by the electricity utility and partners in efficiency, multiplied by public education and moral suasion. The first such initiative will be at Government Headquarters, as a strategic demonstration project. As advanced, cost-effective renewable or efficient technologies (e.g., low-cost solar photovoltaic systems, solid state LED lighting) emerge in global markets, they will be introduced here as well.

W1.3 Monlec/the energy division of MUL will continue to be the designated sole electricity grid holder and manager of the mains power supply, in the interests of the people of Montserrat. As appropriate, electricity generation shall be in-house or on a power-purchase contractual basis with licensed independent power providers; especially if geothermal energy and/or wind are to be brought into the generation mix. Electricity tariffs, fuel surcharges, grid connexion fees and terms, grid extension and the like shall be regulated and managed under the relevant electricity and utilities legislation, with associated scrutiny by the designated regulatory authority. Pricing shall as far as reasonably possible target affordability. This, within the constraint of meeting costs and returns to investment to finance, provide and manage the mains electricity service and related support across time; while reckoning with the implications of the small scale of Montserrat. Given the strategic importance of a stable, adequate electricity grid and generation capacity for national development, if required investments are not feasible on a commercial basis, aid agency support will be sought. (Such support will especially be sought as options are explored to shift as large a fraction as feasible of generation away from ever more expensive and environmentally unfriendly fossil fuels, and towards renewable energy.) Also, as the main concentration of relevant technical expertise, the division will be required to undertake and support a portfolio of demand side management [DSM] initiatives and associated renewable energy, energy efficiency and alternative energy projects. In support of this, appropriate staff training and staff development projects will also be undertaken in collaboration with suitable regional and local partners.

W1.4 Since bio-fuel, hydrogen and hybrid electric vehicle technologies are not currently as technologically mature and/or cost competitive as those prioritised for the first five-year plan, it is in the *second five year plan* that the emphasis shifts to the second major area of energy use, transportation. However, in this period, initial explorations of fuel and transportation alternatives should be undertaken, towards identifying best green energy options. For instance, fuel cell-powered buses for public transportation, hybrid vehicles, alcohol fuels, bio-diesel and electric vehicles should all be investigated and where practicable, explored on at least a demonstration basis.

Action initiatives under this wave of advance will therefore need to target the five identified lines of action: (1) renewable energy, (2) energy efficiency, (3) alternative fuels, (4) transportation sector transformation and (5) capacity building – including especially that of the electricity utility. Of these, renewable energy, efficiency and capacity building are prioritised for the initiatives carried out through this first wave, based on opportunities and needs.

Further to all this, in his *Nicomachean Ethics*, 2,300 years ago, Aristotle aptly pointed out that *strategy is the art of opportunity*. To make the best use of such opportunity, one needs to have deployed in *strength* to the right place at the right time, so that one may capitalise on *opportunities*, counter *threats*, surmount *challenges* and *barriers*, and compensate for or correct *weaknesses*.

Indeed, this is the context for the now increasingly popular PEST-SWOT strategic planning process:

PEST *environment scanning* across <u>p</u>olitical, <u>e</u>conomic, <u>s</u>ocio-cultural and <u>t</u>echnological (and scientific[ix]) factors, leading to

SWOT *alignment of strategy* across <u>s</u>trengths, <u>w</u>eaknesses <u>o</u>pportunities and <u>t</u>hreats

Following up from this, implementation requires addressing the ADCC factors:

ADCC <u>a</u>ction-plans (and steps), <u>d</u>eliverables, <u>c</u>ontingencies, <u>c</u>ontrols

In this light, we may observe that:

a) Montserrat's current 90+% dependency on fossil fuels is economically and environmentally unsustainable.

b) At global, regional and local levels, a sufficiently strong consensus on change to a more sustainable strategy is building up for active planning and implementation to commence.

c) To support a desirable lifestyle in our community across the next generation, such a transformation will be necessary, and the earlier we begin, the easier it will be to effect.

d) The technical and scientific base for such a transformation has begun to coalesce, and resources to undertake the change are also beginning to flow in.

e) The main opportunities for change target (i) renewable energy [especially geothermal, wind, solar and bio-fuels] and (ii) energy efficiency.

f) One major challenge in the process is that the electricity utility faces rising costs, a high level of overheads due to the conjunction of small scale and the technical requirements of a utility, and consumers facing high bills [especially due to fuel surcharges] that now verge on being outright unaffordable. This is compounded by revenue reducing implications of, e.g. end-user adoption of renewable technologies such as PV, and even of energy efficiency [save where these might help postpone need to invest in grid and generation expansion].

g) Montserrat's main strength to undertake the transformation is what would otherwise be a weakness: *we are a small island developing state in recovery and redevelopment in the aftermath of a major natural disaster*. Thus, we need to start over and have the opportunity to do so based on the proverbial "clean slate."

h) In that effort we have many credible partners, and the relatively small scale of Montserrat means that the <u>incremental</u> effort to undertake a *sustainable* rebuilding process would not be outrageously expensive relative to what we already have to do.

i) Indeed, this enables us to market ourselves, across time, as the Caribbean Island where the sustainable, green energy future is already happening.

j) Through the creation of an Energy Office as a focal point for action on sustainable energy, project opportunities may be identified, plans may be developed and funding sourced [especially through "green future" funding mechanisms], capacity built up, and implementation monitored and managed in the face of contingencies and challenges.

k) Then, based on capacity built up, lessons learned and successes achieved, successive waves of advance may be undertaken.

B] CRITICAL ACTION POINTS AND KEY SUCCESS FACTORS:

The first *strategically critical action point* for the implementation plan 2008 – 2012 is the creation of an Energy Office [EO]:

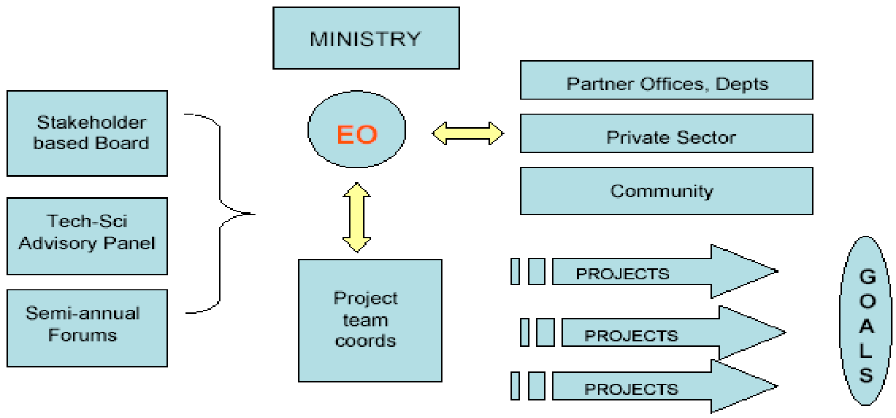


Fig PB.1: *The Energy Office* [SOURCE: TKI]

The creation, adequate staffing and resourcing of such an office then allows for addressing other *critical action points*:

a) Through the creation of an energy policy and associated implementation plan with a list of priority objectives and associated *major initiatives* [whether initiated by GOM, or aid agencies, or the private sector or NGO's or in the wider community], an agreed framework for action through a coordinated programme will have been created, to be channelled through the Energy Office. This framework also forms a basis for budgeting, sourcing of major development funding, grant-making for smaller projects, Carbon trading and similar initiatives to raise required financial resources.

b) A further envisioned function of such an office is to work as in effect a facilitating agency with grant-channelling capacity for *small but valuable projects* that may emerge across time. Such a function then allows for capacity building through training and mentoring of the leadership in such small scale projects, through the use of a team of project coordinators.

c) Through a network of partners across the society, in the region, in the UK and globally, various specific resources [especially in-kind provisions and/or key skills and effort committed to projects for short-term tasks] can also be made available to key projects.

d) Through the use of a Technical and Scientific Advisory Panel, high-level review of technical issues can be undertaken, and associated strategic level advice can be obtained on a regular basis.

e) The use of a Stakeholder-based Advisory Energy Board and of semi-annual forums on the state of sustainable energy in Montserrat, participative engagement of the community can be institutionalised, and transparency encouraged.

f) The principal governmental accountability for the Energy Office would be through the ministry in which is based. In this context, the EO will need to create a legislative agenda and draft associated regulations, starting with a review and recommendations made during its first year.

g) Similarly, in its first year, the Office will need to develop and carry out a project to improve collection, compilation and use of local energy related statistics, especially those relevant to emissions monitoring and Carbon Trading.

h) Related to that, permanent, around the clock, all-year monitoring of basic scientific energy information will need to be improved, especially wind and solar energy data, and perhaps as well wave and tide data. A collaborative project with the Meteorological Office, MUL and other partners would be a useful way to approach this.

i) Similarly, the Energy Office would be a useful basis for working with ongoing projects to explore and identify our geothermal potential.

j) The office would also be a focal point for Government support of *the ongoing wind and geothermal energy initiatives*, especially when they move to the stage of being actual commercial development projects. In this context, the Office could also help support tendering processes as requested by the Ministry of Finance, e.g. through advice requests to the Technical and Scientific Advisory Panel.

k) Onward, the office could help monitor and support technology, management [and, if relevant, ownership] transfer under the terms of the relevant contracts for Geothermal and Wind energy development and operation.

l) In its first five years, the Office will need to facilitate several priority national renewable energy initiatives, as described in the Declaration and Rationale: especially, geothermal, wind, solar, bio-fuels. Research and demonstration level projects on solar PV, bio-fuels, renewable energy air conditioning and similar pioneering initiatives will also require support, resourcing and coordination.

m) Such initiatives will have to be balanced by appropriate initiatives and measures designed to sustain the viability of the national electricity utility as a vital strategic asset. So, in partnership with MUL, the Office should examine the best balance on generation plant mix, grid upgrade and maintenance requirements, costs, revenues, DSM opportunities, commercial/aid funded investments in key green energy upgrades and reasonable adjustments to tariff structures and rates. Appropriate projects should be jointly undertaken under these heads.

n) Similarly, it will need to support priority energy efficiency initiatives. Perhaps, these can be clustered through a collaborative effort of MUL, associated (perhaps newly created) ESCO's, key local financial institutions and collaborating merchants and the local construction industry. Such a cluster may conveniently be coalesced through a project that creates an "affordable efficiency" green energy programme. (A waste management effort for energy-related hazardous wastes involving e.g. mercury and lead, should be integrated.)

o) The Office should also provide support for the envisioned Public Utilities Commission[PUC].

p) The Office should serve to monitor global developments in the energy industry, e.g. solar energy and the pebble bed modular reactor programmes of South Africa and China.

q) Through collaboration with the Community College, UWI, and other local, regional and international partners, the Office should support the emergence of training and capacity building programmes for sustainable energy.

Key success factors for these action points include an agreed policy and action plan, adequate staffing, organisation, financing and general resourcing of the office, as well as the building up of a critical mass of support in the community, government and key aid agencies.

C] UNCERTAINTY AND RISK MANAGEMENT:

Energy is now a highly dynamic sector, and fossil fuels are perhaps the most volatile key strategic commodity in the modern world. Similarly, the major envisioned renewable energy resource, geothermal, has a relatively high-risk exploratory component.

Factors such as these indicate that there is significant risk involved in energy related initiatives, and in some cases we are unable to sufficiently quantify associated probabilities to move beyond uncertainty to – however roughly – *calculable* risk.

This indicates that much of the risk and uncertainty management has to be based on envisioning PEST-SWOT analysis scenarios on the [1] "business as usual" [BAU] and [2] "sustainable alternative" [ALT] policy tracks, leading to contingency planning relative to [a] "optimistic," [b] "moderate"/ "likely" and [c] "reasonably pessimistic" projected future worlds.

Thus, a robust policy framework may be built up:

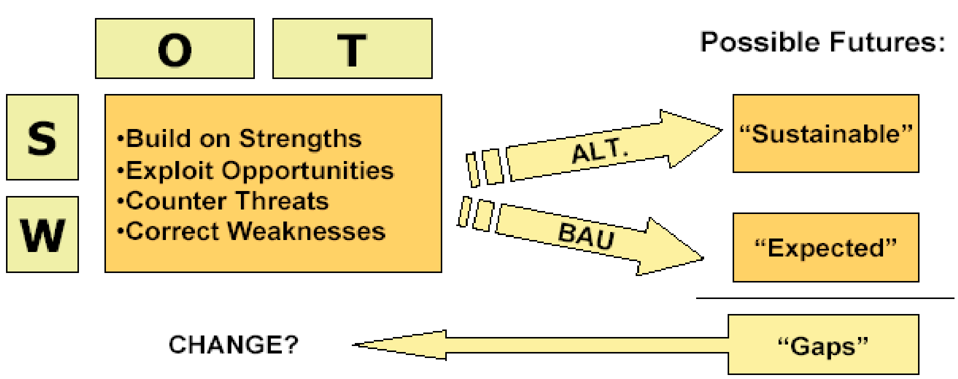


Fig. PC.1: *Policy options and possible futures* [SOURCE: TKI, also, cf. Bariloche Foundation.]

The general result of such an analysis is already known: the most robust policy track for Montserrat involves moving away from fossil fuels to cost-effective renewables, and to energy efficiency. This escapes the increasingly high costs and instability of the fossil fuels markets which now provide over 90% of Montserrat's commercial energy. It significantly reduces environmental damage. Also, by insisting on cost-effectiveness, across time we move towards such renewable technologies and efficiency measures as are economically warranted.

These strategies, across time, would put us into an end state where we are much less vulnerable to the oil markets, use resources that are not likely to run out for the foreseeable future, and are cost-competitive for adequate performance. However, they tend to be more capital-intensive than fossil fuel alternatives, and often face resource intermittency challenges. (Indeed, that is responsible for much of the extra capital cost to provide an adequately reliable energy supply available when we want it, in the quantities we desire, and in forms we find most useful.) Also, there will be need to adapt or create new infrastructure and equipment that is better fitted to the emerging green energy framework.

This raises a need for supporting the transition period through capital injections and thus implies associated financial risks. These risks obtain for consumers, for the electricity utility, for small businesses, and the financial institutions, all of which currently are challenged to provide the breadth and depth of expertise required to address the required renewable energy and energy efficiency investments. (There are balancing risks to remaining with business as usual, for which the same actors are equally challenged to assess the relevant risks.)

These risks, uncertainties and challenges are best addressed through training, general capacity building and technical cooperation partnerships. For these, the services of one or more established ESCOs with experience in the Caribbean would be very helpful, and could find focused expression in the creation of a local ESCO, or an ESCO-DSM arm of MUL.

D] PROGRAMME GOALS, OBJECTIVES & LINES OF ACTION:

In light of the above factors, the Montserrat energy policy implementation programme for 2008 – 2012 should seek to achieve the following goals:

I. To exploit available opportunities for migrating from fossil fuel technologies towards relatively mature *renewable energy technologies*, especially geothermal energy and wind, while preserving the viability of the electricity utility (as our strategically vital grid holder);

II. Improving *efficiency of energy use* through a programme of energy audits and related changes in equipment and energy-use patterns through an affordable energy efficiency initiative;

III. Building basic *capacity* for full green energy transformation.

Corresponding to these overarching goals, the following more specific and measurable objectives [from which associated projects, activities and inputs will be developed] may be identified:

1. The creation of an Energy Office to coordinate implementation under the energy policy, initially within three months from the adoption of the policy, and on a more permanent

basis within a further six months. In parallel, the initial creation and consolidation of the Stakeholder-based Advisory Energy Board and Technical and Scientific Advisory Panel.

2. Initial forum on energy, Calabash Festival 2008, and second forum on energy, Christmas Festival 2008. Thereafter an energy forum every following festival season.

3. Through the office, supporting *the continued aid-funded exploration of geothermal potential in Montserrat*, and then -- if a resource is proved -- supporting onward *Tenders Board bid process* and *development of geothermal energy on a commercial basis* through the BOAT model, as is specified under the terms in the Declaration.

4. Similarly, through the Office, supporting exploration of *wind* potential and development of a wind component of Montserrat's electricity generation assets of up to ~ 900 kW rated capacity (or about 300 – 400 kW effective in light of capacity factor constraints); as well as associated grid capacity improvements required to host such a large proportion of intermittent generation plant. Also, utility long-term viability enhancement.

5. Development of an energy audit, affordability-enhancing *demand side management* [DSM] and associated energy services initiative, working with the electricity utility, the building industry and other partners in efficiency, augmented by public education and moral suasion projects. (This initiative should then lead on to *efficiency-enhancing building code reform*; which should also incorporate relevant *waste management* [e.g. fluorescent lamps (mercury) and storage batteries (lead)] and *environmental management* initiatives [cf. ISO 14000].)

6. Creation of an initial monitoring capacity for solar, wind and other similar forms of energy through collaboration with the Meteorological Office and other relevant partners.

7. Consolidating that capacity and putting it on a permanent basis.

8. Enhancing capacity for collecting analysing and reporting on fossil fuel import and carbon emissions statistics.

9. Initial programme review and adjustments to the energy policy and implementation plan.

10. Creation of an initial programme of short courses and workshops on energy transformation for technical, managerial, business, community leaders and other interested participants, through collaboration with the Community College, UWI, and other partners.

11. Onward, development of formal educational programmes in energy related areas.

12. Initial exploratory research and demonstration-level technical capacity-building exercises in more advanced renewable energy and energy efficient technologies such as emerging solar photovoltaic systems, bio-fuels, solid state LED lighting, etc.

13. Pilot testing and demonstration exercises for adoption of the more promising advanced technologies.

14. Evaluation, policy rollover and drafting of the second implementation plan.

15. Transitioning to the second sustainable energy implementation plan.

In sum, and relative to the five major lines of action identified in the policy Declaration, in this initial five-year wave of advance towards a green energy future, Montserrat will emphasise initial transition to mature renewables, shifting to affordable high-efficiency technologies and approaches, capacity building and initial exploration of fuels and transportation sector transformation.

E] STRATEGY, FINANCING AND LOGISTICS

A **strategy** can be described as *a planned (or emergent) pattern of resource deployments and associated activities towards a goal, in a given situation*. Thus, a robust strategy will identify environmental factors and trends, especially opportunities and challenges or threats, and also relevant internal factors: strengths and weaknesses. It will then align actions to situations by using the SWOT factors: *using our strengths to exploit opportunities, counter threats and compensate for or correct weaknesses.*

In the case in view, the prospective Energy Office is the primary means of mobilisation and deployment of resources to support initiatives and activities towards the goals of the sustainable energy plan, and so its basic resourcing is critical to success of the plan. Thus, once a GOM budgetary funding base is established to cover its basic operations [perhaps ~ US$100,000 per year], and as a similar base is established to seed priority projects [set relative to their budgetary requisites and our available/allocated financial or in-kind resources], *matching* grant, soft loan, carbon trading and other funding for strategic projects may then be sought on a case by case basis. Also, through partnerships with local, community based organisations and other groups, additional funds, facilities, equipment and personnel can be sourced on a project by project basis, and may be identified as *in-kind community contributions*. Some income generation may be created through modest but realistic fees for project support services, especially for the larger projects. Further, if a reasonable sized initial small-grants fund [perhaps, about US$ 250,000] can be placed in the care of the Office, it can then be used to set up a project to mobilise a wave of small community level, capacity-building, exploratory and/or demonstration-oriented sustainable energy projects across Montserrat.

The resource deployments and progress or gaps relative to *project milestones* and *deliverable results* can then be monitored and managed through the envisioned project team structure [cf. Fig. PB.1 above], using an operational form of the classical *log frame* [logical (or, perhaps more aptly, "logistical") framework]:

Project Narrative	Critical Success Factors	Indicators	Assumptions & Risks	Contingencies
Wider SD Goals:				
Project Outputs:				
Project Activities:				
Project Inputs:				

Fig. PE.1: *Implementation-oriented Project Log Frame*

In this implementation-oriented version of the log frame:

a) The *project narrative* outlines (in points form) the project based on stating the sustainability goals pursued [here, energy sustainability for Montserrat], then identifying (i) deliverable results or outputs that contribute to achieving those goals, (ii) the activities that generate the outputs, and (iii) the input resources required to undertake the activities.

b) The *critical success factors* [CSF's] are that cluster of "those few key things" that must be done or must be provided if the relevant aspects of a project are to succeed. *If progress grinds to a halt, one therefore looks for an unmet CSF.* (Funding and permits are two typical examples.)

c) The *indicators* are means of observing and verifying that the CSF's are in place, and/or to what extent, thus, for keeping the project on track. (E.g. "typical" indicators may be documents that verify that permits are granted or funding is available to the project.)

d) *Assumptions* are environmental or situational conditions (e.g. support by key permission-granting decision-makers, and of funding agencies, etc.) that need to be in place if the CSF's are to be achieved. They may be low, moderate or high risk, and as a rule if they fail, one or more CSF's will not be met. So, projects should be designed to minimise the degree of risk on their assumptions, or if that is not possible, they must have contingency plans.

e) *Contingencies* are the work-around plans and associated resources for what happens if an assumption fails.

This form of the log frame is therefore useful for integrating logistical, financing, strategic and management considerations throughout the project cycle. It may be applied across that cycle, from (1) identification of a project opportunity, to (2) developing a well-structured project, to (3) sourcing funds and other resources, to (4) implementing, monitoring and oversight, to (5) completion and formal evaluation. Indeed, a log frame [in a specified format] is often insisted upon by Grant Agencies, for just this reason; and where it is not a requisite of grant applications, one is often generated in-house by the Agencies; so it is to our advantage to provide a log frame ourselves. Last but not least, it is a powerful tool for training in the logic of the project cycle and in monitoring and coordinating associated activities and resource flows.

Accordingly, the log frame is a "best practice" tool of choice for managing the integration of strategy, financing and logistics, and is adopted as the key instrument for this aspect of the implementation plan. [Cf. Appendix G.1.]

F] PROGRAMME-LEVEL MILESTONES AND DELIVERABLES:

A glance at the identified goals and objectives shows that the first wave of advance under the energy policy naturally falls into three partly overlapping phases: [I] initiation and initial operations, 0 – 15 months, [II] consolidation and major operations, 12 – 48 months; [III] review and preparation for onward waves of advance, 49 – 60 months.

These phase boundaries mark major *programme-level* ***milestones***, and major initiatives (such as geothermal development) may have their own milestones that are worth attending to at a programme level. Similarly, the programme of semi-annual public forums on energy imposes a pattern of regular public event milestones. As we approach each of these milestones, a pause needs to be taken to assess progress, gaps relative to intended achievements, and major contingencies as necessary. This may be captured in a reporting process on progress/gaps, challenges and contingencies, which then become key programme-level *deliverable results* [***"deliverables,"*** for short] that allow for national, strategic level decision-making and guidance.

The relevant timelines and milestones for major initiatives under the energy implementation plan 2008 - 2012 may be shown through a *Gantt chart*:

Ref.	***Initiatives***	***Actors***	***Timelines***	***Current Status***
			2008 2009 2010 2011 2012	
1	Energy Policy & implementation plan [Q1, 08]	GOM, UN ECLAC, GEM/TKI		This: work in progress.
2	Energy Office [EO] initiation [Q2, 08]	GOM, DFID	**(operational)**	Pending policy approval
3	Wind Energy & utility viability enhancement [Q 2 08 – Q2 09]	GOM, MUL, DFID, UN ECLAC	**(operational)**	Proposal and initial consultations
4	Geothermal, pre-commercial exploration [Q1 08 – Q4 09]	GOM, DFID, UN		Phase 1: scoping study, in progress
5	Geothermal development [pending success of exploration] [Q1 09 – Q2 10]	GOM, Tenders Board, EO, Developers	**(operational)**	Tenders Board bid process, pending successful exploration
6	Affordable Energy Efficiency & DSM initiation [Q3 08 – Q4 09]	GOM, EO, MUL, DFID, ESCOs*	**(operational)**	Opportunity identification in progress
7	Initial setting up of a Public Utilities Commission) [Q3 – 4 08]	GOM, MCW, EO		Pending completion of Law and associated policy
8	Establish ongoing wind, solar monitoring [Q2 – 4 08]	GOM, EO, Met Office		Early steps taken
9	Improving statistics collection and analysis on energy [Q3 – 4 08]	GOM, EO, Stats Dept, Customs		Opportunity/need identified
10	Developing workshops & courses on sustainable energy [Q3 08 – Q2 10]	GOM, EO, DFID, M'rat Comm Coll, UWI, Caricom		Opportunity/need identified
11	Small, capacity-building, community-based energy projects grants scheme [Q1 09 – Q4 12]	GOM, EO, Aid Agencies, community based partners		Opportunity/need identified
12	Advanced energy technologies exploratory projects [Q3 09 – Q2 12]	GOM, EO, MUL, DFID, partners		Opportunities to be identified
13	Public GOM forums on sustainable energy [July, Dec, in years 08 – 12]	GOM, EO, NETF/ Energy Advisory Board, Tech & Sci Advisory Panel, [TSAP], PUC*	* * * * * * * * * *	Pending EO set-up
14	Evaluation, revision, policy rollover and new plan [Q1 09, Q1 – 4 12]	GOM, EO, NETF/ Energy Advisory Board, TSAP, Dev't Unit: SDP*, DFID		Pending policy approval

* NB: **ESCO:** Energy Services Company, **SDP:** Sustainable Development Plan; **PUC:** Public Utilities Commission

Table PF.1: *Suggested timeline for major initiatives under the implementation plan 2008 - 2012*

G] PRIORITY PROJECTS AND INITIATIVES:

The above goals, objectives and timelines highlight a cluster of priority projects and initiatives:

1. Geothermal[x] exploration and development

2. Energy Audits, Demand Side Management and Affordable Efficiency, starting with a project at Government Headquarters that uses it as a demonstration project. (This should integrate waste management aspects.)

3. Wind[xi] development & associated grid and plant enhancements

4. Solar thermal and solar photovoltaic development

5. Associated support to the restructuring and re-orientation of the electricity utility to sustain its viability as a key strategic asset, the national grid holder.

6. Data gathering and analysis to identify more precisely technical and economic prospects for wind, solar and similar forms of renewable energy, leading to a development and implementation process.

7. Upgrading of national capacity to collect and analyse energy-related statistics.

8. Capacity building, including training workshops and courses.

9. A small grants energy projects scheme, connected to the capacity building initiative.

10. More structured, research-level investigation, exploration and capacity building to handle other emerging technologies focused on the electricity and transportation sectors. This includes bio-fuels, thin film solar cells, dye-sensitised Gratzel type TiO_2 solar cells, vertical axis wind turbines and other relevant technologies

H] CREDIBLE, TRANSPARENT, CAPACITY-AUGMENTING PARTNERSHIPS:

Several of the above priority projects will require augmenting of our existing national capacity.

In the case of geothermal and wind energy development, this may be best carried through by applying the Tenders Board process, in a context of aid agency funded initial exploration and feasibility investigations. These initial investigations, themselves, will logically require UK and/or international technical assistance. (Indeed, as of this writing, such is already in train for both cases.)

Once the scope of the resource has been credibly identified, quantified and reported in reports that make recommendations regarding feasibility, the Tenders Board process will apply. Thus also, a bid process relative to the BOAT energy development model as discussed in Schedules 2 and 3 to the Policy Declaration above, will apply. This should result in credible, capacity augmenting partnerships on energy development.

On education and capacity development, and on projects to facilitate small initiatives and research-level investigation, partnerships should be made with such existing regional, UK based and international institutions as would be helpful. Where it is advisable, steps to promote transparency would be appropriate, though this should be tempered with an appreciation that such capacity building -- for excellent reasons relating to the difficulties of assessing the quality of novel partners for such services -- frequently simply uses existing networks of relationships with well-known, credible, preferred suppliers of expertise.

I] PROJECT-TEAMS & RESOURCE ALLOCATION:

The Energy Office is envisioned as the hub of a project-team based implementation structure, i.e. One that applies matrix style organisation principles to couple resources and support from various partners to various selected projects targetting the goals of the energy policy.

This allows making advantageous use of existing and prospective partnerships across and beyond the government and into the community and even private sectors, with room for regional and international partners as well.

J] OUTLINE-LEVEL PROJECTED PROGRAMME TIMELINES

This has been presented at F above.

K] OVERALL ORGANISATION, OVERSIGHT AND GOVERNANCE:

This has been presented in diagrammatic form in Fig PB.1 above.

Principal oversight of and public accountability for the energy policy implementation process is vested in the host Ministry for the Energy Office.

In the interests of participative democratic governance and transparency, the Office is also first connected to a Stakeholder-based Advisory Energy Board, and an associated Technical and Scientific Advisory Panel. Resource-providing partners sit on a coordinating committee for the project teams, for which the Head of the Energy Office would be the designated Executive Secretary.

Project team leaders are then enfolded in the governance, coordination and oversight process by forming an energy projects task force that incorporates the coordinating committee and the project leaders.

SUMMARY & RECOMMENDATIONS: The outline initial energy policy implementation plan, 2008 – 2012, above, shows how the proposed Energy Office and other associated instruments may credibly be harnessed to begin the green energy transformation of Montserrat's economy. This transformation would shift our society to a more sustainable energy base.

APPENDIX PA.1:

An outline proposed operating budget, Energy Office

In addition to project funding and possibilities for modest income generation through fees for services, the Energy Office will require a basic operating budget. This is preliminarily estimated as follows:

DRAFT Estimated Annual Operating Budget

Montserrat Energy Office

Ref	***Description***	***US$***	***US$***
	INCOME:		
I1	GOM/DFID		135,000
		TOTAL:	**135,000**
	EXPENDITURES:		
	Staff:		
S1	Senior Technical Officer and Head	30,000	
S2	Technical Officer	20,000	
S3	Administrative Officer	20,000	70,000
	General Facilities & Equipment:		
FS1	Startup provisioning of office (1st year)	20,000	
FS2	Startup provisioning, basic technical equipment (1st yr)	20,000	
G1	General Office expenses	12,000	52,000
	Technical Operations:		
T1	Expendable technical supplies	1,500	
T2	Technical Literature	1,500	
T3	Travel & Conferences	5,000	8,000
	Other:		
C1	Contingencies		5,000
		TOTAL:	**135,000**

APPENDIX PA.2:

Legislative and Regulatory Agenda:

While in general the Energy Policy has a good fit to existing legislation and regulations, such that the major task is to clarify, apply and then make optimal use of existing law and regulatory praxis, there are several points where some adjustment or, possibly, novel laws or regulations may prove useful:

1] Regulatory effect of Declaration of Energy Policy:

The policy declaration above, once passed by the relevant Council, has a regulatory effect, as *it first and foremost clarifies and gives procedures for the application of current and prospective law, regulations and relevant aspects of regional or international agreements to the particular context of energy policy*.

2] Establishment of an Energy Office:

By virtue of its remit as the implementing arm of the energy policy, *the Energy Office will be a regulatory agency, applying the vested regulatory powers of its covering Ministry on areas within its mandate.*

In so acting, it is envisioned that it will closely coordinate its work with the Environment Department and the Development Unit, given the relevance of energy to environmental and sustainability of development matters. It is therefore proposed that memoranda of understanding between the relevant Ministries and Departments be jointly developed to clarify the terms and conditions of such coordination.

In addition, the Office will serve as a point of reference and counsel on technical regulatory matters, e.g. on certification of the quality and utility of energy efficient equipment and of the acceptability of the credentials of energy service companies.

3] Establishment of An Advisory Energy Board, and Technical and Scientific Advisory Panel:

These adjuncts to the Energy Office will carry out functions bearing on transparency and consultation that will function as a part of the regulatory process. The similarly established regular public forums on the state of energy will also have a regulatory effect, by establishing regular, *public,* policy review milestones.

To constitute the Board, a reasonably short list of *representative* stakeholder groups [perhaps up to 10 – 12] should be prepared through the Energy Office in consultation with the existing NETF. On approval of the list of groups by the Ministry, nominees and two alternates would be submitted by the chosen representative groups. The Ministry would then forward the list to the Executive Council.

On approval of one member each per stakeholder group by the Executive Council [here holding veto power over prospective members and alternates], the Board would be empanelled. It should meet not less frequently than quarterly; to hear reports by the Energy Office, other Ministry officials as relevant, and the responsible Minister on the state of and outlook for energy and to make stakeholder-representative recommendations relative to that state and outlook. At the immediately following Board meeting, the Energy Office will be required to report on the status of follow-up actions on these recommendations. It should also jointly plan and present the semi-annual public forums on energy with the Energy Office.

Similarly, at these fora, the Office, Board and Minister will make a report on the state of and outlook for energy, taking public recommendations. At the next public forum following, the energy office will be required to report on the status of follow up actions on recommendations by the general public.

Members would serve three-year terms, with a rotation of 1/3 of the members in each year; no member being permitted to serve two terms in succession. Subject to this, any person may serve an unlimited number of times. (In the first instance, members to serve short 1 or 2-year terms would be selected by personal choice, and if that is inadequate, by a random process.)

The Head of the Energy Office, *ex officio*, will serve as Secretary to the Board, and the Energy Office will be its Secretariat.

Members of the empanelled Board and also the Ministry would jointly nominate local, regional, UK and international candidates to sit on the TSAP. These nominees should be well-qualified and experienced professionals representing relevant technical expertise in key scientific and engineering energy fields, transportation, finance, law and regulation, sustainable development and any other technical field deemed relevant. Providing a geothermal initiative is under active exploration and/or is commercially developed, the Chief Scientist, MVO, would sit on this panel, *ex officio*. (The TSAP would mostly serve through correspondence, but as appropriate within budgetary and availability constraints, semi-annual meetings and special meetings should be convened.)

On Executive Council approval of the list of proposed invitees, TSAP candidates would be approached, and membership determined based on agreement to serve. The Panel would then be established, with a similar three-year term to the Board. However, given the challenges of obtaining such highly qualified technical support, there will be no restriction on a member sitting twice in succession. Overlapping of memberships would be left to natural attrition, for the same reason.

Again, the Head of the Energy Office, *ex officio*, will serve as Secretary and that Office will be the Secretariat.

4] Electricity Generation and the Grid as natural monopoly:

The current law for electricity generation in Montserrat no longer stipulates that Monlec/MUL shall be the sole provider of Electricity, especially in respect of small renewable energy sources or the use of so-called standby generators. However, the established utility has the power to determine conditions under which grid connection may be instituted, i.e. it is implied in current law that it controls the true natural monopoly, the grid.

This should be preserved, and if necessary enshrined in an updated form of the law; perhaps stipulating an appeals and arbitration process in case of dispute.

5] Net metering and similar grid connexion:

In addressing the prospective rise of low cost solar photovoltaic systems -- e.g. the possibility that Nanosolar of California has through shifting to a printing technology [with an emerging protective patents "wall" of some 180 filings to date], currently lowered the capital cost of solar PV to less than US$ 1,000/ kW nominal capacity -- the issue of grid connexion and net metering comes up.

In effect, if households, businesses and firms begin to adopt such PV technologies on a large scale and/or similar technologies, they may wish for these to be grid connected and to have a two-way electricity billing process, as from time to time they may be net sources rather than users of electricity. Existing metering and grid connexion technology permits such two-way billing and integration into the grid.

However, this technology is normally applied in large scale jurisdictions with large grids and power stations, so that the effect of such intermittent small generators is relatively small. In Montserrat, with the prospect of the introduction of relatively large wind capacity, and the relatively small scale of the national grid and peak load [currently about 2 MW], it would be wise to go slowly on this, using pilot test cases as a guide to what could happen to the grid as a whole if substantial numbers of small intermittent generators are added over say the next 5 – 10 years.

Thus, it is wise to retain the principle that *the national utility holds the national grid as a natural monopoly and is authorised to grant or withhold permits on reasonable grounds*, pending a process of gradual testing and capacity building to manage a grid with a high degree of penetration by intermittent power sources at various scales of operation.

6] Geothermal Generation Law and the OECS:

Currently, the OECS, through the Geo Caraibes project, has developed a standard form generic law on the control of geothermal electrical generation.

That law is premised on the principle used in the Policy Declaration above, that mineral, treasure and water rights -- per longstanding Commonwealth legal principle -- are <u>publicly</u> owned [i.e. "Crown"]. It may be useful to pass an appropriately modified form of this legislation here, bearing in mind the usefulness of having compatible legislation across the OECS sub-region.

7] Public ownership of geothermal resources and the Tenders Board bid process:

The same principle of public ownership of the underlying goods, even without explicit regulation or law on the matter, has a further effect.

For, there is an existing, well grounded power to regulate the terms under which exploration, commercialisation, development, and operation of geothermal power plants are carried out. In particular, *as the geothermal resource in question, if proved, would be worth well beyond EC$ 100,000, the standard Tenders Board bid process, per relevant law, applies.* [This process also includes reference to advisory committees, which would be relevant to the use of the Energy Office's Technical and Scientific Advisory Panel as such an advisory body.]

Thus, also, the Schedules 2 and 3 to the Policy Declaration above instantiate and fulfill a classic purpose of regulation: to clarify and give procedural force to existing law. In so doing, they first establish the principle that a modified BOOT/BOT framework, *BOAT,* is a main candidate to be applied on a best practices basis to geothermal generation in Montserrat:

B – *BUILD:*	The contract operator undertakes specific relevant technical pre engineering studies, financing, full technical design, construction and commissioning of the plant and related infrastructure.
O – *OPERATE:*	The operator manages the plant and harvests appropriate returns for this effort. (*Ownership* of assets is left to the terms of the particular agreement entered into with local and/or regional and/or international partners in light of where financing advantages etc. may lie.)
A – *AND:*	Simultaneous with the development and operation of the plant, a capacity-building and technology transfer process is carried through as a part of Montserrat's ongoing rebuilding and redevelopment.
T - *TRANSFER:*	The capacity-building and technology transfer lead up to a scheduled transfer of management (and, where relevant, ownership) of relevant assets at the close of the franchise period. In the final five years of the contract, management of the plant would be progressively handed over to a successor Montserratian entity, in agreed stages. At the end of this period, any relevant assets owned by the international partner are sold to the emerging Montserratian entity at a price negotiated based on their audited residual value.

Secondly, they establish that there should, per best/effective and transparent practices, be a prequalification for accepting any bid by a prospective geothermal development partnership, joint venture or corporate body, on the following terms:

> . . . there are three *core criteria for pre-qualification* of bidders to develop geothermal energy in Montserrat:
>
> - *Financial capacity* to undertake a venture that (on credible preliminary technical reports) may cost up to ~ US$ 12.5 – 15 millions at the initial 3 – 5 MW level, and would require perhaps up to three or more years of initial investment in exploration and development before commissioning of a plant and associated income-generation.[xii]
>
> - *Proven technical capacity* to credibly undertake geothermal development in a new and hitherto largely unexplored geothermal field.
>
> - *Involvement of a Montserratian entity in any proposed partnership* involving external components, in a context of capacity-building through technology,

management [and if applicable, ownership] transfer under the modified BOOT or BOT development model identified in Schedule 2 [above] as BOAT.

The recommended requisite technical capacity is further stipulated as follows:

The successful bidder should:

(a) have successfully developed at least one Geothermal field;

(b) have thus built and operated at least a 3 – 5 MW plant for something like five years;

(c) have produced electricity at reasonably competitive cost relative to alternatives in their local market;

(d) have done so at a production costs reasonably comparable to the global "benchmark" of about 4 ¢ [US] per kWh of electricity at levellised cost; also,

(e) in the case of consortia, or partnerships, or other forms of joint ventures *at least one member should meet points (a) through (d) of this criterion.*

8] Tax Holidays, Financial Incentives, Royalties and Carbon Trading:

A key provision of the policy as declared above, is that the various financial incentives for investors and developers of pioneering industries apply. [NB: Reference may be made to the draft geothermal development law prepared under the Geo Caraibes project, for use as an exemplar and to illustrate competitive pricing targets.] There may also be access to soft loan funds under the clean development mechanism or similar international instruments, arrangements and emerging "green economy" markets.

However, it also notes that *certain resources used for renewable energy generation are based on what are by virtue of the law on minerals, treasure and water rights, publicly owned resources.* Thus, permits for exploration, licences for development and production, and thereafter royalties rest on permission granted to identify, develop and use a public resource with intent to provide benefits to said public. Royalties should therefore be applied on the base principle that the value of the relevant renewable resource used is the effective opportunity benefit of shifting from a more traditional, comparable fossil fuel source to the renewable source, on a levellised unit cost basis.

On that basis, the anticipated levellised cost savings should also be shared on an equitable, negotiated basis, over the working life of the relevant facility, across:

(a) royalties to the public purse [partly compensating for fuel import revenues foregone],

(b) reasonable profits to the innovator/investor [bearing in mind the degree of risk],

(c) revenues to cover incremental access, operating and maintenance costs of (and associated reasonable profits for) the holder of the national grid that transmits the resulting electrical energy, and

(d) reduced costs to the consumer.

It is also reasonable that the projected costs, savings and spreading of benefits be reviewed (and if necessary adjusted) from time to time, per an agreed schedule. Given the volatility of the underlying fuels and financial markets, this schedule should have contingency provisions for unanticipated developments.

While geothermal energy is principally in view, the principles also apply to wind, solar thermal and photovoltaic energy and other prospective renewable energy sources that use underlying publicly owned or in-common goods. Thus, it will be wise to make a formal decision to include such renewable sources in the ambit of law and regulation, but to also recognise that -- due to the pioneering and for now relatively costly (and, often, risky) nature of many relevant technologies and investments, as well as the major public good provided by shifting to renewable energy -- it may be appropriate to stress incentives rather than revenues through royalties.

It will also be important to accurately assess the resulting carbon emissions savings, as investment in renewable energy *may* be able to attract substantial carbon trading funds in the emerging markets, with particular reference to capital investments in plant that enhances grid parity of such renewables.

9] Zoning, planning and reservation of renewable assets:

It is observed above, that on wind development, the four areas identified as credible potential sites for wind development were in large part taken up by other initiatives such as housing development or an airport.

To some extent this was inevitable given the exigencies of the survival-threatening crisis Montserrat has faced in recent years. However, there is need for planning and zoning of development in ways that protect potentially vital national assets such as wind farm sites.

As appropriate, the existing regulations and law should be re-examined and amended as appropriate to avert unnecessary pre-emption of such key sites.

10] Energy Services Companies [ESCO's]:

In connexion with energy audits and energy efficiency improvement, many ESCO's have arisen globally and regionally. To facilitate the development of such capacity here, it is proposed that ESCO's with qualifications and experience acceptable to other member states of the Caricom region, and/or other relevant jurisdictions such as the UK, should be deemed credible to practice in Montserrat.

This should facilitate the creation of *demand side management* [DSM] and *affordable efficiency* initiatives.

11] Bio-fuels and transportation sector transformation:

As a part of the global process of shifting away from fossil fuels, there is a trend to introduce bio-fuels, especially ethanol and biodiesel; first, as additives, then eventually as fuels in their own right.

This immediately raises issues on the compatibility of such fuels with the existing and prospective stock of vehicles. Thus, there will be a need to recognise in regulations on fuel quality that (especially for ethanol blends, as the proportion of ethanol rises beyond about 10% [E10]), there may emerge compatibility issues. This may require a reservation that some provision of low ethanol blends should be made on a scheduled phase-out basis across the next decade.

Trans-esterified biodiesel fuels are compatible with diesel engines manufactured since the early to mid 1990's, and the changes for older engines are minor. Thus, no similar provision should be necessary for such vehicles. Gasification and synthesis-based biodiesel fuels are very similar to existing hydrocarbon diesel fuels and should similarly require no major adjustments. However, some monitoring capacity to assess and certify factors such as lubricity should be developed on a local or regional basis.

Two other prospective fuels, mixed alcohol fuels such as developed by Holtzapple and n-butanol, should also be assessed and if necessary regulated. Other similar prospective bio-fuels may also exist. The Energy Office, working in collaboration with local and regional agencies, would be a suitable means for this.

Financial incentives and other support for pioneer bio-fuel growers and refiners will be helpful, also.

12] Fuel Cells, hydrogen and hydrogen carriers:

As fuel cells and the use of hydrogen gas and/or hydrogen carriers such as alcohols as the requisite fuel begin to emerge over the next decade, there will be need to recognise, build capacity for handling and to regulate the emerging commercial processes.

In particular, hydrogen gas, in either compressed or liquefied forms, is a novel technology and it is one that has significant safety challenges. (NB: These challenges should not be exaggerated: the very familiar gasoline is a considerable explosive; e.g., one US gallon of this substance is typically compared in explosive potential to eight sticks of dynamite.)

Accordingly, if and as vehicles using such fuels and fuel cells emerge, there will need to be an established capacity to be able to handle them safely and effectively. The provisions above for exploratory development of pioneering renewable energy technologies and for training and capacity building will be relevant to preparing Montserrat for such an onward, long-term transformation of its transportation sector.

In addition, the modularity of solar PV, wind, fuel cells and the like leads to a potential transformation of the energy side of building industry and associated developments in the agriculture and/or commercial/industrial district sector. For instance, such districts may wish to undertake combined local electrical generation and heat-use or air conditioning to gain the energy savings associated with the high [up to 70+ %] efficiency of cogeneration.

Similarly, especially if/as solar PV systems and/or fuel cells achieve producer-end grid parity, such buildings, installations or districts may wish to create miniature grids that mutually support their electrical and/or thermal energy needs and/or may wish to engage the national grid on a net metering basis. In the interests of green energy transformation, this should be accommodated through the use of the single-purchaser, grid as natural monopoly model as a vehicle to facilitate exploratory and then strategic demonstration projects that on proving their robustness, can be integrated into the grid on a more widespread basis. ESCOs [and/or possibly research agencies in the early phases] could provide relevant technical support for the process.

APPENDIX PA.3

Carbon Emissions Trading and similar opportunities

According to currently available statistics, Montserrat emits about 40,000 tonnes of CO_2/year, or about 8 – 10 tonnes per resident, and about 1.6 lbs/EC$ of GDP. The basis for this is that over 90% of our commercial energy derives from fossil fuels, where burning one gallon of gasoline or diesel fuel emits about 20 lbs of CO_2.

This has several consequences: we are vulnerable to the sudden, sharp, upward fluctuations and trends that have characterised the global oil market in recent years, while at the same time our levels of consumption are on a global scale rather small, though per capita we are about mid-ranking. Therefore, we may find carbon trading feasible only on a project by project lifetime basis; such as the emissions averted by developing and operating a wind farm. For such a case, using wind power as a suitable exemplar, a sample calculation was provided in Section A of the Policy the Rationale above:

> . . . our entire emissions may be about 40,000 tonnes of CO_2/annum, even at a hard to get US$ 30/tonne, that would not be a lot on an annual basis. In short, we need to trade on the basis of power plant lifetime avoided emissions, not year to year, tonne by tonne reductions. So, we note that across a 30 year lifetime, 300 kW of *available* wind capacity from a three-turbine 900 kW farm would generate 30 times 2,629,800 kWh, or about 78.9 million kWh. Montserrat's current ~ 36% efficient high speed diesel plant uses about 0.064 gal of diesel fuel per kWh generated, and so emits about 1.43 lbs CO_2/kWh. Thus, as a rough guide, installing the wind turbines would reduce our emissions by about 51,200 tonnes; worth about US$ 1,536,000 at the "best" currently available price, from the available range, US$ 4 - 30/tonne of avoided CO_2 emissions.
>
> That is a reasonably trade-able number, one that could potentially reduce the capital costs of the envisioned wind plant significantly.

Now, Carbon emissions trading is an emerging market, and one in which there were hiccups caused by a situation where there was an initial glut of emissions permits [probably in significant part caused by perhaps overly generous estimates of existing emissions levels of fossil fuel power plants], leading to a sharp dip in prices over the past year or so.

As Dean William H. Schlesinger of the Duke University Nicholas School of the Environment and Earth Sciences observes as well, in a recent editorial in the Journal, Science:

> In 1990, the U.S. Environmental Protection Agency set a limit on SO_2 emissions from obvious point sources and allowed those who emit less than their quota to trade excess allowances. As a result, regional acid deposition was dramatically reduced. Can the world do the same for CO_2?
>
> Fundamental differences in the biogeochemistry of SO_2 and CO_2 suggest that establishing a comprehensive, market-based cap-and-trade system for CO_2 will be difficult. For SO_2,

> anthropogenic point sources (largely coal-fired power plants), which are relatively easy to control, dominate emissions to the atmosphere. Natural sources, such as volcanic emanations, are comparatively small, so reductions of the anthropogenic component can potentially have a great impact, and chemical reactions ensure a short lifetime of SO_2 in the atmosphere. CO_2, in contrast, comes from many distributed sources, some sensitive to climate, others sensitive to human disturbance such as cutting forests. It is thus impossible to control all of the potential sources. [Science 24 November 2006: Vol. 314. no. 5803, p. 1217.]

In short, given the different dynamics at work, it would be wise not to put over-much reliance on the success of sulphur dioxide trading in the 1990's as an exemplar.

Dean Schlesinger then goes on to note that the fossil-fuel combustion contribution to the incidence of carbon dioxide in the atmosphere is one of the smaller components of the flux, "which is dominated by exchanges between the forests and the oceans," a process which is believed to have been nearly in equilibrium over the past several thousand years, apparently post- Ice Age. He then presents the view that the rise of unbalanced emissions due to burning fossil fuels accounts for the "vast majority" of the rise in atmospheric incidence. In that context, he considers the potential for sequestration in forests and in soils, stating that "these projected gains are often small and dispersed over large areas." He also states that they may lead to displaced deforestation in other areas to make up the gap between supply and demand for forestry products. He then goes on to advocate for "a tax or fee on CO_2 emission from fossil fuel sources is the most efficient system to reduce emissions and spread the burden equitably across all sources: industrial and personal," with offset provisions in income tax law to retain taxation neutrality [as opposed to *incidence*, apparently].

Advocates of other schools of thought would doubtless point out that if things so clearly variable as forests and the oceans held a near-equilibrium for such a protracted length, it probably indicates that there are equilibrating ["negative feedback"] mechanisms at work that tend to dampen out rises or falls in the levels of CO_2.

So, while we need to be aware of and reflect on the merits and limitations of such alternatives, proposals and of the associated scientific, economics and policy debates, the above issues mean that the evolution of the carbon trading market will be difficult to predict with any high degree of confidence. That is, *the inherent riskiness of carbon trading is relatively high.* This circumstance first calls for consultation of expert, experienced, disinterested [or at least balanced] advice before entering that market to find income sources to support our transformation to a green energy economy.

A further consideration is the issue of "additionality," i.e. *for many of the more attractively priced trading instruments, it is necessary to credibly show that the emissions reductions due to the project in question would not otherwise have occurred but for the investment of the partner seeking offsetting emissions reductions here in Montserrat.* Proving such a negative anchored to an opportunity not taken up in the real world is quite hard to do, and at minimum calls for accurate, credible emissions statistics and costings of projects and alternative investments and expenditures on the business as usual and more sustainable paths. Each of these in turn calls for enhanced capacity, which as an education investment, will require technical and financial aid from our development partners.

Indeed, this is the context for the priority project to upgrade our fuel imports and emissions statistics. It would also be a basis to request technical assistance to enter the emissions trading market on several of the sustainable energy projects under consideration.

PART C:

Policy Rationale, General Appendices and Endnotes

MONTSERRAT ENERGY POLICY, 2008 – 2027:

INTEGRAL ATTACHMENTS & APPENDICES

MONTSERRAT ENERGY POLICY, 2008 – 2027, IV:

POLICY RATIONALE

INTRODUCTION: As a classic dictionary definition suggests,[xiii] **The Montserrat 2008 – 2027 Sustainable Energy Policy,** as declared in the policy statement above, lays out:

> **priority strategic initiatives** that jointly and cumulatively undertake . . . a **course of action** for our community in Montserrat, that will help our nation to identify and fulfill a desirable and achievable **vision**:
>
> > (1) of how we will obtain energy from technically and economically feasible, environmentally sound sources; and
> >
> > (2) of how we will then use it effectively and efficiently to contribute to an ever more wholesome, prosperous and earth-friendly lifestyle.
>
> . . . . based on our **commitment** to certain vital and valued underlying God-fearing ethical principles (such as The Golden Rule[xiv] [i.e. *"do to others as you would have them do to you"*]) and associated sustainable development goals (as adopted from time to time).

In declaring that the national energy policy is based on the concept of *sustainability*, we mean by that, that as our principal value-commitment, *we intend to more adequately and more fairly meet our energy needs in our own generation, but at he same time we commit ourselves to not compromise the ability of future Montserratians to meet their own energy needs.*

We will therefore, so far as is reasonable, increasingly use renewable -- i.e., in principle inexhaustible -- energy sources, effectively and efficiently. This not only gives us as much independence from the volatile oil market as we can get, but also it helps us to avoid unnecessary depletion of key earth resources, and reduces avoidable damage to the atmosphere from excessive use of fossil fuels.

Thus, promising renewable energy sources such as geothermal energy, wind energy, solar energy and bio-fuels will be a major focus for our efforts. This will be augmented by an emphasis on energy efficiency through the ever increasing use of cost-effective energy-efficient equipment to deliver the energy based services that are vital to a wholesome lifestyle that more adequately and more fairly meets our needs. Also, we will avoid energy waste through shifting to energy conserving habits and strategies at personal/family levels, and in our farms, firms and institutions across our community.

Through these means, we will shift from our present, ever more plainly unsustainable energy source and use patterns, towards those that are indeed sustainable and contribute to a sustainable, wholesome, prosperous, earth-friendly society.

Decision-makers, technical officers and stakeholders tasked to envision, develop, state, clarify, apply, manage and implement such a policy will thus need to consider and critically reflect on the following:

A] GENERAL BACKGROUND AND OVERALL RATIONALE

Much of our economic activity -- from transportation, to manufacturing, to commerce, to agriculture, tourism and other services, and even information technology and telecommunications -- is based on the impressing of orderly motion to matter.

Therefore, "*work" in the economic sense is closely tied to "work"/ "energy" in the physical sense, so that energy sources, use-patterns and costs all play a critical role in our lives and in our prospects for development.* In turn, that means that s*ustainability of our energy sources, energy-using machines, equipment and systems, as well as the energy based services they deliver, is vital to the economic and social well-being of modern Montserrat.* Further to this, the author of a precursor to this policy document[xv] observed that, fifty years ago (before electrification), Montserrat's energy services were by and large based on human and animal effort, and on traditional renewable energy sources: fuel-wood, windmills, etc. There was also a significant use of fossil fuel to operate motor vehicles and lighting, etc.

However, through the spurt of emigration and development that took place from the 1950's-60's on, our energy base shifted to fossil fuels; substituting machines for low cost labour. This generally transformed our level of development and consumption patterns. Unfortunately, that desirable improvement in our lifestyles has also meant that Montserrat, like much of the rest of the Caribbean, was now some 90% dependent on imported fossil fuels for energy services. Thus, we have been vulnerable to the sharp jumps in the global oil market over the past thirty odd years. The core driving force for such jumps (and their implication for food and other prices. etc.) may be seen from Fig A1:

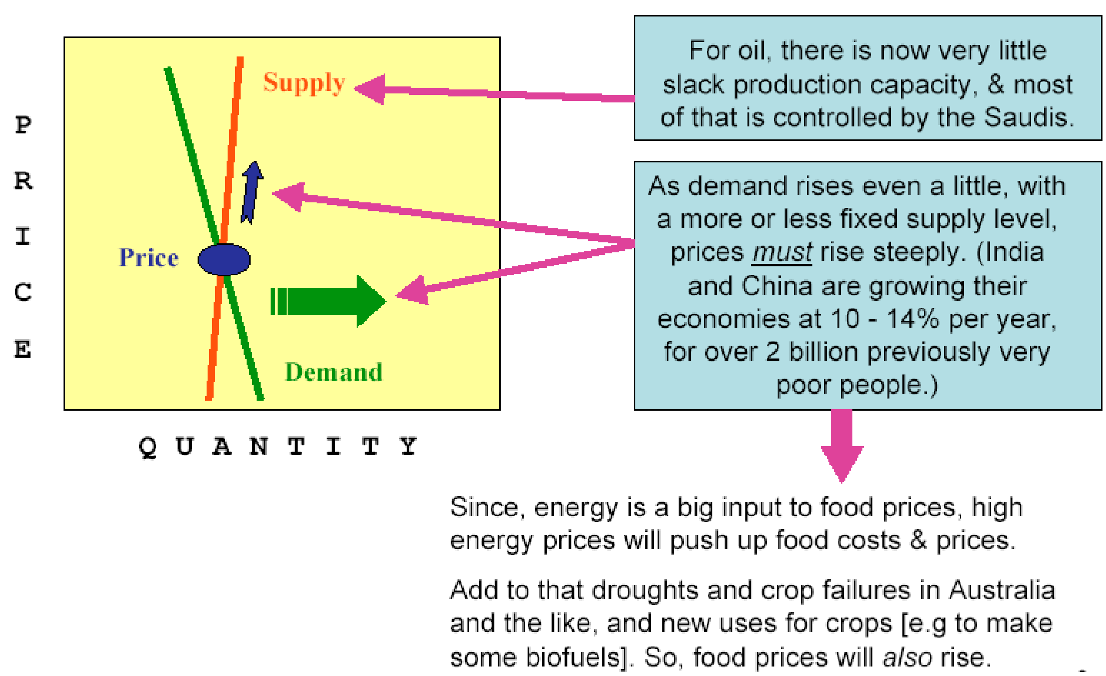


Fig A1: Some *basic dynamics of the oil market and linkages to food (and similar) markets, 2008*

Thus, the most likely *underlying* force in oil price volatility and resulting cost-push inflation of key commodities such as food lies not so much in oil cartels or speculators -- or even in the unintended consequences of diversions of crops from food to fuels -- but in implications of supply and demand. For, the global supply for oil has been tight in recent years, with much of the relatively small slack in the hands of one supplier, Saudi Arabia; controlled by the House of Saud. At the same time, due to the Asian economic miracles of our time that are lifting billions out of poverty, demand for many basic commodities has been strongly growing to feed industry and consumption.

This means there is strong demand-pull for many key commodities, e.g. both oil and corn.

That lends support to a recent analysis[xvi] by former vice-chairman of the CIA's National Intelligence Council, Herbert E Meyer [now working in the bio-fuels industry]. According to Mr. Meyer, in China in 1995, per capita consumption of meat reportedly stood at 25 kg/person-year. By 2007, that had moved to 53 kg/person-year. On "reasonable" estimates of corn-based feeds required to produce that meat, such would push China's demand for corn for animal feeds from about 150 to 350 million tonnes. Thus, we would *expect* that large acreages formerly idled under long-standing farm price support programmes in the USA (a major exporter) would have come back into actual production in recent years. Consequently, it is unsurprising to see that in 1995 American production of corn stood at 192 million tonnes,[xvii] but by 2007, it had grown to 349 million tonnes.

Of the 1995 figure, 14.7 million tonnes were used to make ethanol, with 4.9 million tonnes of dried distiller's grain going back into the grain markets. By 2007, with the rise of bioethanol, 62 million tonnes were used to make alcohol; with 21 million tonnes of dried distillers grain going back into the grain markets. Thus, there were 308 million tonnes of grain for consumption or export, representing a significant rising trend in actual grain available for human food in the US and overseas.

Even so, prices have risen, even sharply. Why?

Part of that is indeed speculation, some is the rising demand for converting corn to ethanol, and part is in the general context of longstanding droughts in Australia, etc. But, a good part of that is simply that grain crop production, storage and distribution use significant amounts of energy [and oil-derived fertilisers, etc]. So, costs to farmers, processors and distributors have shot up as the price of oil has gone up – as happened in, say, the 1970's; i.e. before biofuels were a significant issue. (Let us also compare: there is no serious speculation in the market for *fresh water*; as, in that market there is not the sort of global supply-demand constraint that speculators can exploit. Speculators, cartels and oligopolies, etc., are thus *secondary* causes of commodity price volatility.)

Whatever the merits on the details of such analyses, oil prices credibly face a generally rising trend. Unless there are breakthroughs in substitutes for energy and fuels, and/or the price rises to the point where widespread economic recession triggers a sharp drop in demand -- thence a sudden rise in inventories and a sharp fall in price similar to that of the late 1990's – this will likely be so for the foreseeable future.

Against that general backdrop, we may observe that, as Mr. Edgecombe noted in the recent study (circa 2004):

> *. . . 2 million gallons of fuels [are] imported annually, Roughly 30% is used for transportation. 65% is used to generate electricity, 5% is used for cooking. The energy bill amounts to $15 million, or about 20% of all*

> *imports*. The problem for Montserrat is that an increase of say, 10%, in the cost of oil at the pump does not produce the same increase in cost here. The cost is instead, magnified by numerous added charges that occur between the time the oil is pumped and the time it is delivered- To compound the problem, the costs of the numerous by-products of oil that Montserrat imports, also increase along with the costs of all other manufactured goods. But in the last year alone the price oil has increased, not by 10%, but by 60%. The effect is likely to be a 30% overall increase in the cost of goods and services that Montserrat imports. This 20 million dollar addition to the import bill for the same amount of goods and services will have to be paid . . . [but] there has been no corresponding increase of productivity in Montserrat. Tourism is Montserrat's main industrial hope. Oil price increases tend to suppress travel, however, and Montserrat, being an undeveloped and difficult destination will find it harder to compete . . . [p. 8, emphasis added.]

Of course, over the past several years, the increase the author notes turned out to be built up from three major factors:

> [1] a seasonal surge and fall-back in oil prices (e.g., in part driven by winter heating oil demand in the North),
>
> [2] a trend to higher prices driven by the hunger for raw materials to feed the fast-growing emerging industrial economies and middle classes of China and India,
>
> [3] shocks due to the always unstable Middle East and/or other man-made or natural disasters such as hurricanes hitting US Gulf Coast oil platforms and refineries, multiplied by the usual speculation in commodity markets.

Indeed, as this policy rationale was being drafted in early 2008, oil price had surged from an early 2007 starting low of about US$ 50 per barrel to over US$ 100 per barrel. It then fell back to just under US$ 90 per barrel (on fears of the onset of a recession in the United States). Next, it rebounded to US$ 135+/barrel – with serious suggestions that it is headed for US$ 200/bbl within 1 – 2 years. (This is similar to the quadrupling of oil prices across the 1970's, from about US$ 3/bbl to about US$ 12/bbl.) All of these are ominous as to the long-term trend in oil prices. *Such volatility is plainly unsustainable.*

It is revealing further context to note that Montserrat's GDP [roughly: national economic product based on value added by Montserratian factors of production] for 2000 – 2004 was reported by the Statistics Department to range EC$ 79.34 - 94.57 millions, the five-year average being EC$ 86.92 millions; or US$ 32 millions. In short, as Fig. A2 shows, according to available statistics,[xviii] the CIF values of fuel imports over the past decade have surged from the post-volcano crisis trough of about 2% of GDP at current prices, to about 15 – 20 percent of GDP.

All this, in a context where overall imports also exceeded national economic productivity; *an unsustainable overall situation.*

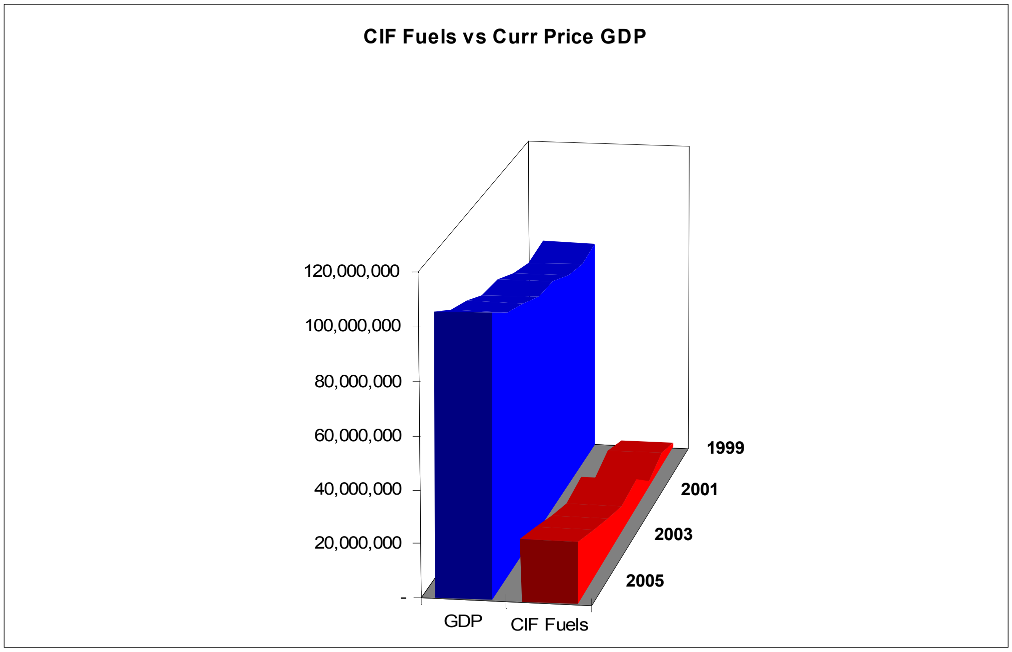


Fig. A2: *Energy imports compared to GDP, 1999 – 2007.* (SOURCE: M'rat Statistics Dept.[xix] Cf. Appendix G.2.)

The bottom-line is stark: *Montserrat is vulnerable to sharp upward oil price movements, in a context where our economy is already in a dangerously delicate condition.*

This unsustainable exposure to market shocks has been compounded by a rising wave of global concern that fossil fuels are linked to potentially dangerous and destructive climate trends. (Indeed, we should also bear in mind that recent reports tell us that perhaps 90% or more of tourists may factor in environmental considerations in choosing a destination -- a challenge; and, an opportunity.)

To take in a broader view of the local, regional and global energy picture and outlook, it is convenient to now excerpt some opening remarks in Dr Raymond Wright's recent draft for the *OECS Renewable Energy Policy* document:

> Climate change will be the greatest of many significant challenges for humanity over the remainder of this century. Any tool that can be used to address climate change will be useful. There are three major contributors to a green energy future. The first is nuclear power; the second is the hydrogen economy [expected to emerge starting about 2025], spearheaded by fuel cells; and third and importantly is the use of renewables as an energy source . . . .
>
> Renewables cover a wide spectrum of energy sources. They include amongst others, *wind, solar, hydropower, geothermal, biomass, bio-fuels, and ocean energy.* Caribbean countries which are energy deficient in respect to fossil fuels should maximize the use of renewables as they plan their energy future . . . .

> [F]ossil fuels, particularly oil, have become gradually more expensive, over the past five years and as a finite resource, prices are likely to remain high . . . .
>
> According to the International Energy Agency (IEA), the world's primary energy demand will rise by 60% between 2002 and 2030. Two-thirds of the increase will come from developing countries. Electricity demand will double and the requirements for all fossil fuels are expected to grow at sustained and substantial rates. More importantly, the IEA suggests that fossil fuels will still account for more than 80% of the energy mix in 2030, just as they do today . . . . The world is not about to run out of oil. However, while demand, now 82 million barrels a day, continues to grow, production of easily extracted oil will peak eventually, with production declining after that. There are varying positions as to when the peak occurs, ranging from 2016 to 2030 . . . .
>
> In the context of energy deficient countries, such as those of the OECS, renewable energy sources will reduce import cost as well as emissions. [pp. 1 – 4, explanatory parenthesis added.]

In short, we face a deeply challenging situation, and must make soberly considered, proactive, robust responses that:

[i] acting in good *time*,

[ii] will identify and deploy our *strengths* to capitalise on our *opportunities*,

[iii] similarly, will use strengths to counter *threats* and overcome *challenges*; and,

[iv] will compensate for and/or – where possible – correct *weaknesses*.

Thus, if Montserrat is to thrive in the very challenging days ahead, we need to construct, implement and manage a well-considered pro-active energy policy. Wright identifies four key stages in such a strategy, for which the ongoing energy policy development process is step one for Montserrat:

1. Creation of *a national energy policy* emphasizing the use of all economically viable renewable resources.
2. Encouragement by way of *tax regimes* of the use of renewable energy and the promotion of energy efficiency.
3. The setting of reachable *targets*, obligatory or non obligatory, for the development of renewable energy in each nation's energy mix.
4. The utilization of *carbon trading* as a vehicle to encourage the development of renewables.

In turn, this underscores the task for of the ongoing policy-making process: *that deliberative, logical, fact-driven, consultative, step-by-step sequence of activities through which we will lay out a national strategy to address long-term global, regional and local energy challenges*. Then, through carrying out the strategy, we will make best use of our opportunities, in the context of our identified strengths and weaknesses across time; so that we can chart and set out on a feasible path to a sustainable, desirable *green energy* future.

What such a future potentially looks like can be put in words derived from the classic Bruntland definition of sustainable development:

> *A sustainable/green energy strategy will enable us to better and more fairly meet our energy needs, whilst not compromising the ability of future Montserratians to meet their own energy needs.*

To do so, as Fig A3 shows, *we first have to identify* ***opportunities***, as it is opportunity that makes for alternatives, and without real choices, we have no capability to undertake strategic initiatives.

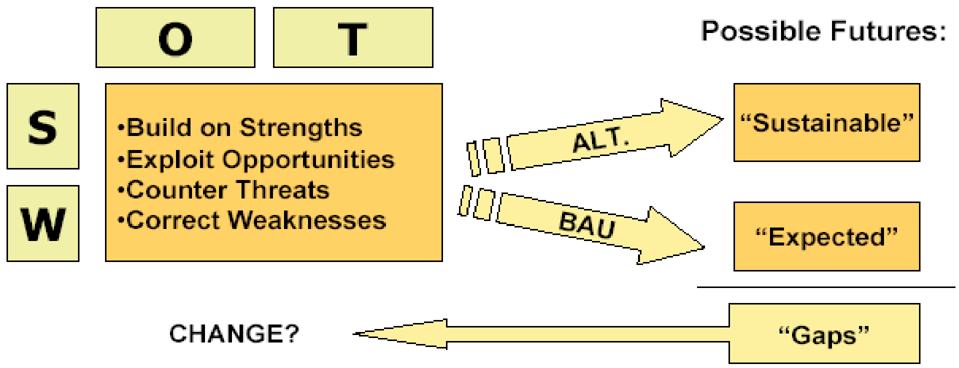


Fig. A3: *The role of opportunities and sustainable alternatives in change from business as usual [BAU]*

Business as usual for energy in Montserrat is fossil fuels, but as seen above, that is plainly unsustainable. Thus, we have to identify opportunities that can become the foundation for more sustainable, green energy alternatives. That leads us, by way of a key example, to further consider the facets and subtleties involved in renewable energy opportunity number one: ***geothermal energy***. For, even as we suffer the ongoing damaging volcanic effects of the power of superheated water, steam and hot rocks deep beneath the earth's crust, that automatically means that *Montserrat has a significant potential to harvest some of that geothermal energy through energy development.*

Such a basis for renewable electrical and thermal energy is potentially much cleaner, significantly cheaper and less prone to price jumps than fossil fuel based electricity and process heat generation; at least under the circumstances we face as a small island developing state. Furthermore, some have speculated that our geothermal potential may even be up to 500 - 900 MW; a huge number that if it proves anywhere near to the truth, could open up many new industries. Among these would be electricity export to neighbouring islands, especially Guadeloupe.

The Guadeloupe [and/or Antigua] electricity prospect has been much discussed in the public eye and in the local media, but there are other, subtler, smaller scale renewable energy opportunities. For instance, one opportunity that may still open up even if our actual discovered resource turns out to be much lower, closer to the 5 – 10 MW scale would be to bring back a high capacity fibre optic cable to Montserrat, and to host web server farms driven by low cost, highly reliable geothermal energy used for electrical supply and air conditioning. Similarly, over the next 8 – 15 years, as Dr Wright outlined, the world will quite likely begin a long-term transition to hydrogen-powered fuel cell vehicles. This requires large-scale energy-intensive hydrogen gas production, for which purpose geothermal energy, wind energy, and ocean thermal energy conversion [OTEC] are excellent potential sources. Also, bio-fuels will be needed locally, regionally and globally, and we have sunlight, water [including sea-water], enough land for at least local or sub-regional production, and an educated population in a legally and politically stable jurisdiction. So, with geothermal electricity and post-geothermal hot water or steam, such could be produced locally.

On balance, the geothermal opportunity is therefore sufficiently attractive that it is renewable energy opportunity number one for Montserrat. However, as the mention of wind and OTEC just now underscores, there are other green energy opportunities that should not be neglected. Thirdly, we must also reckon soberly with a deeply embedded challenge for geothermal energy: *a high degree of risk attending to the exploration phase of geothermal developments.*

This was, for instance, highlighted by the National Renewable Energy Laboratory [NREL] of the United States of America, in their *Geothermal Technologies Program Strategic Plan,* August 2004, p. 8:

> *Only about* **one exploratory well in five** *discovers a viable hydrothermal resource.* At costs usually exceeding $1 million per well, investors are often reluctant to assume the risk of an exploratory drilling program . . . [Emphases added.]

This is so for two reasons. *First*, the exploratory phase (inclusive of interest charges to the point where a successful geothermal power plant is commissioned), costs about ten percent of typical overall start-up costs, or about US$ 300/ kWe of plant capacity. So, we note what Cédric Hance of the US-based Geothermal Energy Association therefore observed, in a report for the US Department of Energy (DOE) on how risks and required rates of return to equity investments in geothermal development have tended to interact *on average*[xx]:

> In finance, high risk means high rates of return.
>
> Equity invested in geothermal projects is expected to yield an annual rate of return of about 17% (Owens, 2002) . . .
>
> Since *it takes a minimum of 3 to 5 years to put a geothermal power plant on line*, the initial [direct] exploration cost might in fact represent a much higher cost for the project.
>
> (e.g. $150/kW borrowed during 4 years at 17% corresponds to an actual cost of $150*(1.17)^4$ = [US]$281/kW when the power plant is finally on-line [after about four years] and begins to pay-back). [*Factors Affecting Costs of Geothermal Power Development* Aug 2005, p. 9. Emphasis added. (N.B.: The USA has the largest geothermal power programme in the world, and the underlying cost factors are typical of global conditions. Indeed, the actual reported first costs for the two Bouillante plants in Guadeloupe are very near to this figure.)]

Second, the underlying reason for this high degree of risk is the complexity of the geology of geothermal resource regions, coupled to the specificity of the location of suitable networks of porous rocks, crack networks, faults and surrounding impermeable rock strata. These are sufficiently hard to assess, that normally geothermal resources are identified from exploratory wells, and such wells are usually only drilled near to where there are direct surface indicators such as hot springs, fumaroles and chemically laced waters; just as we have near Plymouth. So, our surface indicators, unfortunately, do not significantly tip the odds in our favour: *for, it is under these circumstances that the <u>on-average</u> odds just cited from NREL work out.* (The fact that an "ordinary" well drilled at the old Groves Agricultural station did hit hot water and/or steam (as did a few other wells in the vicinity) may help a tad, but alas -- per its purpose as an ordinary well -- no coring[xxi] and well-temperature log data were kept.) We must also bear in mind the case of St Lucia, where hot waters were indeed discovered, but these were too acid for development.

In this context, preliminary geochemical and geophysical investigations and associated modelling exercises -- impressive 3-D computer "pictures" notwithstanding -- serve as guides to where to drill, rather than highly reliable "maps" of what lies underground. It is drilling that reveals reality: *at up to about US$ 1 million or even more per roll of the die.* For, a fairly large cluster of specific and hard to discern factors have to come together all at one place and time to help lead enough ground water into hot zones, then to trap it and, finally, provide the clues and networks of cracks that allow discovery and commercial level harvesting of the resulting geothermally heated water and steam.

However, once a successful hole has been drilled, it usually reveals sufficient about the relevant zone that the chance that succeeding wells will also be successful dramatically rises, to about 60 – 80%. Or, as the proverbial wise old fisherman says: *the problem is to catch the first fish*; for, where one fish is, there usually are others. Unfortunately, this particular fishing trip is fairly expensive and risky.

On the brighter side, as also noted just above, the geothermal deal *may* well have an additional sweetener.

For, *if* bio-fuels become major fuels over the next decade or so in the aftermath of the oil price jumps and climate concerns mentioned above, fresh and/or post-generator geothermal steam and hot water may provide at least some of the required thermal energy to drive the chemical processes to make these renewable fuels from biomass. This could potentially move alternative fuels such as ethanol, bio-butanol, Holtzapple's ligno-cellulose-derived mixed alcohol fuels,[xxii] or biodiesel[xxiii] to the front burner.

Also, since hydrogen (often suggested as the long-run likely successor to petroleum) is of very low density and requires special handling, it turns out that *carbon-chain based organic molecules are often a more concentrated, easier to handle store of hydrogen than hydrogen gas itself*. So much is this the case, that a promising approach for fuel cells is to use alcohols to store the hydrogen then release it in the cell, to make electricity. However, bio-fuels emit carbon dioxide if burned or otherwise oxidised. (Bio-fuels make up for this, by virtue of the fact that much of the carbon in plants is directly derived from the carbon dioxide in the atmosphere, i.e. such fuels are in effect (nearly) carbon-neutral.)

Now, too, as just pointed out*: bio-fuels normally require electrical and thermal energy for processing from biomass,* e.g. trans-esterification to make traditional bio-diesel out of vegetable oils, or distillation to concentrate alcohol fuels obtained through fermentation into usable form. So, through using geothermal heat energy and/or cogeneration, Montserrat *could* become a significant bio-fuels refining centre for the Caribbean. Indeed, if technical and economic challenges are overcome, direct geothermal heat and/or the waste heat from geothermal electricity production may have particular utility in producing bio-fuels from algae species that may have 30 – 50+% of their body mass as oil suitable for use as or conversion to such renewable fuels.

The key relevance of this is that -- based on the major studies carried out by US government research labs -- *such algae may supply up to 5,000 – 20,000 gallons of oil per acre per year.* [As well, the associated remaining biomass is suitable for use as animal feed, amino acid sources and conversion to other bio-fuels such as ethanol or butanol or mixed alcohols, some of which would be required for further transformation if FAME- based biodiesel (i.e. *Fatty Acid Methyl Esters*) is a desired product.[xxiv]] That is, in principle, if and when the challenges are overcome, a single 200 - 500 acre "estate"[xxv] could provide bio-fuel feed-stocks comparable to the approximately two million gallons of fuels that were reportedly imported into Montserrat per annum, circa 2002 – 2004. In addition, the required lands could be such as were not otherwise croplands, and the water could be brackish or salty (or even sewage – a source of required micro-nutrients[xxvi]), depending on the relevant species and strains of oil-rich algae. Such numbers are potentially quite attractive and could transform our second largest major line item of fossil fuel consumption, *transportation*.[xxvii]

Likewise, Montserrat's tourism industry is in part based on the fact that we are a part of the Caribbean "sun-belt" that receives an average of 4 – 6 kWh per sq. m per day of energy from the sun. So, there is also a significant *technical* potential for solar energy, both as heat and to generate electricity.

But, *technical potential* as just identified and *economic/financial feasibility* do not necessarily go together.

Thus, we now consider solar photovoltaic systems as a second illustrative -- and cautionary -- instance of a commonly encountered challenge to otherwise highly desirable renewable energy technologies:

> **SOLAR PV "CASE":** If an "average" Montserratian "wall" house uses, say, 300 kWh/month of electricity, or about 10 kWh/day, that means that 2 sq. m of surface could apparently supply the electrical energy needs of the household. Unfortunately, due to various factors, the practical efficiency of such photovoltaic systems is likely to be some 10%; so, we would probably need 20 sq. m of collecting area (or about 33 ft by 7 ft), with additional allowance for the support framework for the active collecting area. Consequently, the resulting high initial cost (easily US$ 5 – 10 per Watt of electrical output capacity) of buying and the onward cost and effort of maintaining such a system, leads to an equivalent cost per kWh (typically US 25¢ - $ 1.25/kWh) which is often quite higher than that for fossil-fuel derived grid electricity; except in situations where integrated resource planning approaches and/or grid extension requirements shift the balance. Thus, *until promising follow-on generations of solar cells -- such as Nanosolar's nanoparticle ink-based, printed thin-film Copper Indium Gallium Diselenide [CIGS] cells, or dye-sensitised TiO_2 Gratzel cells and/or amorphous silicon or polymer ("plastic") cells -- bring capital costs sharply down, photovoltaic systems will remain a niche item.*

Happily, by contrast, solar water heaters are economically competitive right now, providing, they can be made *affordable and accessible* to the *average* consumer. To promote this, an energy audits and credits scheme with payment through the energy bill -- similar to Demand Side Management [DSM] initiatives in Canada and elsewhere -- may be a useful innovation.

Now, also, Montserrat is in the trade wind belt. Well chosen sites can enjoy 12 - 15 mph average wind speeds for much of the year. This is moderately ideal for wind turbines that can credibly produce at least up to 1/5th of our national electricity requisites.[xxviii] Indeed, the remains of old sugar estate windmills dot our landscape, and in the late 1980's and early 1990's, Monlec actually installed such wind turbines on St George's Hill. These last suffered damage during hurricane Hugo, in 1989; and were abandoned *in situ*, in the aftermath of the volcano eruptions from 1995 on.

An encouraging recent exemplar is seen from recent events in the Falkland Islands (circa 2007):

1. These South Atlantic islands have a reported 15-knot average wind speed -- similar to (but somewhat faster than) ours here in Montserrat.

2. Last August, through Enercon, a German supplier, three 300 kW wind turbines were set up for Stanley, the capital.

3. According to a FINN (Falkland Islands News Network) report of a town hall meeting, each of these was giving about 100kW, and automatic switching was expected to significantly upgrade that 33% *availability factor* (which is "typical"/maybe slightly low).

4. FINN: " . . . it is estimated that it will take eight years of operation to pay for the equipment. Conservatively, that's 20% return but Enercon estimates the return should be more like 35%."

A similar configuration of three 300 kW turbines could be installed and commissioned here within several months to a year, by contrast with the typical estimates of about three years or more for geothermal development. Thus, it may well make sense to do this in the short term, even while geothermal exploration and development are underway. So, by about the turn of 2009, we could have a wind farm integrated into our national power grid. This would immediately put us in a position where, even with an availability factor of just 33%, 10 - 15% or more of our electricity generation could be from credibly cost-effective renewables by early 2009. It is possible as well, that appropriate arrangements could be made for Carbon Trading credits to subsidise the installation.

However, since our entire emissions may be about 40,000 tonnes of CO_2/year; even at a hard to get US$ 30/tonne, that would not be a lot. In short, we need to trade on the basis of power plant lifetime avoided emissions, not year to year, tonne by tonne reductions. So, we note that across a 30 year lifetime, 300 kW of *available* wind capacity from a three-turbine 900 kW farm would generate 30 times 2,629,800 kWh, or about 78.9 million kWh. Montserrat's current ~ 36% efficient high speed diesel plant uses about 0.064 gal of diesel fuel per kWh generated, and so emits about 1.43 lbs CO_2/kWh. Thus, as a rough guide, installing the wind turbines would reduce our emissions by about 51,200 tonnes; worth about US$ 1,536,000 at the "best" currently available price, from the available range, US$ 4 - 30/tonne of avoided CO_2 emissions. At half that price, which is probably far more achievable, we are looking at about US$ 750,000 of Carbon-trading subsidy.

That is a reasonably trade-able number, one that could potentially reduce the capital costs of the envisioned wind plant [perhaps – using Wigton, Jamaica, as a cost model -- US$ 1,300/kW or so] significantly. (As an added benefit, the introduction of new capacity would relieve the high duty cycle required for the diesel plant, and would allow increased maintenance, reducing its operating costs overall, while increasing its reliability.)

We may notice, too, that the ocean's surface waters – which, when sun-heated to over 80 degrees Fahrenheit, become the "fuel" for hurricanes -- have another side. For, when such warm surface waters are coupled to the quite cold, clean and nutrient-rich water at 2 – 3,000 feet depth using the OTEC technologies mentioned above, electricity can be generated [and freshwater too], with side-opportunities to undertake high-value temperate zone aquaculture based on the pumped up cold waters: Abalone, Maine Lobsters, Salmon fish farming, Kelp etc. So, with deep ocean waters fairly close to shore, Montserrat has OTEC potential, but this is a long-term prospect, most likely suited to providing electricity for hydrogen production as the global hydrogen economy emerges.

As was noted above, certain crops such as high-energy varieties of sugar cane, fast-growing fuel woods, hemp, wastes, sewage, algae and the like can be used to make bio-fuels and even Hydrogen – the "fuel" for fuel cells. Such alternative, renewable fuels and their biomass crop precursors are increasingly viewed as a major wave of the future for transportation and similar systems that give greener alternatives to fossil fuels. Since they are local sources, they also improve energy and economic security. Indeed, they may also help to slow the rate of cost increase of fossil fuels, through providing an increasingly acceptable, available and even affordable substitute.[xxix] Of the varied possibilities, *ethanol, bio-butanol, bio-diesel* and possibly Holtzapple's *mixed alcohol* fuels are the most likely to be significant.

To generate these fuels, fast-growing, high yielding sources of sugars, starches and herbaceous or woody biomass that grow on marginal lands and use materials that would otherwise be wasted or viewed as weeds are at a premium; especially, if they are also relatively easy to process from biomass to fuel, without requiring too much energy in the process.

For the major current bio-fuel crops, Montserrat (along with other regional territories) does indeed possess abundant sunshine, and has good rainfall. But locally, cropland space is at a premium, as, we have been compressed into about forty percent of our island by the volcanic disaster over the past decade or so. However, certain varieties of algae may yield up to a potential 5,000 – 20,000 gallons of vegetable oil per acre per year (and could give additional feed-stocks or useful products from the other half of the biomass). That oil is roughly comparable with the energy potential of petroleum based diesel fuel. Indeed, one argument on the origin of oil is that it was made by in effect burial and resulting application of heat and pressure to such algae.[xxx] Thus, several hundred acres of algae cropland would (providing that technical and economic hurdles are surmounted over the next decade or so) be able to produce sufficient vegetable oil to in principle replace our current fossil fuel imports.

Be that as it may, our renewable fuels future probably by and large rests in access to fuels grown in other regional territories that have more available land space, and with which we have suitable economic arrangements; such as through the *Caribbean Single Market and Economy* [CSME]. Thus, we immediately see that *the success of our current and future regional partnerships policy is now a key factor in building a successful sustainable energy policy.*

For instance, since harvested biomass may require significant processing to transform it into suitable fuels, our prospective access to geothermal heat *may* make us a suitable refining centre. This allows us to match our low-cost geothermal heat and electricity to our immediate neighbours' relatively larger space to grow some of the required biomass. (Nevis, of course, has a similar potential; as does Guadeloupe.)

By way of further illustration, let us consider a project through which Antigua were to grow a several thousand acres of algae (in brine on otherwise marginal or "useless" lands), and press or centrifuge it to make oil and compressed dry algae cakes. Then, we could transform the biomass into biodiesel, using our geothermal energy and electricity; perhaps also exporting volcanic ash as a source for micronutrients for the algae farms. Such a synergistic agro-industrial arrangement (if feasible) would be a highly desirable outcome that would increase employment both here and next door. It would probably also significantly reduce fuel costs both here and there [relative to those hinged to oil at US$ 200 – 300/bbl], further fertilising economic growth. But – as was noted above -- it would be critically dependent on the degree of success of currently ongoing, fairly risky, geothermal explorations and solution to the technical and economic challenges of developing viable oil algae farming.

Further afield, larger regional partners such as Guyana, Suriname, Haiti, Belize and Jamaica, could be encouraged to develop bio-fuel industries based on not only energy cane and ethanol, but other high-yield biomass crops that could then be used to generate synthetic fuels and related products in bulk through fermentation or gasification and synthesis. Thus, a regional energy and chemicals market could develop within the CSME zone.

Similarly, through enhanced efficiency of energy use, we can begin to more closely manage energy demand, reducing the required levels of investment in energy production and so cutting energy costs to the consumer. This brings to bear the opportunity to form *Energy Services Companies* [ESCOs] that can provide energy use improvement services to the region.

For instance, through energy audits and shifts to energy efficient appliances, equipment and lighting, there may be significant costs-saving cuts in energy consumption. ESCO's would provide technical help in identifying the savings opportunities, then help finance, implement and monitor the indicated changes. Splitting the resulting cost savings with the customer pays for the projects, repays required loans and interest, as well as providing a reasonable profit as a return to (and incentive for) those undertaking the risk of job-creating enterprise.

An excellent related possibility is *cogeneration* [or combined heat/ refrigeration/ air conditioning and electrical power]. E.g., by using the heat that currently goes up the smokestack of the generating plants, we could harvest heat for industrial processes, or could make ice and chilled water for use in air conditioning. This last is vital for modern computer office technologies. Such an approach can easily yield an overall energy efficiency of 70% or even more; as, heat can be used as heat with great efficiency and refrigeration systems routinely return at least as much useful output as they require as energy inputs.

Clearly, there are major potential opportunities to be harvested by shifting to a more sustainable energy policy for Montserrat, and also significant challenges to be overcome. The energy policy to be developed is therefore intended to provide a credible and feasible strategic approach to make the most of these opportunities, whilst also robustly addressing our challenges. The first step to seeing how that may be is to address the links among:

B] ENERGY, ECONOMIES AND SUSTAINABLE DEVELOPMENT

First, let us further clarify the concept and economically relevant utility of energy. For, energy is a thing which is important, but not as an end in itself; instead, it is a necessary means to many desirable or even vital ends. Namely: *anything that can be made to exert a force that imparts orderly motion to matter that was originally at rest (by scientific definition) has within it -- or is itself -- a form of* ***energy****.*

This immediately implies that our economy, society and lifestyle may profitably be analysed from an energy perspective. So, *we may view work-/energy-flows as value-adding flows*, in terms of energy **sources**, energy-using **equipment** and associated technologies, and the resulting desired (and paid-for) energy-based **services** that we need or enjoy. Diagrammatically:

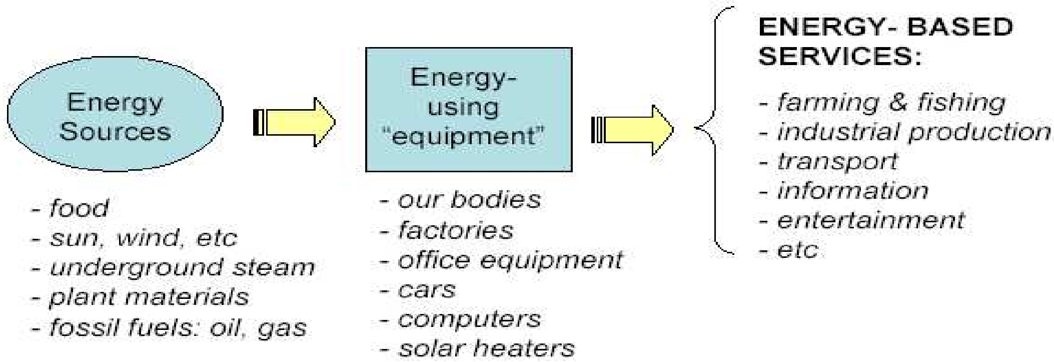


Fig. B1: *Energy Sources, Equipment and Services.* [SOURCE: TKI, 2008.]

In short, we can usefully analyse the economy as a whole not only in terms of *value-adding cash flows* [one basis for estimating *Gross Domestic Product*, GDP], but also from the physical view of associated *intelligently directed, order-creating energy flows*. This view also immediately implies that we -- usually -- do not desire energy as an end in itself, but as a physical and technical *means* to the *ends* we desire.

So, if a novel technology provides a financially and/or energetically cheaper or technically superior path to those ends, it may be more desirable than the current way of doing things. For instance, that is how cars, vans and trucks replaced horses, mules, donkeys, oxen, carriages, waggons and carts as primary means of transportation. Similarly, the relative unreliability of wind led to the rise of steam powered shipping, once the technology was available. Also, electrical lighting is so far superior to oil or gas powered lamps, that this is the basic reason that electrification of towns began.

Indeed – contrary to popular opinion -- Edison did not really invent *the* light bulb. (Others had already made more or less physically functional incandescent lamps before he did.) Instead, he created *an innovative, practical direct current [DC] electrical lighting system*, from generators to distribution networks to delivery in homes and offices, and of course, reasonably long-lasting light bulbs that could work with the system. Then, Steinmetz and others produced an improvement: alternating current [AC], which can be easily stepped up or down in voltage, which also makes it suitable for long-haul transmission. Soon, compact and powerful AC motors (Tesla was especially important for this) were introduced, and helped effect a miniature industrial revolution, replacing muscle, steam and belt power with silent, reliable, cost-effective electricity.

Bringing this right into our homes, during the Second World War [WW II], workers in aircraft assembly plants sometimes found it useful to "borrow" the power drills in use in the plants to make aircraft in order to do weekend projects at home, and soon the home power tool and do-it-yourself [DIY] industries were born.

But all of this is energy *equipment* and associated *services*.

The electrical energy was coming from somewhere -- <u>sources</u>: *usually, coal-fired boilers that generated steam used to run engines that turned the electricity generators.* Or, through massive hydoelectric projects (that also helped reduce the perennial problem of flooding), dammed up water would be allowed to fall through modern versions of the old fashioned Miller's water wheel; again, spinning the generators. Then, increasingly from the 1950's on, *oil* (then *natural gas*) was used to replace coal, *diesel engines* often took the place of boilers and steam turbines, and fission-powered *nuclear power plants* were introduced. (These last typically work by creating heat through the splitting of the nucleii of atoms of heavy elements such as Uranium or Plutonium, then using the heat to make steam, which spins the generators.)

Consequently, when electrification came to Montserrat in the 1960's, it was in the form of oil-fired diesel powered engines spinning the generators, and it transformed the local economy. This has been a part of a global trend in energy use, here viewed as at the turn of the millennium:

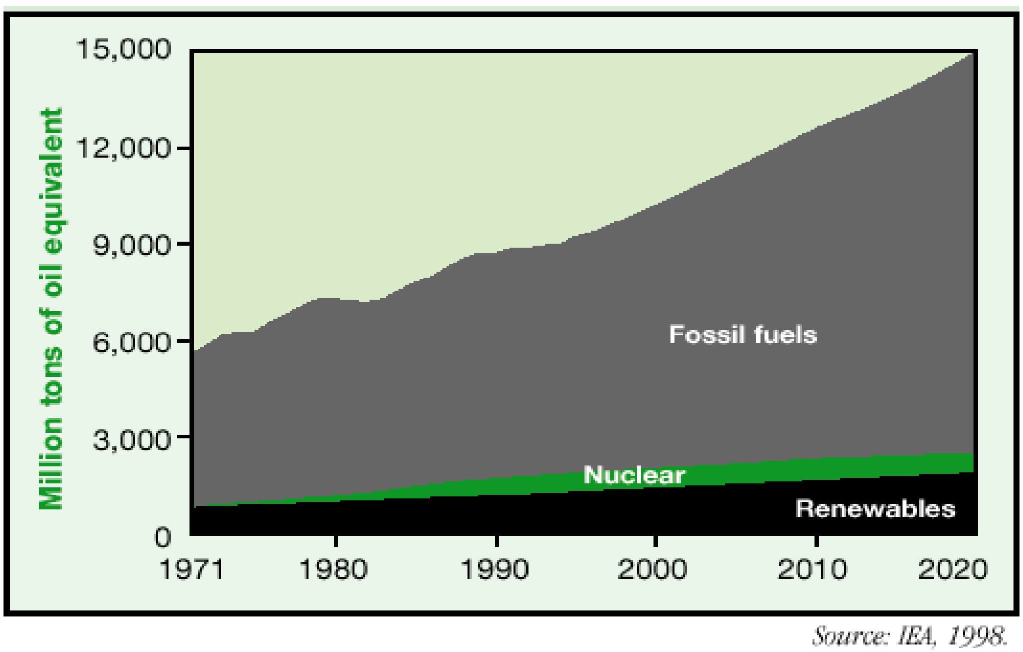


Fig. B2: *The International Energy Agency's 1998 projections of global fuel use* [SOURCE: IEA.]

In short, no sooner had the Kyoto Protocol come out in 1997 than it was projected to be essentially dead in the water, by the well-respected, OECD-linked *International Energy Agency.*

Why is that so?

Part of the answer can be seen from the Clinton Administration-era US Senate's Byrd (D) -Hagel (R) 95-0 bipartisan, unanimously passed resolution of July 25, 1997 refusing to ratify the Kyoto protocol if it failed to meet cerrtain criteria; and, in anticipation of its probable (and in the event, actual) format:

> Whereas the [US] Department of State has declared that it is critical for the Parties to the Convention to include Developing Country Parties in the next steps for global action and . . . . Whereas *the exemption for Developing Country Parties is inconsistent with the need for global action on climate change and is environmentally flawed*;

Whereas the Senate strongly believes that the proposals under negotiation, because of the disparity of treatment between Annex I Parties and Developing Countries and the level of required emission reductions, *could result in serious harm to the United States economy, including significant job loss, trade disadvantages, increased energy and consumer costs, or any combination thereof* . . . .

Resolved, That it is the sense of the Senate that--

(1) the United States should not be a signatory to any protocol to, or other agreement regarding, the United Nations Framework Convention on Climate Change of 1992, at negotiations in Kyoto in December 1997, or thereafter, which would--

(A) mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties, *unless* the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period, or

(B) would result in serious harm to the economy of the United States . . .

In short, **precisely because of *the strong, direct links between physical energy use and level of economic activity for a given level of technology*, <u>neither</u> leading developed <u>nor</u> leading developing nations were willing to seriously curtail economic activity in the interests of slowing down the projected climate change trends,** which are generally thought to be largely due to the increased injection of Carbon Dioxide [CO_2] into the atmosphere.[xxxi]

So, it is unsurprising to see that, in fact, the subsequent nearly unanimous global sign-off on the protocol has not been accompanied by an actual reduction in the emissions of CO_2, much less a return to pre-1990 levels. Indeed, current discussion is that China (the "developing country" most in view in the US Senate Resolution) may now well be overtaking the USA as the leading emitter of CO_2. Further to this, much of the current sharp upward trend in oil prices is driven by the demand for such fuels to drive the paidly growing economies of China and India (the other "developing country" principally in view in the Resolution). [NB: Both are nuclear, space-faring powers.]

For the much-desired reduction in fossil fuel use to happen, a drastic, cost-effective shift in energy sources and technologies would have to happen, globally. In our case, since about 2003, from current statistics, the Montserratian economy emits about 1.6 lbs of CO2/EC$ of GDP. The root of that is the fact that for every US gallon of gasoline or diesel fuel we burn, we emit some 20 lbs of CO_2. Thus, since our technology-base and energy sources are at a plateau at present, Montserrat has a fairly stable relationship between economic activity and CO2 emissions:

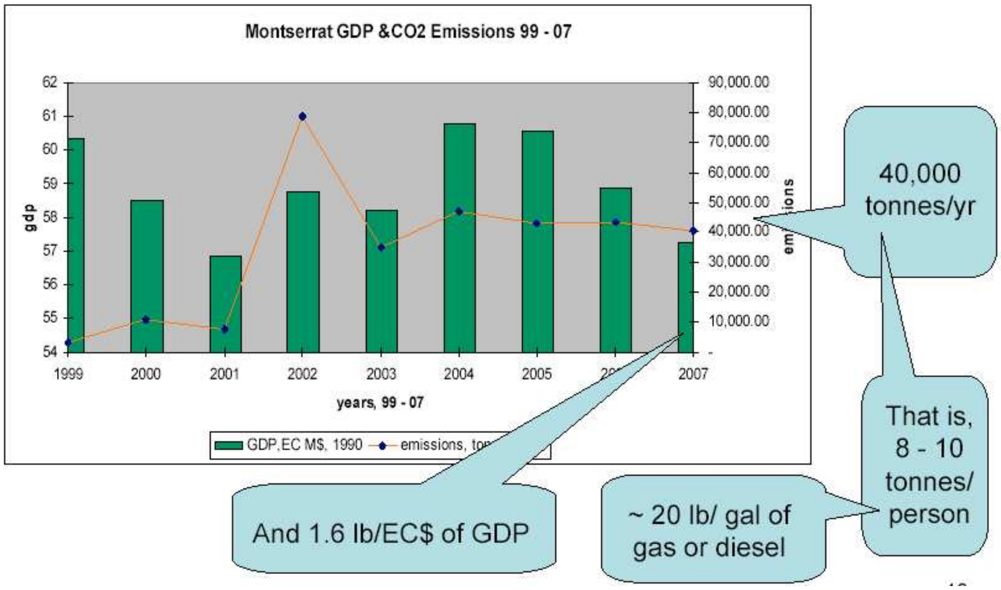


Fig B3: *A comparison of Montserrat's Real GDP trends, fuel use and Carbon Dioxide emissions* [SOURCE: Statistics Dept, 2008. Cf. Appendix G.2.]

As the figure shows, our fuel use roughly tracks GDP in EC$ 1990, a measure of our real level of economic activity, and gives rise to associated carbon dioxide emissions.

We may also readily discern the economic rises and falls due to the post evacuation rebuilding in the North, which trailed off towards 2001, and that due to the Airport, Roads and ash cleanup projects from 2003 – 2004. It is not coincidental that our last two General Elections, which were held in the economic troughs of 2001 and 2006, issued in changes of political leadership. In short, for reasons of basic political survival, *politicians accountable to electorates tend to be extremely sensitive to factors and trends that may lead to economic slowdowns.* And, for good reason: voters have a *right* to expect that those they elect will look out for their interests, in the short and long term.

That means that *we have to find a successful way to bring together economic, environmental, political and energy use/work interests, not only for now but across time, if we are to build a successful sustainable energy policy*. It would also be advangageous if the energy strategy helps to jump-start our economy into self-sustaining growth that is not dependent on occasional injections of external capital to trigger mini-booms, that then fade away as soon as the projects wind down. This requires a linkage between energy policy and economic development through transformations that cut energy related costs for current technologies and/or shift the technological base of required energy-based services so that on a per unit basis, they require significantly less energy and monetary inputs for equivalent (or better yet, superior) outputs.

Therefore, since electrical forms of energy are increasingly important in all areas of life and production, we next consider a typical "static" model for levellised costs of electrical energy [Adapted, Ampere Commission, Belgium, 2000]:

Cost in ¢/kWh = Fuel cost in ¢/BTU[xxxii] multiplied by the plant's heat rate in BTU/kWh

+ Other variable costs (e.g. operations and maintenance) in ¢/kWh

+ Capital costs and other fixed costs expressed as an annuity in ¢/kW of capacity, divided by the expected maximum operating hours per year

[+ External costs in ¢/kWh] . . . **Eqn. B1**

Here we observe:

a] Fuel costs per unit of output are first directly driven by the efficiency of a fuel based power plant, with 3,412 BTU/kWh as the lower (100% efficiency) bound; and with typical heavy fuel oils providing some 146,000 BTU/gallon (or about 40.7 MJ/litre).

b] A geothermal plant or a wind turbine do not use fuels directly, but to operate the plant will in general require *some* fuel inputs; usually reckoned under operations and maintenance. (It can be argued that since avoided Carbon emissions can be traded in markets, such renewable energy plants have an equivalent *negative* direct fuels cost – income from fuel not burned, per unit of output. Typically, from current Carbon trading market reports, that is potentially US$ 4 – 30 per tonne of avoided CO_2 emissions,[xxxiii] depending on instrument used to trade Carbon Credits. [NB: *Burning one gallon of gasoline or diesel fuel emits about 20 lbs of* CO_2.] As seen from Section A above, providing we can access an appropriately favourable deal, this could *potentially* harvest up to ~ US$ 1.5 millions (with up to US$ 250,000 probably more likely) as a green-funds subsidy to the cost of investment in a three-unit, 900 kW wind turbine facility modelled off the successful Falklands Islands exemplar.]

c] By the Carnot theorem of Thermodynamics, there is a physical upper bound to heat engine energy efficiency, $\eta \leq (T_h - T_c)/T_h$. That is, for heat engines, the random agitation of the molecules of hot gases cannot wholly be converted into work. [So, for a machine working between say steam at 523 Kelvins (250 °C) and ambient air at say 303 K (30 °C), energy efficiency -- per the relevant Thermodynamics -- cannot credibly exceed 42%. (Monlec's current *high speed* diesel plant has an observed efficiency of about 36%.)]

d] The "fuel" cost item is also convenient to use to cover the *fair market value* -- or some acceptably comparable value to that[xxxiv] -- of the geothermal steam/hot water resources used in the production process. For, *steam/hot water is a substitute for fuels*. This value can then be treated *separately* from pioneering investor holidays for business income taxes or the like,[xxxv] and assessed as ***royalties***, in cash value and/or in kind. (That is, any cash royalty payable would be net of the agreed value of training, technical services and management fee equivalents or of provision of "free power" for Government entities, etc.)

e] Similarly, the assessed value of the resource used, for royalty purposes, would be net of the expenses and investments made by the power producer to extract it from the ground on the behalf of the Government.

f] On this *activity-based costing* approach, an explicit, *stakeholder-understandable* trade-off can then be made on geothermal energy production royalty level and resulting cost to the designated local *single purchaser* of the income-generating electricity produced by the plant. Onward, we would then be able to discuss the public interest question of the balance of price, profits, business investment incentives, taxes and royalties and benefits to the consumer and community in a balanced context.

g] A windmill "escapes" the Carnot efficiency limit, as it is converting the *orderly* motion of wind – its "substitute for fuel" -- into equally orderly rotation of the blades and generator. However, since the blades must interfere with the flow in order to harvest energy, Betz worked out an upper limit for wind turbine efficiency, *59.3% of available wind power*. In turn, wind power is a function of the cube of the wind speed, and -- due to reduced surface friction -- wind speed under commonly observed [but not universal] circumstances rises roughly as the seventh root of height, i.e. *doubling the height of a turbine may increases wind speed by 10% and available power by 34%.*

h] For air of density 1.2 kg/cu. m, moving at 6.7 m/s [~ 15 mph], the power in the wind will be 180 W/sq. m cross section, so that at most 107 W can be harvested from it. For a windmill with 15 m long blades [~ 49 ft], the theoretical upper limit on power in such a 6.7 m/s wind is 75.6 kW. With an *availability factor* of 33 – 38%, this yields 218,000 – 252,000 kWh per year; enough *on average* for 60 – 70 houses at 300 kWh/month.

i] The next line-item is annual operations and maintenance, which is partly a function of the technology chosen, partly of resource inputs of various kinds [thus, of the activities that use these resources], and partly a function of the management of the plant across time. (Younger's estimate for a local 5MWe geothermal plant is 2 ¢ (US)/kWh.)

j] This item also takes in leasehold, user fees [e.g. for roads, piers etc] and the like that may be assessed by Government as a part of the operations and facility use by the power producer. Similarly, the use of a targetted breakdown of such assessments allows stakeholders to understand and contribute to decisions regarding the trade-offs between tax and quasi-tax revenues and ultimate costs for electricity.

k] Capital costs (etc) have to do with how much a plant costs to bring to commissioning into regular operation, which for geothermal plants is typically about US$ 800 – 3,000/KWe, with the high end being more usual. So, for instance, a 5 MW plant at US$ 2,500/kW will cost US$ 12.5 millions.

l] This then has to be equated to the present value [PVA_n] of an *annuity* across the plant's working life, perhaps 30 years [n = 30]; and then the deduced level annuity year-by-year term [CF] is applied to the formula. For this, the *weighted average cost of capital* across equity, debt and grants/soft development or green fund loans [r] would have to be worked out, perhaps using:

$$CF = PVA_n / \{ [(1 + r)^n - 1] / [r(1 + r)^n] \} \qquad \text{. . . \textbf{Eqn. B2}}$$

m] For instance, using US$ 12.5 Mns at 10% across a 30-year lifespan, that annuity term, CF, is US$ 1.326 millions. Applying it to a 5 MW plant with a 95% availability factor [41,638,500 kWh/yr], this yields a levellised cost contribution of 3.18 ¢ (US)/kWh. (*If more recent figures that suggest a capital cost of ~ US$ 3,000 – 4,000/ kW are closer to the mark, a similar calculation at the midpoint of that range [US$ 3,500/kW] yields CF = US$ 1.8564 millions, or 4.46 ¢ (US)/kWh.)*

n] "External costs," the final term in Eqn. B1, reflect the way in which a transaction between a buyer and a seller often has impacts on third parties not involved in the transaction, and on the wider community. Thus, efforts are now increasingly being made, through regulatory interventions, to *internalise* some of those costs to the cost of making and distributing then buying and using electrical energy.

o] However, it is quite difficult to assign non-controversial values to resulting costs, benefits and discount rates. (Theoretical and practical controversies also attend the underlying welfare and environmental economics.) The AMPERE Commission's estimates range up to approximately 60 - 70% of other costs for coal plants, and down to 2 – 3% for wind turbines and nuclear plants. [Cf. p. 1-7.] It is reasonable that a geothermal plant will more closely resemble the latter than the former, so no explicit externalities calculation will be needed.

p] The Younger report's projection is that if a 5 MW geothermal plant is feasible, and can be built for some US$ 2,500/kWe, the cost *to produce* electricity for local use would fall to about 4.5 ¢ (US)/kWh. If the capital costs are more like US$ 3,500/kWe, this would proportionately rise, e.g. if the Younger estimate for the operations and maintenance costs are used as a ballpark figure, we are easily looking at electricity *production costs* of about 7 ¢ (US)/kWh. Thus, it is credible that a shift to Geothermal energy would materially reduce consumer rates [bearing in mind the impact of fuel surcharges], which might "reasonably" be "guestimated" as about 2 – 3 times this figure. So, for instance, a household using 300 kWhr/month might on this *scenario* see a bill of about EC$150 - 200, which would not be highly subject to onward jumps in fuel prices. *[These are of course rough, illustrative calculations based on generic estimates, not hard and fast costs.]*

Thus, Equations B1 and B2 allow us to compare the cost-effectiveness of various alternative electricity generation technologies as alternative means of supplying the highly desirable form of energy, electricity. Ultimately, that yields something rather like Table B1, which then allows us to see what alternative technologies make best sense for Montserrat, in terms of both environmental soundness and economic cost-effectiveness. For, if our energy related development projects are to be truly sustainable, they will have to meet both criteria. The current result, unsurprisingly, is that *wind and geothermal energy are excellent alternatives, but the general use of solar photovoltaic electricity awaits more cost-effective technologies.*

Some balance on climate concerns will therefore need to be struck. For instance, given our minimal contribution to the global emissions, we can reasonably adopt the least-regrets principle *that no Anthropogenic Global Warming-based policy action should be taken unless it is reasonable on other grounds as well*, which will disarm critics and/or show itself justified in the possible situation that some of the critiques of the IPCC policy-level approach (e.g. that by the well-known hurricane scientist William Gray et al) turn out to have merit in light of future data and analysis. For instance, while CO_2 emissions are a source of significant concern and debate on their potential impacts on global climate (especially through proposed interactions with water vapour -- a far more significant *greenhouse gas* [GHG]), we have independent grounds to shift away from oil addiction in light of the volatility of that market (which just hit then passed US$ 90 – 100/barrel), and possibly a great opportunity with geothermal energy.

Thus, we may specify and warrant the declared statement of intent for Montserrat's sustainable energy policy, through modifying the classic Bruntland statement [1987]:

> . . . *across time, and in light of identified opportunities, challenges, strengths and weaknesses we shall more adequately and more fairly meet our energy needs in our own generation, but at the same time we commit ourselves to not compromise the ability of future Montserratians to meet their own energy needs.*

Operationally, as a component of any proposal or feasibility and/or technical investigation, a brief Environmental Impact Self-study should be included. If the project credibly has significant impact an independent EIA should be commissioned and it should undergo formal review by the appropriate department, with a stakeholder participative component as integral to that. Established EMS's should reflect reasonable best practice, whether or not they formally include systems such as ISO 14000, and should undergo regular independent audit and reasonable regulatory review.

However, care must be taken that this process does not become unduly bureaucratic, complex, costly, arbitrary and burdensome. Perhaps, this can be in part achieved through a simple cost-benefits analysis based on balanced scorecard across the relevant factors, joined to an effective appeals/arbitration process to the technical and scientific advisory panel, here acting as ombudsman.

So, let us now narrow our focus to the main identified strategic cost-effective green energy opportunities:

Technology	Capacity factor, *%*	Turnkey Investment cost, *US$/kW*	Current Energy cost, US *c/kWh*	Potential energy cost, US *c/kWh*	CO2 Emission, *grams C/kWh*
Biomass, Electrical	25 - 80	900 – 3,000	5 - 15	4 - 10	-
Biomass, Thermal	25 - 80	250 - 750	1 - 5	1 - 5	-
Wind, Electrical	20 - 30	1,100 – 1,700	5 - 13	3 - 10	-
Geothermal, electrical	~ 95	800 – 3,000	2 - 10	1 - 8	-
Solar PV, Electrical	8-20	5,000 – 10,000	25 - 125	5 - 25	-
Solar Thermal, Electrical	20 - 35	3,000 – 4,000	12 - 18	4 - 10	-
Low-temperature Solar heat	8 - 20	500 – 1,700	3 - 20	2 - 10	-
Large hydro	35 - 60	1,000 – 3,500	2 - 8	2 - 8	-
Small hydro	20 - 70	1,200 – 3,000	4 - 10	3 - 10	-
Natural Gas Combined Cycle, steam-cooled turbine		445	2.91 – 3.24		91
Coal Integrated Gasifier CC plant, steam-cooled turbine		1091	3.12 – 3.70		210
Pulverised Coal, Flue Gas Desulpurisation		1090	3.23 – 3.94		238
PWR Nuclear Reactor	85	1,528	2.8		-
Pebble Bed reactor (under development)	~ 85	Est. ~ 1,500 – 2,000	-	< 3.5	-

Table B1: *Energy Technology Options and Economics, costs at plant.* [WEA 2000: Table 7.25, p. 266; Natural Gas & Coal from Table 8.4, p. 281; PWR: Ampere Commission, 1-7 and 1-9, PBMR: MIT & various.]

C] STRATEGIC ENERGY SOURCES AND TECHNOLOGIES FOR MONTSERRAT

There are five major alternative energy opportunities -- and thus strategic alternatives -- for Montserrat: (1) geothermal energy, (2) wind power, (3) energy efficiency linked to *demand side management*, DSM, (4) solar energy [thermal and electrical], and (5) bio-fuels. Each faces pros and cons, and challenges [e.g. an earthquake could "break" a geothermal well, or a hurricane could damage wind or solar systems, and crops for bio-fuels can fail], but so does business as usual – fossil fuels.

We therefore now survey the credibly major opportunities for Montserrat; for, *opportunity is foundational to policy.*

C.1] Geothermal – renewable energy opportunity no. 1

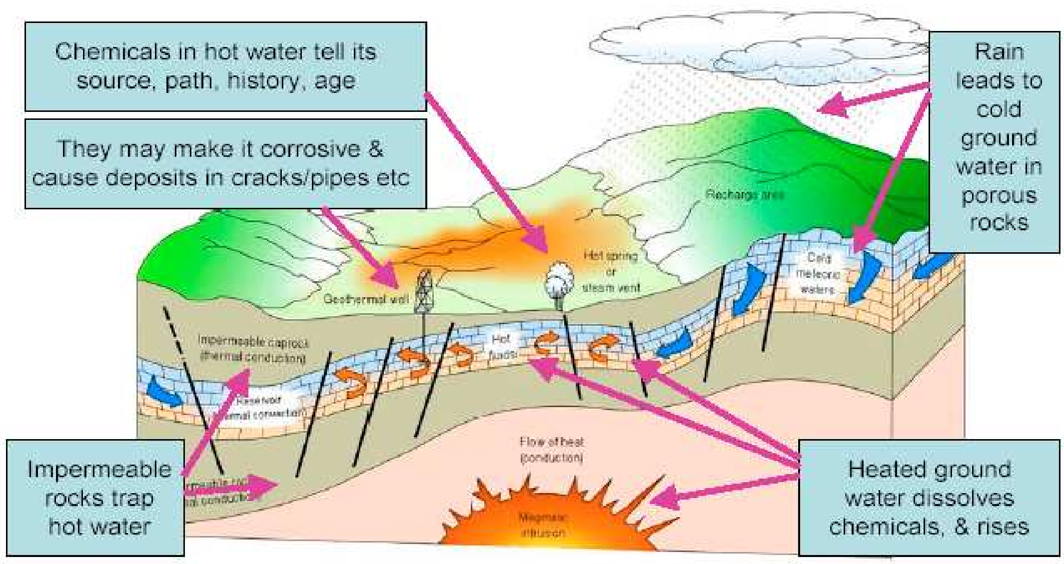


Fig C1.1: *Sources, dynamics, identification and harvesting of Geothermal energy* [Source: IGA/IGG, 2004]

As Fig. C1.1 shows:

> a] Rainfall (and sea infiltration) into permeable rock layers allows for the pooling of ground water in zones heated by magma bodies or other heat sources arising in the earth's crust.
>
> b] Impermeable layers contribute to the trapping process, and faults and cracks in the rocks are important in forming a flow network for the ponded, heated water.
>
> c] The pooled or flowing hot water entrains and/or dissolves minerals which may allow its source, path and history to be deduced – on the usual provisional (but hopefully more or less reliable) basis that holds for scientific modelling.

d] Unfortunately, it also means that if the concentrations of dissolved minerals is high enough, some may precipitate out, partly or wholly clogging natural flow networks and/or pipes in geothermal wells and power plants. (This imposes an operating risk of gradually degraded plant capacity.)

e] On the brighter side, high quality silica (etc.) in the water may be recoverable as a valuable side-product.

f] The resulting geology is specific to the locality, is complex and is -- per many expert reports -- difficult to predict from surface signs.

g] However, faults and other local features allow some to the water to migrate to the surface, giving rise to hot springs, geysers, fumaroles and the like.

h] Such surface signs are a good general indicator of potential geothermal resources, but specific exploration and mapping of geophysical and geochemical signs are only *indicia* of possible locations for test boreholes. For, *the specificity of highly localised flow networks due to cracks and porosity of specific rocks at specific depths in particular locations within the field is decisive.*

i] According to a recent NREL report [*Geothermal Technologies Program Strategic Plan,* 2004], initial exploration (inclusive of interest charges accrued to the time of plant commissioning) may cost about 10% of overall geothermal development, and has often proved to be a critical roadblock due to the relatively high risk. [pp. 4 – 5.] In particular, initial exploratory wells (which typically take from 25 – 90 days to drill [Hance, Cédric/GEA for US DOE, *Factors Affecting Costs of Geothermal Power Development,* 2005, p. 13]) have *about* a 1 in 5 chance of striking a commercially useful flow network [NREL, p. 8], but on such striking, the success probability for successive wells in the vicinity rises to about 60 – 80% [Hance/GEA, p. 17].

j] Since such wells may easily cost up to perhaps US$ 1 million each [NREL, p. 8[xxxvi]] it means that geothermal exploration and development are relatively high-risk investments, especially in the exploratory phases. Overall, *equity* investment reportedly "expects" a return of ~ 17% [Hance, p. 9], a significant number of points beyond say the long term average Standard and Poor rate of return (about 8 – 9%), an index of a relatively high-risk industry.

k] A reasonable estimate for geothermal development timelines has also been advanced by Geothermie Bouillante, Fig. C1.2. Geothermie Bouillante observes of this reference timeline, that "*Time needed for the discovering of the resource and its evaluation can be much longer (10 years and more), especially due to difficulties met in their financing by private operators, often substituted by public and/or international funds.*" [Slide 5. As the timeline for development of Bouillante itself shows [slide 8], actual initial exploration and development there took some 10 - 20 years.]

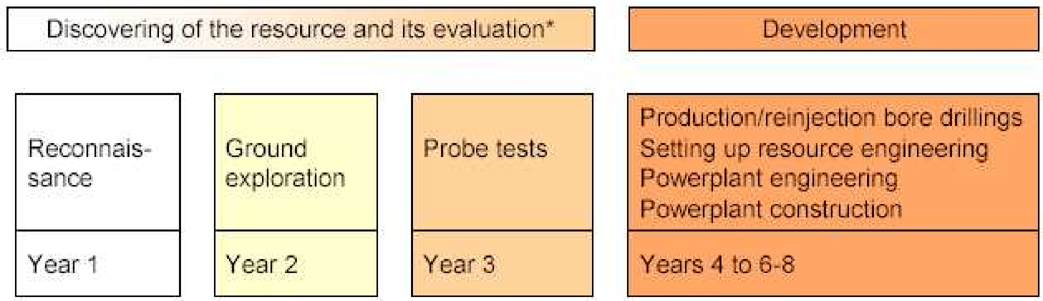


Fig C1.2: *A reference timeline for geothermal energy development.* [Source: Geothermie Bouillante, 2004, slide 5.]

l] Other sources [cf. NREL, Hance etc] concur that *3 – 5 years is a reasonable "standard" timeline*, and suggest that *a reasonable cost-range for such a plant is US$ 800 – 3,000 per kW of electricity production capacity.* [Cf. NREL, Hance, IGA/IGG and their onward cite from Fridleifsson, 2001.]

m] *The high end of the range is more likely to be the case*, and it would be reasonable to expect US$ 2,500 – 3,000/kW. *This costs a 5 MWe plant at about US$ 12.5 – 15 millions.* (Cf. Younger report to MUL, 2006, p ii; etc.)

n] However, it is also noteworthy that, *to date, plant designs and specifications tend to be unique*, per the local temperature, pressure, flow rate and chemical composition conditions:

> Because the temperatures of most geothermal resources are low relative to the combustion temperatures of fossil fuel, the size and cost of surface plant equipment are greater. ***Almost all geothermal plants to date have been built specifically for individual sites.*** *While this may permit optimal energy capture, it also prevents the economic gains from mass production.* Furthermore, the chemically reactive nature of typical geothermal fluids requires protective measures to prevent equipment damage from scaling and corrosion. Mitigating these problems can be expensive . . . [NREL, 2004, p. 10; emphases added. (NB: This remark implies, potentially to our benefit, that *if and as more generic off-the-shelf technologies emerge, this may shift plant capital and operations and maintenance costs downwards*.)]

o] In this context, unfortunately, the high temperature but excessively corrosive geothermal waters discovered in St Lucia may be a relevant factor in estimating risks here. One hopes that *the known differences in volcanic behaviour (thus the associated geochemistry) between the northern and southern parts of the EC volcanic island arc will tell in our favour.*

p] Consequent upon the above factors, and as suggested by Geothermie Bouillante in the above remark on delays in such projects in the initial phases, two models for geothermal energy development have emerged in our region: *[1] wildcatting, wholly commercial development, [2] development fund aided development.* In the Caribbean, the sole long-term success story, Bouillante in Guadeloupe, has adopted the latter model, commissioning a 4.5 MWe plant in

1986, and one of 11 MWe capacity in 2004; which last is therefore a source of current empirically anchored information on geothermal development prospects for our region. [Young, 2006, p. 4; Geothermie Bouillante, 2004, slides 8 - 9; ADEME, 2006, slides 3 - 5].

q] Dr Simon Young's somewhat sobering observations on the comparative success of the development models to date in the region -- though the Geo Caraibes project may now enable several projects under the first model to now become successful through incorporating elements of the second approach -- are therefore worth reflecting upon:

> " . . . *financing of the initial, high-risk exploration phases [for geothermal development] is both difficult and expensive.* In the eastern Caribbean, there have been two approaches to overcoming this twin problem.
>
> The **first** is for **international aid funding** of early exploration, so that a credible geothermal model can be established and commercial developers bear less of the risk of an unsuccessful project. This facilitates the attracting of more experienced developers . . . and also enables Governments to negotiate a much better deal for licensing and power production . . . .
>
> The **second** is for early involvement of a **commercial developer**, who must tie up a license for exploration and power production and usually a power purchase agreement before getting access to funding for exploration. . . . **This approach has not yet been successful in the Caribbean** *and, in several cases, has resulted in the stymieing of development due to exclusive exploration licenses being tied up for many years or hawked at an unrealistic price to third parties who might otherwise be interested in development."* [*Montserrat Geothermal proposal*, July 2006, p. 4. Emphases added.]

r] Up to date, the former approach has repeatedly been challenged to overcome barriers as discussed above, though the current Geo Caraibes World Bank-GTZ-GEF-OAS project has apparently helped several initiatives on the first model to move ahead; *by introducing elements of the second model.* Happily, active geothermal exploration and development programmes are now in train through this project in *Dominica, St Lucia* and *St Kitts-Nevis.*

s] Currently, Montserrat (which as a UK Overseas Territory is ineligible under the Geo Caraibes project) is ~ 6 – 12 months behind the three islands benefitting under this injection of international aid money. Happily, though, through initial development aid assistance through the UN Economic Commission for Latin America and the Caribbean [ECLAC] and DFID, initial, aid-based, pre-commercialisation geophysical, geological and geochemical explorations have now been begun in Montserrat. That is, elements of the successful Bouillante model are now being incorporated into the Montserrat case. (Kindly, cf. excerpt from the project concept note, following.)

t] Further to this, the Geo Caraibes active projects may confer so-called *second mover advantages*, whereby we may be able to leverage experiences, discovered data, emerging geophysical modelling techniques [as they become validated by success in other islands], and the availability in the region of resources such as drilling rigs, transportation to the region having already been paid for by someone else.

u] Consequent on all of the above, as the recent Professor Paul Younger report [2006] identified:

> "... available data on the hydrothermal system of Montserrat reveals the existence of several major hydrothermal circulation systems . . . one of which is safely accessible at present in the Elberton-Richmond area . . . [which] is a realistic prospect for exploratory drilling (estimated to cost not more than US$1M *[now perhaps quite higher - oil price up, drill rig demand up]*), with a view to developing **a power plant of 5 MW capacity** . . . *The capital cost of such a plant is estimated at around US$13M,* and it could be expected to have operating costs in the region of 2 cents (US) per kWh. The overall [production] cost of electricity (levellised over a 30-year plant design life) is estimated at not more than 4.5 cents (US) per kWh, and possibly as low as 4 cents per kWh. It is conceivable that a substantial proportion of the development and operating costs of the system could be recoverable by trading the carbon-emission reduction benefits of the plant . . . . **it is likely that it will take at least 26 months, and possibly as long as three years, before commissioning of the plant can be achieved."** [Younger, Paul: *Preliminary Assessment of the Technical Feasibility and Likely Costs of the Development of Geothermal Power Generation on the Island of Montserrat, East Caribbean* (UK: Institute for Research on Environment and Sustainability; University of Newcastle Upon Tyne, February 2006), p. ii. Emphases added.]

It is therefore reasonable that Montserrat should undertake a process of collaborative, international aid assisted geothermal development. Indeed, such a process was sparked by the visit of the UNECLAC energy expert, Mr. Manlio Coviello, in late September 2007. This emergent strategy was further advanced by the subsequent initiative of DFID, Montserrat, to approach DFID, UK, for incrementally released funding of the high-risk exploratory phases, acting in coordination with the Government of Montserrat. Under this initiative, the process of identifying (and thus valuing) the resource and associated potential for geothermal energy – *if* successful -- would be prior to the "Phase 4" onward commercial process of development of the prospective identified resource.

The initiative has been summarised in a project concept note entitled *Montserrat - Evaluation of Geothermal Potential:*

> *A three phase proposal* to carry out and monitor the geophysical, geological and geochemical operations and studies, together with a small bore test drilling programme to determine whether the Island has the potential to develop commercially viable geothermal power.
>
> ***A successful conclusion to this programme would enable bids for commercial exploitation to be sought*** . . . . The successful conclusion of this project will lead to the establishment of the objectives set out in Strategic Sub-objectives 1.2.2, 1.2.4 and 1.2.5 of the Government of Montserrat Draft Sustainable Development Plan. If the results are positive it will establish a strong basis for future negotiations with credible partners for the construction of a commercial geothermal energy plant on the Island . . . .
>
> > **Phase 1** - Scoping Survey
> >
> > An initial scoping survey to define the actions/operations which need to be carried out in the next phase of investigations, and more accurately define the costs of future phases . . . .

Phase 2 - Preliminary Investigations

This phase will be better defined following the conclusion of the Phase 1 Survey, but will contain . . . . Geophysical and geological studies . . . . Geochemical monitoring (in parallel) . . . . Analysis of the data from the above, together with all previous available data to define Optimum test drilling sites . . . .

Phase 3 - Small diameter [i.e. "slim-hole"] test drilling

Following completion of the Phase 2 Investigations, tender documents will be prepared for the on-Island small diameter test drilling.

The test drilling and reporting works would be completed in around 12 months . . . .

Phase 4 - Commercial Exploitation *(not covered in this proposal)*

The results of the Phase 3 test drilling works will (with about a 75% certainty) confirm and define (or otherwise) the potential for geothermal energy generation on the Island.

At these stage reputable companies specialising in the exploitation of this resource could be approached for offers to take forward the development process (at their cost/risk). Estimated cost for installing a 5 MW plant are around US$15m. This would result in a credible, transparent partnership to the benefit of the whole island

[. . . .]

ANTICIPATED PROGRAMME

Phase 1 - Scoping Survey- Feb. 2008-April 2008
Phase 2 - Preliminary Investigations-April 2008-Dec. 2008
Phase 3 - Trial Drilling- Jan. 2009 – Dec. 2009
Phase 4 - If proven -*Commercial* Exploitation-Jan. 2009-July 2010-Possible date for commissioning of plant

It would of course be highly desirable to accelerate the suggested time-line, if possible. (Possibly, this can be done through overlapping activities under Phases 2 and 3.)

As at the time of writing, an aid agency- sponsored scoping field visit envisioned in Phase 1 just above has now been undertaken, and on the strength of reports and recommendations, expressions of interest and then bids for full fledged explorations under Phases 2 – 3 would be invited on submission of the visiting experts' report. As further identification of the potential emerges through these following phases (and on a positive result), commercialisation of the process would follow, i.e. "Phase 4."

For that, it is recognised that the highly specialised technical nature of geothermal development and operations points to *a local-regional-international partnership, arrived at through a Tenders Board bid process*[xxxvii] [per the publicly owned nature of the underlying resource; on Montserrat Law on mineral, treasure and water rights], as the most credible way for us to acquire first an effective, functioning plant, then also the onward capacity to operate it across time using fully local resources. Accordingly, on the results of Phases 2 – 3, it would be logical for invitations for expressions of interest by prospective joint ventures to be issued.

On receipt of responses, this would be followed by prequalification relative to (1) financial capacity to undertake the development process, (2) technical capability shown by operational experience, and (3) involvement of a suitable local partner. A standard Tenders Board bid process would follow, based on the well-established Commonwealth legal principle that *the underlying resource is a public good, per the established law on mineral, water and treasure rights*. This would then lead to award of a contract for developing and operating the envisioned plant (in a context of technology transfer, capacity building and transition to full local ownership and management), under the BOAT model envisioned in the Declaration above.

A key underlying consideration is the point that if Phases 2 – 3 are successful in identifying an exploitable resource, it would put GOM in the position of requesting bids for proposal from pre-qualified firms and/or partnerships to develop a proved resource. Thus, through application of the existing law that in effect vests mineral, treasure and water rights, in the people, development and operation of a geothermal power plant would controlled by our democratically elected and accountable governments across time, in a transparent fashion. Moreover, by reducing the degree of risk through a pre-commericalisation exploration process, we would not be dealing with high-risk wild-catting[xxxviii] exploration and development of geothermal energy.

To that end, it appears advisable that:

> i] Phases 1 - 3 for exploration should be advanced and expedited if possible, especially if trial drilling can reasonably be initiated relative to initial and interim findings of the initial geochemical and geophysical investigation.
>
> ii] So soon as reasonable results are in hand from Phases 1 – 2, letters of invitation should be issued for expressions of (new or continued) interest by local, regional and international firms and partnerships. (NB: these should specify anticipated basic terms and conditions of geothermal development in Montserrat, perhaps along the lines of the suggested BOAT modification of the BOOT/BOT model; which entrenches participation by local firms and technology, management and ownership transfer across the life of the plant as appropriate to the specific terms of a successful bid.)
>
> iii] On the basis of responses to said letters of invitation, the independent *Technical and Scientific Advisory Panel* [TSAP] attached to the anticipated Energy Office, should rate the proposers on a balanced scorecard basis, and rank and weight them in order of pre-qualification as bidders. This should be communicated on a strictly confidential basis to GOM, to guide the onward Tendering process, as per revisions now in train through the Ministry of Finance.
>
> iv] On successful completion of the exploratory drilling and associated confirmation of the existence of a credible commercial geothermal resource, formal invitations to submit sealed bids to the Government Tenders Board should be issued to the prequalified expressers of interest, leading onward to full development.

C.2] Wind:

As discussed above, the Falklands Islands exemplar strongly indicates that it is initially apparently feasible to invest in, install and commission a modern wind farm of perhaps ~ 900 kW nominal capacity. This could potentially support up to US$ 500,000 to perhaps as high as US$ 1.5 millions of

Carbon credits on the investment and associated passing on immediate savings to the consumer linked to avoided fossil fuels use, on both capital and operations costs. At the same time, the reduced stress on the already existing high-speed diesel units would reduce their operations and maintenance costs, multiplying the benefits.

This is a very attractive cluster of potential benefits, and it should be more closely studied, towards possible implementation across 2008. (Already, steps are in train through a partnership of the local power utility and DFID to undertake just such an investment.) Capacity for such a wind farm credibly will cost US$ 1,100 – 1,700/kW, nominal, i.e. the overall initial investment would likely be of order US$ 1.2 – 2 millions.

However, wind power has in it certain characteristics and subtleties that policy makers, implementers and stakeholders should appreciate, even as we go about an expedited investment process. The first of these is the asymmetry in the available power in wind:

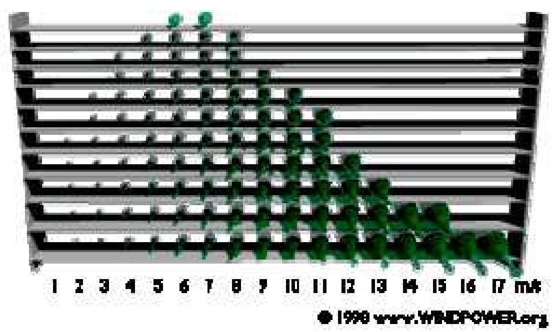


Fig C2.1: *Wind's Weibull speed distribution and availability of energy* [SOURCE: Windpower.org]

As the graduated size of the wine bottles (which obey a similar law whereby volume goes as the cube of bottle height for the same shape) suggests, in Fig. C2.1, faster winds have more power, as power per unit cross-section of wind is proportional to the cube of the speed.

So, given the typical Weibull distribution of wind speeds, a strongly disproportionate fraction of the total power from a wind energy source is delivered when the wind is blowing relatively fast. Indeed, sometimes, there is just too much energy available, e.g. in a hurricane, and the results are destructive. When the wind slows down, hardly any energy is available for harvest. This means that there is a useful range, outside of which there is either an inadequate resource or a potentially disastrous condition. (This is typical behaviour for many renewable resources.)

In the case of Montserrat, the early-mid-80's wind studies (as reported by British Electricity International [1987]) identified that our wind resource may reasonably be characterised by a Weibull distribution [Cf. Eqn C2.1 below] with *shape parameter* k = 3.0 and *scaling parameter* λ = 1.075 times *mean wind speed:*

$$f(x;k,\lambda) = \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k}$$

. . . Eqn. C2.1

In looking at average wind speeds, these studies also showed a typical pattern of annual variation for sites in Montserrat, with troughs about March-April and peaks during the summer and at about the turn of the calendar year.

This is borne out by the current monitoring at Geralds Airport:

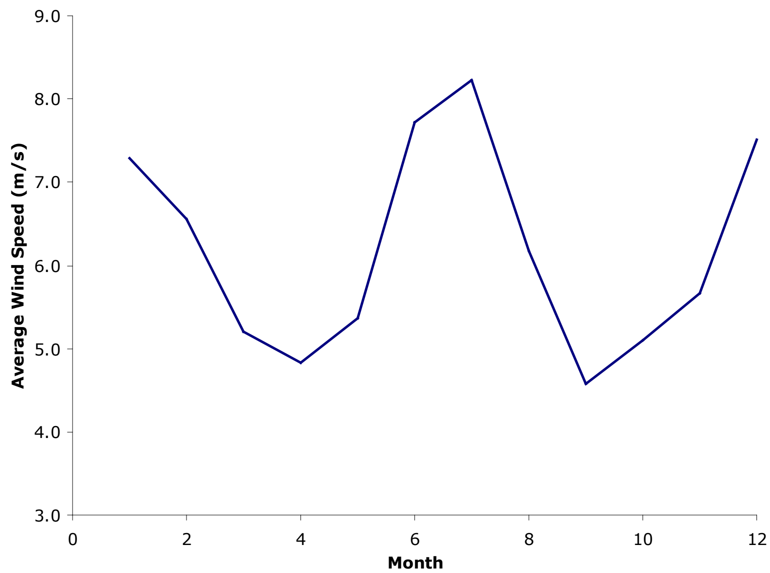


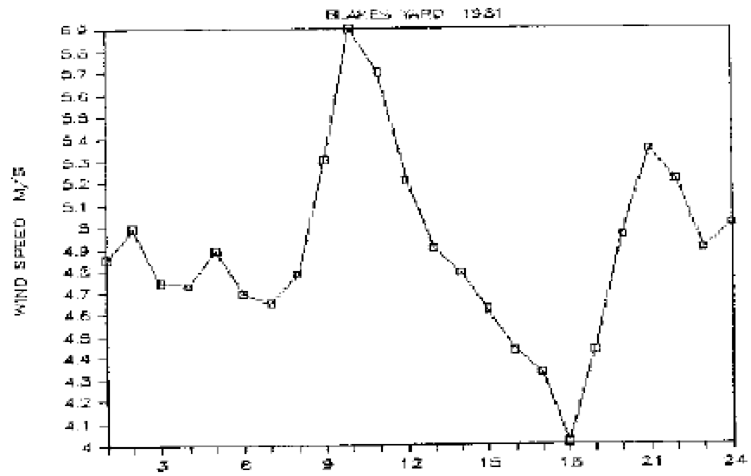
Fig C2.2: *Annual observed winds, Geralds, Airport, 2006* [SOURCE: Graves, R., Imperial College M. Eng. Engineering Summer Study, 2007. Data from Met Office, Montserrat]

Observe as well, how the average wind speed fluctuates from about 4 – 5 m/s in the troughs, to about 8 – 9 m/s at the peak periods. This means that our wind resource fluctuates significantly around the "typical" stated average for the EC of about 6.7 m/s. This will affect wind turbine economics as it means there is a significant seasonal variation in availability factor.

Often, wind turbines are rated at speeds about twice the identified levels, and are de-rated at factors depending fundamentally on the cube of wind speed. This is however reflected in the sort of availability factor numbers already cited. By way of comparison, the *Wigton wind farm* at Spur Tree Hill ridge, Manchester, Jamaica, has an installed capacity of 20.7 MW and is expected to yield an average power of 7 MW. The 3 MW *Tera Cora* plant in Curacao, based on mid-1990's technology, has an availability percentage of 93.2% and a capacity factor of 0.38. The Wigton 900 kW turbines cost some US$ 1,270/kW capacity, or US$ 3,740/W average available power. Dr Raymond Wright, the responsible officer for the project, also notes that by moving from 250 kW class turbines to ~ 1 MW ones, site construction costs for the same overall capacity go down by some 30%.

A further subtlety lies in the daily typical variation of wind power and demand. As Greaves [2007] compared:

Panel A: *Wind resource, Blake's Yard, 1981 [Source: British Electricity International Wind and Siti Study, 1987]*



Panel B: *Load Profile, September 8 – 12, 2007 [Source: MONLEC, 2007 (unpublished)]*

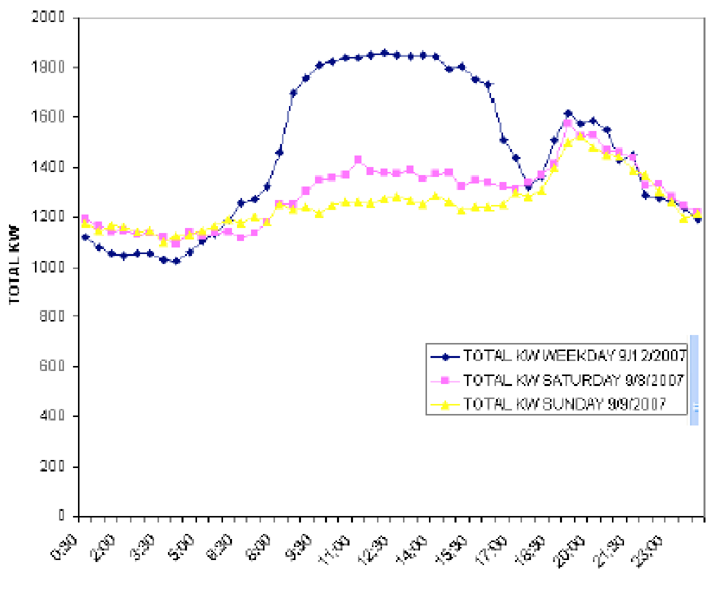


Fig. C2.3: *Diurnal wind speed vs. Electrical power demand, Montserrat.* [Source: Greaves, 2007]

Panel A displays the diurnal wind as reported by the BEI study based on early 1980's data. Panel B displays, for a week in September 2007, a "typical load profile across week-days and on the week-end. During week days, a clear plateaued peak demand at just under 2 MW is visible, probably corresponding largely to demand for air conditioning, computers and other office equipment. On the week-end, this plateau disappears, and a typical evening demand peak takes over, at about 1.6 MW. This same peak appears on week-days, as a secondary peak at the same level.

The wind resource, as shown in Panel A, peaks between 9:00 am – 12:00 noon, at about 5.5 – 6.0 m/s; then fairly rapidly trails off in the afternoon, with the trough at about 4 m/s at 6:00 pm. This also fits in with the annual pattern displayed in Fig. C2.2. However, the afternoon continuation of the demand plateau is not well-matched to the available wind resource, which is trailing off at that time.

In the short term, this speaks to the need for a mixed portfolio of generation assets, with wind penetration being consistent with the need for system stability and load-following capacity. In the longer term, *if it turns out that due to inability to identify a viable geothermal resource, tied to the relatively high risks of the exploration stage of geothermal development, wind has to carry the bulk of our renewable energy electrical load, it suggests an opportunity for* **pumped storage hydro-power systems:**

Fig C2.4: *Okinawa's Yambaru saltwater pumped storage hydroelectric unit* [SOURCE: Seawaterpower.com]

As Fig. C2.4 shows, the Yambaru plant in Okinawa pumps seawater up to a reservoir unit on a high bluff overlooking the coast, which serves as in effect a gravitational potential energy storage battery. This up-pumping is done during off-peak demand hours. Then, when demand rises to peaking levels, the stored energy is turned back into electrical energy through standard hydro-power techniques. (This is of course physically relatively inefficient, but it allows reallocation of electrical energy across time from off-peak to peak hours, through a proven energy storage system.)

However, it must be noted that since Montserrat's soil and rock tend to be porous in relevant areas, any such reservoir will have to be lined to reduce seepage to acceptable levels – especially if the water in question is salt water, as is so in Okinawa.

Further to this, on a smaller scale, recent technological developments suggest a synergy that may be harvested through the recent merger of Monlec and the Water Authority. For, there is a need for enhanced storage capacity for water in the North, especially as the Little Bay development project will credibly attract increased residential settlement and commercial demand in the prospective new town and neighbouring areas. We can therefore consider the possibility of wind-driven pumping to lift the potable water up to the storage reservoirs, joined to in- water-line turbines to harvest excess gravitational potential energy and turn it into electricity.

C.3] Energy Efficiency and Demand Side Management [DSM]:

In a certain sense, energy efficiency -- the provision of adequate, affordable energy services with a minimum of waste relative to the state of the art of energy-using technologies -- should be regarded as "opportunity number one." For, it is probably the quickest line of action to get off the ground, and could give significant savings to users of electricity almost immediately. However, the geothermal energy opportunity, for national policy reasons, has rightly taken that place.

But then, a consideration on the time credibly required to implement geothermal exploration and development (about three years) introduces option 2, wind, which could be put into operation here within the year, and at lower capital cost; albeit it raises intermittency challenges. Energy efficiency, by that criterion, comes in even higher, as it could in principle begin right away, through public education, followed rapidly by energy audit and associated initiatives that could in principle be initially implemented within 3 – 6 months to one year.

"Demand Side Management" -- DSM -- now enters this picture, through the observation that power generation and distribution systems should have the capacity to carry the instantaneous peak load (and a reasonable buffer on top of that), even though such peaks usually occur for only a relatively small fraction of the time. If the utility fails to do that, the resulting short but intense overloads can destabilise and degrade the system, and can damage the utility's own equipment as well as customer equipment. This forces Caribbean electrical utilities, including our own, to build in a considerable amount of reserve, peaking capacity in the system; which naturally increases costs of generation at peak hours, and requires financing of the required peaking and reserve capacity. So, if instead, demand can be managed, reducing peak loads, investments in additional capacity can be postponed, yielding savings to the utility, as future sums hold less present value than current ones in a world with a positive rate of interest.

This has been the traditional rationale for demand side management, DSM; especially when *studies fairly commonly show that DSM initiatives could produce savings in electricity use and peak demand of up to 20 – 40%.* Accordingly:

> Since the 1970s, utilities . . . have been implementing DSM programs designed to reduce residential and commercial electricity demand through information dissemination programs, subsidies, free installation of more efficient technologies, and other conservation related activities. [Auffhammer, Blumstein and Fowlie, 2007]
>
> . . . many different [DSM] program approaches . . . can be used including:
>
> > 1. General information programs to inform customers about generic energy efficiency options.
> >
> > 2. Site-specific information programs that provide information about specific DSM measures appropriate for a particular enterprise or home.

3. Financing programs to assist customers with paying for DSM measures, including loan, rebate, and shared-savings programs.

4. Direct installation programs that provide complete services to design, finance, and install a package of efficiency measures.

5. Alternative rate programs including time-of-use rates, interruptible rates, and load shifting rates. These programs generally do not save energy, but they can be effective ways to shift loads to off-peak periods.

6. Bidding programs in which a utility solicits bids from customers and energy service companies to promote energy savings in the utility's service area.

7. Market transformation programs that seek to change the market for a particular technology or service so that the efficient technology is in widespread use without continued utility intervention. [Nadel, Zhirong, and Yingyi, 1995.]

So, despite recent debates about the effectiveness of DSM initiatives [e.g. Loughran and Kulick, 2004], it remains credible that well-conceived, ably executed DSM initiatives are a valuable investment for utilities, customers and governments. [Cf. Auffhammer, Blumstein and Fowlie, 2007.]

Moreover, in a world that is now increasingly concerned over greenhouse gases and facing unprecedented prices for fossil fuels, something more is necessary, to facilitate the shift to green energy. What that something more is, can be best seen through shifting our perspective from the traditional emphasis on supply of electricity to addressing the context in which electrical energy is demanded and using it to manage demand for its product. For, *people do not usually buy electrical energy for its own sake, but to provide useful services*, e.g. lighting, refrigeration, information processing, industrial or agricultural production, transportation, etc.

So, if we shift sources, technologies and usage patterns to a more efficient but adequate basis, we can reduce losses of energy in the transformation process from sources to energy-using equipment to energy-based services, while maintaining an adequate level of services and economic activity. Thus, the key question is not so much *whether* such a transformation will occur as the world moves to a green energy future, but *how well we will manage it.*

So, for instance, recently expressed concerns that if we move to geothermal energy, Monlec's generator staff would probably lose their jobs are somewhat misplaced. For, *if energy import costs continue to eat up an ever-increasing proportion of our national economic product, that would further destabilise our economy as a whole; plunging it into ever-deeper recession.* That would cost many across the whole economy their livelihood.

The key challenge, therefore, is to redeploy the valuable skills and knowledge of workers and managers in our energy sector to more economically sustainable alternatives in good time to avert the further destabilising of our economy.

This can best be done by focussing on provision of innovative cost-effective sustainable energy services based on technologies and sources that are within reach of the technical capacity of our energy sector workers. "Within reach" implies that this includes further developing those skills through training in the new green energy technologies. Therefore, as wind energy, solar energy and (assuming successful development) geothermal energy begin to come on-stream over the next one to three years, we should be actively training and redeploying our generator plant staff and other skilled personnel to jobs that make advantageous use of the rising wave of renewable energy technologies. Equally, given the importance of and trend towards energy efficiency, similar training and innovations should lead to opening up of job opportunities in energy auditing and associated supporting of energy efficient technologies.

All of this hinges on a key observation. Namely**, *there is precisely <u>one</u> existing cluster of relevant skills and managerial expertise in Montserrat: Monlec.*** This therefore points to an opportunity for the utility to create a new line of renewable energy and DSM-linked technical, marketing and financial energy-related services based on its technical expertise in energy production, transmission and use. Such a new focus for business should also seek to capitalise on some of its more intangible assets such as its relatively low degree of risk for loans, its expertise in energy that confers an ability to better assess the riskiness of investments in renewable energy or energy efficiency equipment than our banks and other financing institutions, and its bill collecting mechanisms.

On the strength of such assets, a case can be made for our local utility to consider the following possible DSM innovations (and related ones for renewable energy technologies):

1] Energy Audits and associated recommendations for cost-savings and associated green energy transformation projects for firms, farms, households, small and larger businesses and institutions. (Possibly, a technical co-operation partnership could be entered into through one or more regional *energy services companies*, i.e. ESCOs.)

2] Provision of affordability-enhancing financing mechanisms for such transformation projects, probably in partnership with one or more local financing institutions.

3] For instance, through such a partnership, a Monlec DSM unit could be set up and used to undertake audits and recommend energy equipment changes, with an attached analysis of cost savings. This would lead to agreed terms for sharing these prospective cost-savings between the customer and the technical support-providing and financing partners.

4] Credit could then be extended to customers who agree to undertake a green energy transformation project, and warrants would be issued for purchase of certified green energy-compliant equipment as agreed, through participating suppliers. For instance:

- Compact or traditional fluorescent lamps have about four to five times the efficiency of incandescent lamps [~ 60 – 85 lumens/W vs. ~ 15 – 20 lm/W] and may last three to ten times as long [3,400 – 10,000 hrs]. However, *they pose a potential mercury vapour toxic waste hazard.*

- The emerging solid state, white-light <u>L</u>ight <u>E</u>mitting <u>D</u>iode [LED] lamp may be six to ten times as efficient as the incandescent lamp [potentially ~ 100 – 200 lm/W], and may last about a hundred times as long as an incandescent lamp: up to 100,000 hours of use. Also, it does not pose a mercury vapour toxic waste hazard.

- Similarly LCD televisions and computer monitors are rather more energy efficient than cathode ray tube units – and compound this effect by therefore *reducing* the office air conditioning[xxxix] load to handle the heat given off by the monitors. (This also potentially reduces worker fatigue.)

5] The associated loans for energy efficiency transformation would then be repaid through the energy billing mechanism currently used to pay for electricity, and appropriate transfers would be made to the financing houses, net of a reasonable service charge.

6] A similar mechanism could be used for promoting solar hot water systems and onward solar PV and similar renewable energy technologies.

7] Since green energy transformation is a strategic regional and global issue, the overall package could in principle attract support through international green energy projects and possibly carbon trading credits. To enhance the chances of such aid support, Montserrat could offer itself as a regional demonstration project for such a development, especially in light of the Little Bay new town development that is now in prospect.

8] Associated technical, financial/economic analysis and managerial level training programmes could be developed in partnership with the Community College and UWI, and then offered regionally through distance education systems, or simply franchised.

9] Initially, such courses could be jointly developed through UWI and the Community College in collaboration with MUL/Monlec, and would target its technical and managerial staff. This has the fastest turnaround between training and application, and responds to immediate needs. Perhaps, this can be done through initial workshops ands seminars, leading into more structured courses

10] Onward, as energy rises as a significant career opportunity, energy career-track education at secondary and tertiary levels could receive increased emphasis. On the model of what happened with the sixth formers in Physics who volunteered for involvement with the Montserrat Volcano Observatory from about 1994 – 5 on, this initially should focus on the basic sciences of Physics and Chemistry, as well as associated Electrical and Mechanical technology studies [and, increasingly, information and communication technology studies]. Curricula should then branch out to specific energy-related fields at tertiary level. This should include not only technical studies, but also programmes that retool our decision-making and managerial classes to become effective functional and strategic level sustainable energy managers.

11] Immediately, that means as well that there is an urgent need for public awareness and education initiatives coming from Monlec, the Community College, UWI and other partner institutions. These should build on the opportunity provided by the current "buzz" due to consultations and media discussions on developing an energy policy and also due to related controversies about some of the related alternatives.

C.4] Current and future Solar Energy

Solar energy is inherently an attractive prospect, in a region that commonly enjoys 4 – 6 kWh/day of energy flux from the sun, per square metre:

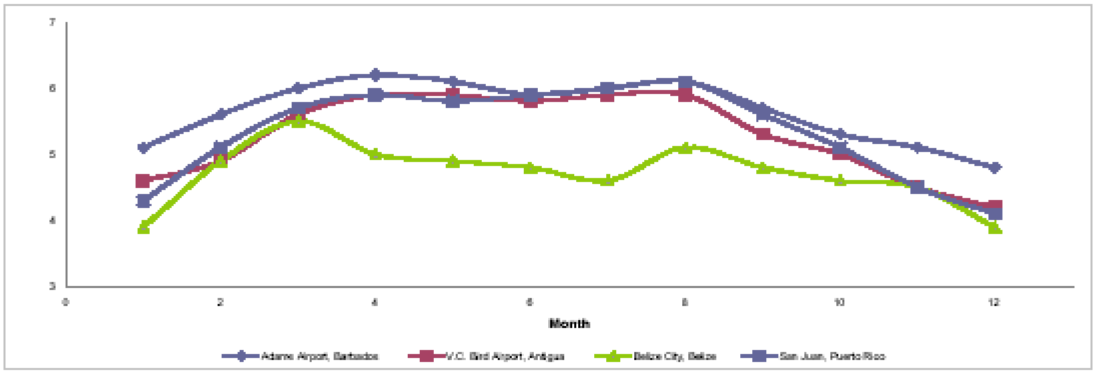


Fig 4.1: *Solar energy per day per square metre availability at select sites in the Caribbean* [SOURCE: Headley, O, as processed, Greaves, R, 2007.]

Of the sites displayed, Vere Bird Airport, Antigua is about thirty miles from Montserrat, so its insolation should be a good proxy for Montserrat's: *about 4.2 – 5.9 kWh/sq. metre per day*, with the peak being June to August, and the trough in December. This yields an annual average of about 5.3 kWh/sq. m per day, or about 1,900 kWh/sq. m per year. While in aggregate this is vastly more than we use, much of that is required to maintain plant life and other environmental systems, and the cost to harvest a practical quantity of that energy, unfortunately, is too often a barrier.

Such insolation is harvested through three primary mechanisms: photosynthesis in plants, heat energy and photovoltaic conversion to electricity. The first is important for bio-fuels, the subject of the following sub-section.

Solar thermal energy can be used directly as heat, e.g. in a solar hot water heating system; or, it may be concentrated and used to generate electricity through heating a working fluid that drives a turbine-generator set. This has the advantage that since it is easier to store heat than electrical energy, such stored up heat can be used to allow actual generation to follow the load (and to make up for times when there may not be sunlight, or reduced light due to cloudy weather or the like. Solar thermal systems usually require a fair amount of space [which is at a premium for Montserrat], but it may be useful to examine the possibility of integrating such a systems with say a binary geothermal plant (as "peaking" plant) and/or to use such units to complement wind turbines. For instance, perhaps the stored heat could be used to carry the evening peak electrical load.

Ocean Thermal Energy Conversion [OTEC] is a related technology that uses the natural heating up of the ocean's surface waters and couples it to cold waters flowing back from polar regions deep under the surface, to make electricity. (This was first demonstrated in Cuba about 100 years ago and is in limited, small scale use at several sites around the world.)

In the case of a classic flat panel solar water heater, it is now generally accepted that solar heating is not only environmentally preferable to say using gas or electrical heaters that use fossil fuels as their source for the electrical energy, but that the units are desirable. The principal barriers are [1] want of affordability [due to their relatively high initial costs], and (sometimes) [2] bureaucratic barriers to actually accessing declared tax breaks or the like. So, the key breakthrough step would be to create a mechanism by which householders and small firms that have a use for such heaters can afford them.

For that, a green energy financing scheme administered through the local electrical utility seems a promising approach, as was discussed in section C.3 above.

Solar photo-voltaic [PV], as was noted in Section A above, is a more challenging case. The key reason may be seen from Table B1. Namely, solar PV systems typically cost about US$ 5 – 25 per Watt of capacity, leading to a current typical levellised cost of electricity of 25 ¢ [US] - $1.25 [US]/kWh, and with a hoped for reduction to 5 – 25 ¢ [US]/kWh.

Such costs are not currently generally competitive, save for specialised, off-grid purposes. However, as advanced multiple junction, thin film, polymer, dye-sensitised cell and other technologies mature over the next one to two decades, this may change significantly. So, since PV technologies may be deployed at consumption-point in homes, farms and commercial or institutional buildings, that may lead to PV becoming competitive at the consumption end of the grid (consumer end grid parity, perhaps at US 8 – 10 ¢ [US]/kWh]), providing affordability mechanisms are in place to spread out the capital cost across sufficient time that there will be a significant demand. Later on PV may become competitive at the generator end of the grid, and so we see an optimistic case 2003 projection for PV, from Germany, with PV taking off 2030 – 40 and then becoming dominant:

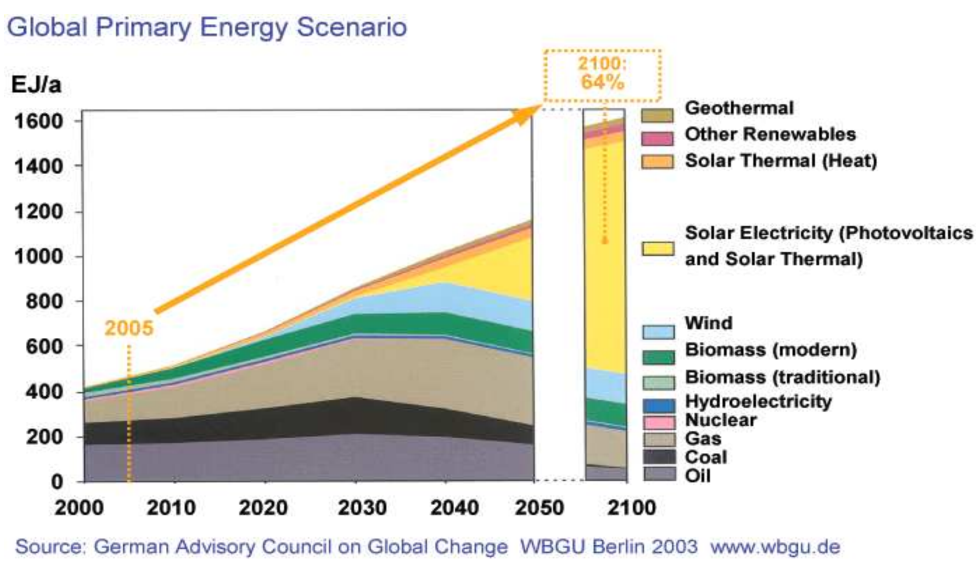


Fig. C.4.1: *A high solar-energy growth scenario for future energy*

On this scenario, PV and solar thermal could easily become the dominant energy base for the global economy, with hydrogen being used as an energy carrier for transportation. In such a scenario, hybrid and/or rechargeable electrical vehicles and Hydrogen based *fuel cells*[xl] would also become important technologies for transportation. Further to this, should fusion technologies approach commercialisation, hydrogen production by electrolysis would be a key stage towards the production of the most likely relevant isotopes for use in fusion power generators, such as deuterium.

Such a scenario may currently seem optimistic, but if PV costs come down enough, in the long term, a solar PV-hydrogen economy may become quite likely.

Accordingly, Montserrat should monitor PV progress, build up technical capacity for photovoltaics and fuel cells, and be prepared to follow trends that may well move such a development from *optimistic* to *likely;* especially if there are real breakthroughs in the PV industry. Indeed, already, there seems to be at least one firm, **Nanosolar** of California,[xli] which reportedly claims to have developed a thin film cell that uses a nano-particle ink that is *printed* onto a roll of fairly thick aluminium metal foil (the bottom electrode), and then self-assembles from particles of *Copper Indium Gallium Diselenide* [CIGS]. A high current capacity transparent conductor is then deposited as the top electrode. All, duly protected by a suite of over 180 patents granted, pending or in application. The resulting cells are reportedly robust and durable – the company offers a 25-year warranty based on its extra-harsh accelerated testing.

The firm claims to have broken through the US$1/W sales price level (of course, doubted by critics). For Caribbean levels of insolation, this might yield a basic levellised cost of about 5 – 6 ¢ [US]/kWh. (NB: *Balance of system costs* to give power in *alternating current* [AC] form and/or when the sun is not shining, would lift this significantly; though Nanosolar claims to have reduced costs there too as the Aluminium film substrate they use is clearly easier and cheaper to work with than glass or wafer substrates.) However, such a PV cost breakthrough would push the markets for electrical equipment towards *direct current* [DC] equipment, especially since most electronics equipment is actually DC and currently uses a power supply module to convert AC mains to DC. (Switch mode converters, similar to the switch mode power supplies now usually used in personal computers can reliably convert one level of DC to another.)

Should such a PV breakthrough succeed in the market, it would raise the issue of *net metering* and associated electricity sales to the grid from traditional consumers, now PV generators in their own right. This brings to the fore a cluster of related issues:

a] In the 1950's – 60's, when Montserrat was initially electrified, the technologies were such that it was necessary to have a guaranteed generator monopoly for Monlec, and it was of great assistance to have Deutche Welle/ Radio Antilles as a major customer.

b] Thus, electricity generation was seen as a natural monopoly due to the high capital costs and economies of scale. Monlec was therefore legally established as a generating monopoly, and other generators [down to the level of small "standby" generator units] strictly, were to be licensed by the electricity utility.

c] This decisively shaped the corporate culture and business model, and Monlec (along with other Caribbean utilities) normally views itself as principally an electricity generator, with an associated distribution network to deliver its product to consumers.

d] Further to this, since Caribbean utilities normally face relatively small demand levels, and would face prohibitive costs in trying to set up a regional grid, required local reserve capacity is large. Thus, electricity production costs and consumer prices would naturally be high relative to world standards.

e] The energy services perspective, multiplied by the prospective rise of more modular renewable energy technologies significantly shifts the scenario. For, first, it must be recognised that energy users do not desire electricity or other forms of energy for themselves, but as means to the energy based services that they need to support production and consumption activities and their desired lifestyle. (Already, this is evident for transportation and telecommunication, where cars and cell phones have become increasingly dominant; both being technologies that are energy based and decentralised.)

f] Second, once a wire-based network has been invested in and established, it is actually the grid that is the evident "natural" monopoly, not the centralised generation assets. For, the overall cost to make multiple grids in the same region or to have a great many off-grid individual point sources that have adequate on-site reserve power, is plainly far more than that to modify access for supply and demand on one in-common electrical energy carrier network. So, once cost-effective modular generation and grid-coupling technologies are available, robust distribution of electrical energy on a moment to moment basis from *net sources-for-the-moment* to *net loads-for-the-moment* arguably becomes an in-principle viable option.

g] Also, it is a waste of the community's inherently scarce economic resources to over-invest in off-grid site-based electricity generation capacity with localised, site by site reserves. But if modular renewable electricity generation technologies emerge in a context where in addition to individual site-based cost advantages, there is a perceived environmental imperative to move away from fossil fuels, it will be very difficult to prevent the emergence of a wave of site-specific mini power plants that in aggregate waste the community's economic resources through unnecessary duplication. In short, grid-connected PV and similar technologies are must-face issues.

h] Now, too, in the 1990's, the logic of network economics just outlined led to the rise of independent/ private power producers. That is, private generator companies financed, built and operated power plants then sold electricity to the grid at guaranteed prices and quantities. Unfortunately, experience with such ventures in the region has not been entirely happy, and there are issues connected to the specific business models of a significant number of the ventures that were undertaken.

i] Be that as it may, the underlying logic still has considerable force. So, the potential rise of low cost photo-voltaics and similar modular electricity generation technologies comes back to the same point, multiplied by the issue of how to have sufficient reserve in the grid from moment to moment to ensure system stability. Further augmenting the point, is the imperative to move away from excessive dependency on fossil fuels to renewable energy technologies. For, many of these technologies are inherently modular and -- if they are going to be cost-effective at all -- will achieve grid parity at relatively small scale.

j] That means we have to find a new model for the electricity utility in our community, one that can accommodate a shift to distributed generation that in significant part uses renewable energy technologies that are modular and usually intermittent. Often as well, that intermittency does not smoothly match our consumption patterns as shown in Fig C2.3 above, especially the double peak on weekdays – one in working hours, one in the evenings.

k] Arguably, the energy services view of Section B above [cf. also point e just above] provides the basis for such a model. That is, we must first recognise that *consumers do not buy energy for its own sake, but to provide desired, energy-based services. So, they will naturally gravitate to credible, cost-effective, convenient, affordable, attractive technologies and associated energy sources.* The logic of this market place dynamic, joined to the implications of network economics applied to a national electrical grid, leads to the conclusion that *our utility should consider becoming the preferred provider of (or broker for) such accessible and affordable energy-based technologies and associated services.* This immediately entails leveraging of technical expertise so that customers can be assured that they will be able to access hassle-free, reliable, affordable, desirable technologies, with back up support through the utility or utility-approved support services. It also suggests that we should seek to use the grid as the natural monopoly to manage the development of a high renewable energy economy.

l] This issue starts with wind development, which may happen as early as 2008. So, while many Caribbean power engineers become very uncomfortable so soon as wind or other intermittent sources approach 20% grid penetration, we will have to carefully assess the stabilising potential of modern grid management systems for relatively small-scale power grids with wind near to, at or well above 20% penetration.

m] If geothermal comes on-stream by about 2010, this will be a very dispatchable supply, with an availability factor that credibly is at about 95%. That would buy us time, as we would then not have to go for very deep wind penetration of the grid augmented by things like pumped storage hydroelectricity to give us ability to address mismatches between daily peak energy source levels and peak demand. However, if the ongoing geothermal exploration process regrettably fails to identify an exploitable resource, then the underlying issue is reinforced.

n] If and as photovoltaics achieve consumer-end grid parity, it would then become attractive relative to extending the grid to now isolated areas. That means that *over the next ten years or so, the first significant penetration of PV systems would probably occur in areas that are remote and that are currently held back from development because of prohibitive grid extension costs.*[xlii] There may also be a relatively small number of households and firms that may either want to go off-grid or to have a net metering interface with the national grid; whereby at some times they are net users and at other times net providers of electricity.

o] As long as the cumulative impact is minor, it would probably be useful to use this as a natural experiment, studying and learning what approaches would be best if and when PV costs fall sufficiently that it becomes a potentially competitive main provider of electricity to the grid. Accordingly, a slow, experience-driven relaxation of grid-connexion permit regulations would be advantageous, and it would be worth the while to pay out a fee to a limited number of select minor private generators that from month to month may be net providers of electricity, under reasonable *net metering* terms.

p] Similarly, should *renewable energy air conditioning systems* take off, that would probably have significant relevance to the daytime peak load, and it would be worth the time, effort and money to undertake a similar exploration of the potential.

q] Thus, through such "natural experiments," there would be a basis of factually grounded technical data to address the situation that may emerge on the scale of 10 – 20 years (or possibly sooner than that), by which PV electricity becomes cost-competitive with the major grid generation technologies. That would give a foundation for gradually developing an emergent, experience-based onward policy.

C.5] Bio-fuels and other "fuels" alternatives:

Transportation is our second most important use of fuels. By direct inference from our fuel import numbers and the fraction that is used for electricity generation, it credibly takes up some 35% of such imports. Hitherto, that consumption has been based on fossil fuels, but over the next five to ten years, renewable bio-fuels will increasingly come into the picture as an alternative. For, crops such as sugar cane, certain fast-growing fuel woods, hemp, wastes, sewage and the like can be used to make bio-fuels and even Hydrogen – the "fuel" [strictly: *energy carrier*[xliii]] for many fuel cells. These alternative, renewable fuels are increasingly viewed as the wave of the future for transportation and similar systems.

There has been much discussion of the anticipated Hydrogen [and/or Solar-Hydrogen] economy. Such an economy will have the major environmental advantage of eliminating Carbon from the fuel cycle; though, there have been concerns about escaping hydrogen and free radical formation in the atmosphere under impact of UV radiation, leading to ozone depletion. Of more direct consequence is the challenge of Hydrogen generation, storage, transport and use in transportation systems. For, currently, the most energetically- and costwise- efficient way to generate hydrogen is from hydrocarbons; electrolysis requiring about 50 kWh/kg of electricity from water to vehicle. So, while concentrated generation of Hydrogen plus carbon sequestration is possible, that only brings up storage and transportation issues, in the context of the implications of the H_2 molecule's being small and energetic; leading to embrittlement of storage tanks for especially compressed gas. Liquefaction is energetically expensive [requiring temperatures of order -250 °C (~ 20 K)], and leads to handling challenges. Absorption storage techniques can attain about the storage density of liquid H_2, but that will be about three-fifths the volume concentration of H atoms in gasoline. H_2 can be burned in suitably modified internal combustion engines, or used in fuel cells (which, per unit power, may still be up to a hundred times as expensive as ordinary internal combustion engines).

Moreover, the introduction of H_2 would require large scale investments in required infrastructure -- of the order of hundreds of billions to trillions of dollars [US] -- which will clearly significantly delay deployment of H_2. Consequently, Hydrogen is an exploratory and long term development alternative, rather than a medium-term solution. But, *since breakthroughs are always possible, we should undertake some exploration and demonstration.*

Electricity is also a suitable means for powering vehicles. The energy storage can be in the form of fuels used in fuel cells [or in current hybrid cars, to run a small engine that spins a generator]. Alternatively, if may come from storage batteries. Unfortunately, such batteries are often expensive, heavy, somewhat bulky and tend to wear out after several years of use. Probably the most likely use of batteries will be with the emergence of plug-in hybrid electric vehicles. But again, we are looking at technologies that are a bit down the road.

By contrast, major bio-fuel alternatives are far easier to handle using current infrastructure and engines; perhaps with relatively modest modification.

For such fuels, a major consideration is productivity potential. According to Holtzapple [2005] and others, biomass productivity potential (as oils, starches and/or sugars or at the upper end ligno-cellulose) can range from about 2 – 8 tonnes per acre per year, to up to about 60 – 90. For instance, *Energy Cane* is a leading land-based crop [~ up to 19 tonnes/year bagasse (ligno-cellulose), and 8 tonnes/acre-year sugar]. *Miscanthus*, a sterile perennial hybrid related to sugar cane (but often misidentified as "elephant grass"), which grows in both temperate and tropical regions, can routinely yield 12 – 15 tonnes per acre-year of biomass, with one crop in Illinois recorded as over 24 tonnes per acre-year. *Water Hyacinth* is, similarly, a leading aquatic "crop" [60-90 tonnes/acre-year ligno-cellulose]. Unfortunately, it is also a potentially ecosystem devastating invasive water plant species (precisely because it is so fast-growing).

Hemp, i.e. *Cannabis sativa sativa* [not *indica*, the "smoke-able" variety], is also noteworthy as a potential source of oils [from the "seeds" -- apparently, properly: *fruit*], of fibres [stems] and of fast-growing woody biomass. According to estimates by Bio Gas Company of New Zealand, hemp can be processed to yield up to about 450 gallons/acre-year of biodiesel and [through fermentation of the biomass] about 1,500 gallons/acre-year of ethanol. Methanol (once called "wood alcohol" as it can be made by pyrolysing wood) production is a similar possibility.[xliv]

Hemp-derived alcohols could be quite helpful; as, *trans-esterification* requires a considerable proportion of alcohols to transform vegetable oils into biodiesel suitable for vehicular use. It is noteworthy that this process is so simple and foolproof that there is now a considerable home-brew biodiesel movement, especially using the so-called Appleseed reactor, based on an old oil drum or water heater tank. (NB: In tropical contexts, some stationary diesel engines, reportedly, can simply directly burn so-called *"straight vegetable oil,"* SVO; and/or filtered *waste vegetable oil*, WVO, a minor source. With a fuel-heater modification [cost: perhaps US$ 1,200], again "reportedly," so can many vehicular diesel engines; though most of these rely on a (small) tank of ordinary or trans-esterified diesel to initially start up – and then to purge the system of SVO before shut-down. Several manufacturers make injector kits that allow modification of a standard diesel to run SVO, without need for a second tank. This harks back to the fact that Mr. Rudolph Diesel's original engine actually ran on peanut oil. [CAUTION: In each case one should check the relevant technical and warranty details; recognising that if a diesel is rated at a durability of 500,000 miles and one cuts off even just 50,000 miles off that, one has in effect put up the underlying energy and materials consumption for diesel engine manufacturing by 10%.])

Alcohols are further important because a fuel cell that first converts alcohol to Hydrogen then uses the freshly generated Hydrogen gets around many of the challenges of using Hydrogen as a fuel.

In this general context, a major industrial challenge is that *ligno-cellulose, the naturally occurring fibre-polymer and glue matrix composite material that forms the herbaceous and woody biomass that dominates the high end of the scale, is much harder to process to generate desired fuels than are oils, sugars and starches.* In effect the sugar-polymer fibres need to be separated from their lignin matrix and broken down through hydrolysis into digestible sugars (which may require well-chosen and/or engineered micro-organisms, especially for *pentose sugars*), then fermented.

Lignin, the other component of ligno-cellulose, can be burned as a fuel (with comparable heat value to coal) and can also be digested or *gasified* through application of heat and pressure, with steam (and oxygen or air) injection, yielding a mixture of hydrogen and carbon monoxide known as synthesis gas [H_2 and CO]. But then, just about any organic materials[xlv] can be gasified in this way, which can then be chemically recombined through the Fischer-Tropsch synthesis process into desired fuels. Unfortunately, the process – though a relatively efficient means of extracting energy from biomass through gasification then synthesising desirable fuels, is capital-intensive and has high operations and maintenance costs. (Historically, it was used to make synthetic fuels to defeat blockades or embargoes, e.g. Germany in the Second World War, and South Africa during the Apartheid era.)

Starchy and sugary crops tend to top out at 2 – 5 tonnes/acre per year of fermentable biomass, leaving micro-algae derived vegetable oil the champion of prospectively "easily" produced bio-fuels.

Of existing or prospective conventional oil-producing bio-fuel crops, calculations standardised to yields in US gallons per acre per year based on various sources indicate that *Palm Oil* with up to 760 US gallons and *Chinese Tallow*, at about up to 700 US gallons, are the highest producers (i.e. about an order of magnitude below the inferred potential of micro-algae). *Honge*, or Indian Beech, which due to a deep tap root is suitable for arid regions, is reportedly able to produce up to ~ 300 gallons/acre per year. *Jatropha*, which is conveniently a smallish, fast-growing crop, reportedly produces "easy to reap" seeds yielding up to 200 - 360 US gallons per acre per year.

Oily crops have a further advantage as well, for as Rapier [March 28, 2006] summarises:

> *1 gallon of biodiesel has the effective energy value of 1/0.65, or 1.5 gallons of gasoline . . . [and] 1 gallon of gasoline is worth around 1.5 gallons of ethanol on a BTU equivalent basis, so 1 gallon of biodiesel is effectively equivalent to (1.5*1.5) or 2.25 gallons of ethanol . . . .* [However, since in North America especially diesel engined vehicles, for varied reasons, are not very popular for personal/ family transportation] it will take some time for a transition to diesels to take place. This is the most serious obstacle to wide-scale adoption in the short-term.
>
> A second disadvantage that is often cited is that biodiesel has a much higher pour point and cloud point than petroleum diesel.

This last challenge is not directly relevant to the tropics, but is a concern in temperate zones, which dominate diesel engine markets. It is, as described by various sources, addressable in principle through the use of an electric pre-heater and/or preheating though the exhaust stream from the running engine (which could be started from a small low pour-point diesel tank). But, such technological changes tend to make for barriers, in this case a pre-heater may easily cost up to US$ 1,200. Long-chain alkane fuels derived from gasification and synthesis, as in effect high quality, more or less conventional (but biomass-derived) diesel fuels, do not face this challenge.

Thus, diesel engines are desirable on energetic grounds but due to various characteristics are often unpopular with consumers. Onward, *plug-in rechargeable hybrid vehicles* then *fuel cell vehicles* will credibly be key trends as the world moves towards a future energy transportation system. Since alcohols are "better" stores of hydrogen than hydrogen gas, these trends – again – underscore the importance of alcohol based bio-fuels and biodiesel fuels as substitutes for current fossil fuels, especially:

> **[a] Ethanol,** which is a currently used gasoline additive, and is under major regional consideration in light of the well-known Brazil success story, which hinges on the ability to use the bagasse side-product as woody biomass burned to generate heat and electricity for the process of making and distilling the alcohol. However, ethanol has the disadvantages that (i) it has only about 2/3rds the energy density of gasoline and (ii) if used at near-100% concentration, requires significant, though not particularly difficult, modifications to vehicles and possibly to handling equipment. For, ethanol -- at the high concentrations required for it to work as a fuel -- is a potent solvent and has different volatility characteristics than gasoline.

[b] Bio-butanol, a four-carbon-atom alcohol similar to but "thicker" than the familiar two-carbon-atom alcohol, *ethanol*. It is commonly used as a thinner for paints, but *it is also a quite close substitute for gasoline; one which can reportedly be handled pretty much as gasoline is, using the same equipment with little or no modification.* In particular, its energy density is about 90% that of gasoline, and it is a bit more efficient in combustion (and has nice octane number characteristics), so that on the strength of the very limited and often unofficial tests to date, it may yield a tad more mileage than conventional gasoline. Its problem to date has been that it has been difficult to get economically feasible high volume production from biomass using bacteria [the traditional biomass-based method of production, tracing to Chaim Weizmann,[xlvi] 1915 - 1916]. However, ongoing developments with fermentation technologies seem to be promising to change that. In particular, the identification or development of strains of yeast to digest woody and/or sugar-containing biomass to give economically feasible yields is in process. An algae-based production pathway also exists.

[c] Mixed Alcohol fuels: Holtzapple's predigestion "composting" and fermentation process based on natural bacteria cultures captured from the rumens of fistulated cows (complete with plastic caps for convenience in tapping fermentation bacteria cultures) to generate mixed alcohol fuels without excessive sterility constraints, is also a significant, but easily overlooked, contender for a cost-effective bio-fuels solution. (Also significant is the fact that the resulting bio-fuels, due to the mixture of alcohols involved, has a superior energy density to ethanol, though not quite equal to gasoline: *up to ~ 83% that of gasoline.*)

Overall, while each of the above potential opportunities embeds risks and challenges, collectively they point to the feasibility and desirability of a sustainable energy based alternative path for Montserrat's energy policy.

D] THE "POLICY ROLLOVER" APPROACH

The above survey of energy opportunities underscores the dynamic nature of the energy sector and especially the initial imperative of risky exploration of geothermal, wind and solar energy prospects.

It is therefore reasonable to propose that after about a year in which initial investigations are undertaken, there should be a review of the implementation plan following, and also of the main policy declaration and rationale.

Going further, since that dynamism is not expected to decrease, at the fifth year, there should be a further major review, leading to a policy rollover keyed to a new five-year implementation plan. That is, circa 2012, the current policy would be updated to a policy for the years 2013 to 2032, and would have attached an implementation plan for the years 2013 – 2017. And so on.

Thus, the policy process will be able to respond to the dynamism of the energy sector, while allowing us to track the capacity of successive policy documents and projections to accurately predict long-term developments. It would also aid us in managing the implementation process by comparing achievements and projections at any point in the ongoing process, towards such adjustments or contingencies as may be reasonable at the time in question.

E] MONTSERRAT ENERGY POLICY ELEMENTS:

The Montserrat 2008 – 2027 Sustainable Energy Policy, is based on **the intent** that: across *time, and in light of identified opportunities, challenges, strengths and weaknesses we shall more adequately and more fairly meet our energy needs in our own generation, but at the same time we commit ourselves to not compromise the ability of future Montserratians to meet their own energy needs.*

To achieve this intent, **priority strategic initiatives** must be identified that that jointly and cumulatively undertake . . .

> *a* ***course of action*** *for our community in Montserrat, that will help our nation to identify and fulfill a desirable and achievable* ***vision****:*
>
> > *(1) of how we will obtain energy from technically and economically feasible, environmentally sound sources; and*
> >
> > *(2) of how we will then use it effectively and efficiently to contribute to an ever more wholesome, prosperous and earth-friendly lifestyle.*

The main task of the above rationale has been to identify the framework for such a course of action, and in turn this framework undergirds the elements in the policy declaration, and its associated goals, objectives, waves of advance and lines of action, across the period to 2027:

I] POLICY VISION -- *TOWARDS A SUSTAINABLE ENERGY FUTURE*:

This is a one-paragraph synopsis of why we need to change from business as usual on energy, to a more sustainable alternative, and of how we will do so.

II] POLICY OVERVIEW – *RISING TO MEET THE CHALLENGE OF SUSTAINABLE ENERGY*:

This presents an introduction to and one-page executive summary of the energy policy. It starts from briefly reviewing the economic and environmental unsustainability of our current over-dependence on fossil fuels, and proposes that we must move towards renewable energy and enhanced efficiency in light of an energy services oriented perspective. Capacity building through transparent credible partnerships and training will play a role, and we intend to be a regional exemplar and centre of excellence on sustainable energy.

III] DECLARATION OF POLICY INTENT:

This identifies where we the people and government of Montserrat intend to go, thus outlining a plausibly achievable view of where we could be over the next twenty years, in light of the principles of sustainable development.

IV] INDICATIVE POLICY TARGETS: FIVE, TEN, FIFTEEN & TWENTY YEARS

This breaks down the overall goal into objectives structured around five lines of action and four five-year waves of advance. The attached Schedule 1 presents a matrix that displays the resulting specific targets for achievement by lines of action and waves of advance.

V] MAIN POLICY INSTRUMENTS:

To achieve outcomes, we must first undertake targetted action, along lines of action shaped by our intents and commitments. To do so, we need means that can work effectively towards the desired ends. These are the policy instruments, starting with the creation of an Energy Office to serve as a focal point for action towards sustainable energy, especially through coordinating priority projects. Legal/regulatory and financial instruments (including Carbon Trading, taxation incentives, consumer and small business level affordability schemes and similar mechanisms) then provide additional tools for moving towards the targets.

VI] FIVE-YEAR INITIAL PROGRAMME OF IMPLEMENTATION:

To give initial effect to the policy, a five-year operational plan is presented in outline, based on the identified targets for the first five-year wave of advance. The prospective Energy Office will be critical to fulfilling the plan. It also is expected to serve as a focal point for strategic initiatives, managed through a project team structure and with transparency through a stakeholder based board, a technical and scientific advisory panel and a regular programme of public forums on the state of and prospects for energy in Montserrat.

VII] ORGANISATION, RESOURCING, OVERSIGHT, REVIEW

The prospective Energy Office, under an appropriate Ministry, is the prospective designated focal point for coordinated action on sustainable energy under the energy policy. As such it would access appropriate GOM resources, and through partnerships with relevant partners in the context of priority strategic initiatives and projects, it would access further resources. GOM oversight would be through the Ministry, and transparent governance would be enhanced through the stakeholder based advisory board, the technical and scientific advisory panel and the public forums. Through these mechanisms, regular review of progress and challenges would be made, and a basis set for developing onward five-year programmes of action under the policy as it evolves across time in light of developing global, regional and local trends and circumstances relevant to energy.

VIII] ONWARD LINES OF ACTION:

The institution of a sequence of five-year programmes of action, and the associated review and revision of the policy, in a context of participative governance provide a basis for proactive onward sustained transformation of Montserrat's energy base to a green energy sustainable foundation.

SUMMARY & RECOMMENDATIONS: Montserrat’s current energy systems helped fuel our transformation to a modern economy, from the 1950’s to the 1990’s.

But, as the new millennium dawned, it has become increasingly evident that -- along with the rest of the world -- *we must now urgently transform our energy systems to a sustainable basis*. That in turn justifies the need for a well- thought- through policy framework that enjoys sufficient robust support and resources that it can help guide that process.

Over the next few months, in light of the opportunities, risks and challenges we face and through the policy process now in train, let us now begin that transformation.

APPENDIX G.1:

SAMPLE PROJECT "LOGICAL FRAMEWORK"

1. PROJECT FRAMEWORK:	2. IMPLEMENTATION, MONITORING & CONTROL		3. PROJECT RISK MANAGEMENT				
	2a. CRITICAL SUCCESS FACTORS	2b. CSF INDICATORS/HOW OBSERVED	3a. ASSUMPTIONS RE ENVIRONMENT: PEST + BP	3b. RISK			3c. CONTINGENCY RESPONSES
				HI	MED	LO	
1a. VISION (SUSTAINABLE?):							
1b. PROJECT: PURPOSE /GOAL(S) :							
1c. PROJECT'S DELIVERABLE OUTPUTS:							
1d. PROJECT'S ACTIVITIES:							
1e. PROJECT'S REQUIRED INPUTS:							

APPENDIX G.2

Montserrat Energy Statistics

The backdrop to Montserrat's energy import statistics is the global fossil fuel market, with a particular emphasis on oil; which is currently produced at a rate of about 85 million barrels per day.

In turn, the oil market faces the issue of *Peak Oil*, a thesis which traces to M. King Hubbert, 1956. Currently, for instance, Matt Simmons, Houston-based investment banker and author of the major 2005 book, *Twilight in the Desert*, observes trends[xlvii] in the Saudi oil well productivity that suggests that these -- the leading conventional oil reserves in the world -- have passed their peak. Such a trend would be compounded by the already strongly rising demand from China and India, which has already helped bid prices upwards sharply, to now over US$100/barrel; where one barrel contains 42 US gallons of crude oil. As these and other major production centres peak and decline in the face of rising demand, oil shortages would naturally drive prices upwards, according to Mr Simmons, perhaps as high as US$ 300/barrel.

Others, such as Shell's US Operations president, John Hoffmeister, suggest that while conventional oil may indeed be peaking as suggested, the rising prices have made/will make non-conventional oil sources such as Canada's Athabaska oil sands, Venezuela's extra-heavy crude in the Orinoco river basin and extra-deep offshore wells economically competitive, which may help stabilise the trend before it reaches that sort of level. For, clearly, widening of technological frontiers and the rising of prices opens space for effective substitutes for conventional oil. (This now includes opening space for renewable energy technologies.)

However, in the short-term, it is evident that whenever demand for oil is near the peak of available production capacity at any given time, increased demand or sudden falls in supply lead to oil price spikes, partly explaining the volatility of the market. Then, if such a spike leads to a combination of rising production from new sources and a fall in demand (or in just the growth trends) due to a resulting or associated slowed global economy, the price will thereafter naturally tend to fall again; at least, in real terms. For, a strong rise in oil prices tends to inflate the global economy, in effect depreciating the value of currencies. That is why, for instance, the late 1990's oil prices of about US$19/barrel were viewed as being more or less comparable to the 1959 levels of about US$2/barrel.

Against that general backdrop, Montserrat's oil import trends are indicative of our high dependency on imported fossil fuels, and of the potential for economic transformation and stabilisation if we can significantly shift electricity production and/or transportation away from dependency on oil. Unfortunately, the current oil import statistics are somewhat questionable [three data sets from two government departments being somewhat incoherent to date], so *the figures below, from the initial set supplied by the Statistics Department circa January 2008, per data request 710, must be taken with a few grains of salt; fuel import numbers may be about 50% of this size (as per an earlier data set which was apparently used for the Edgecombe study circa 2004). The portrayed 2002 spike is perhaps in part at least an artefact*:

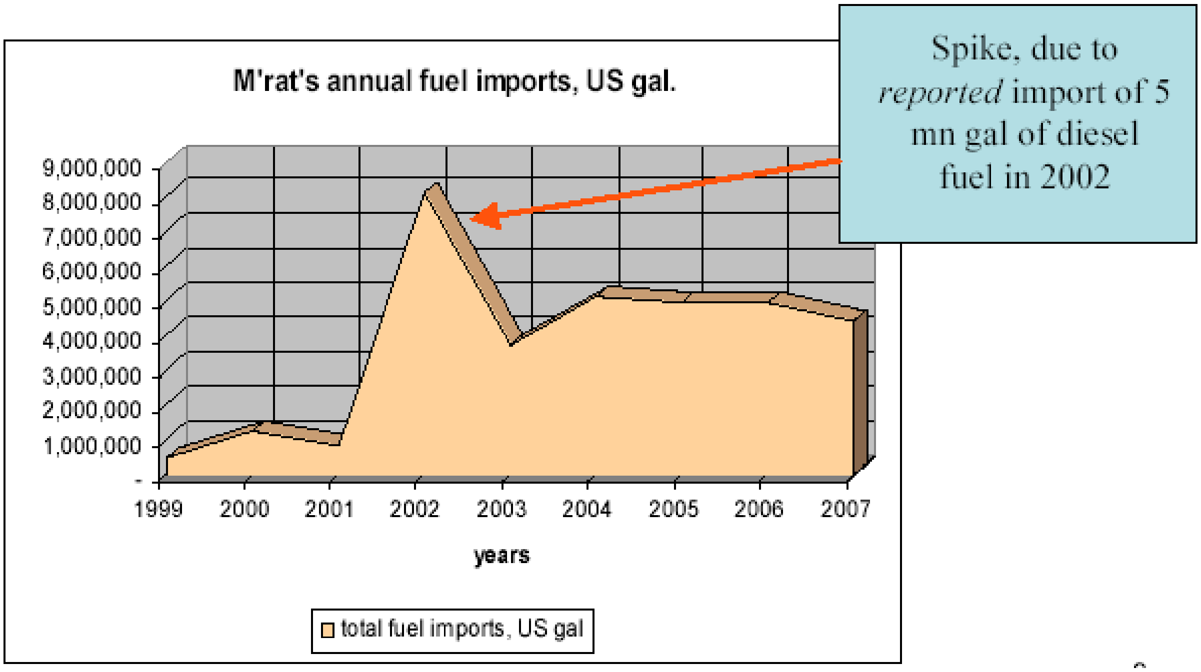


Fig. G2.1 *Montserrat's aggregate fuel imports, by bulk*

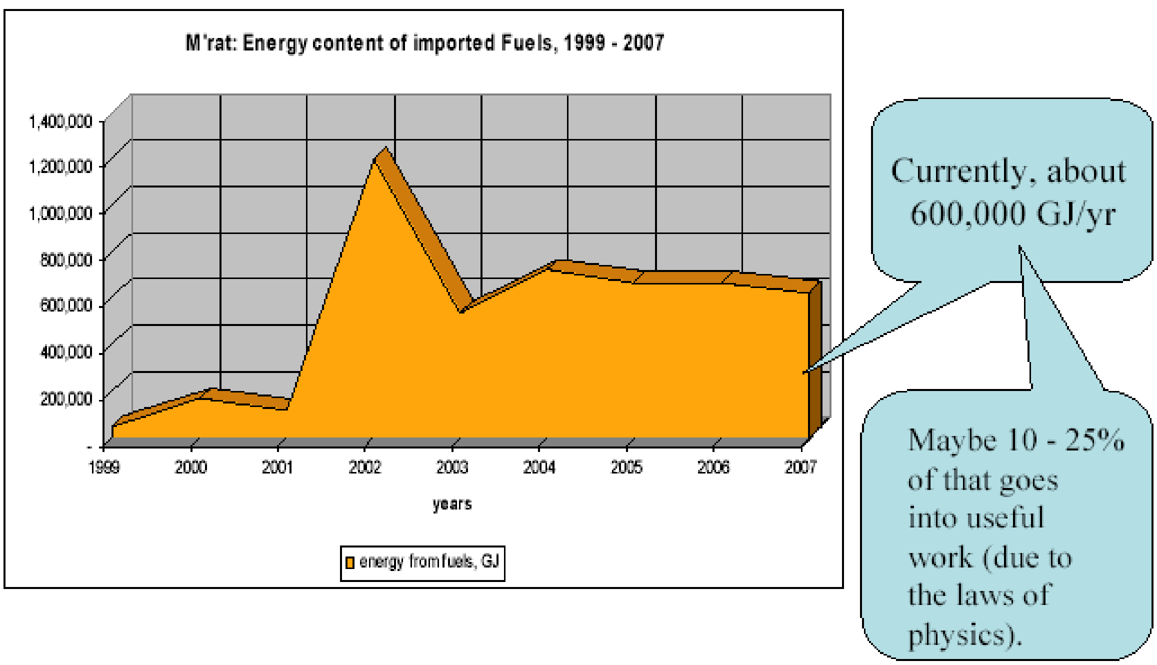


Fig. G2.2 *Montserrat's fuel imports, by energy content*

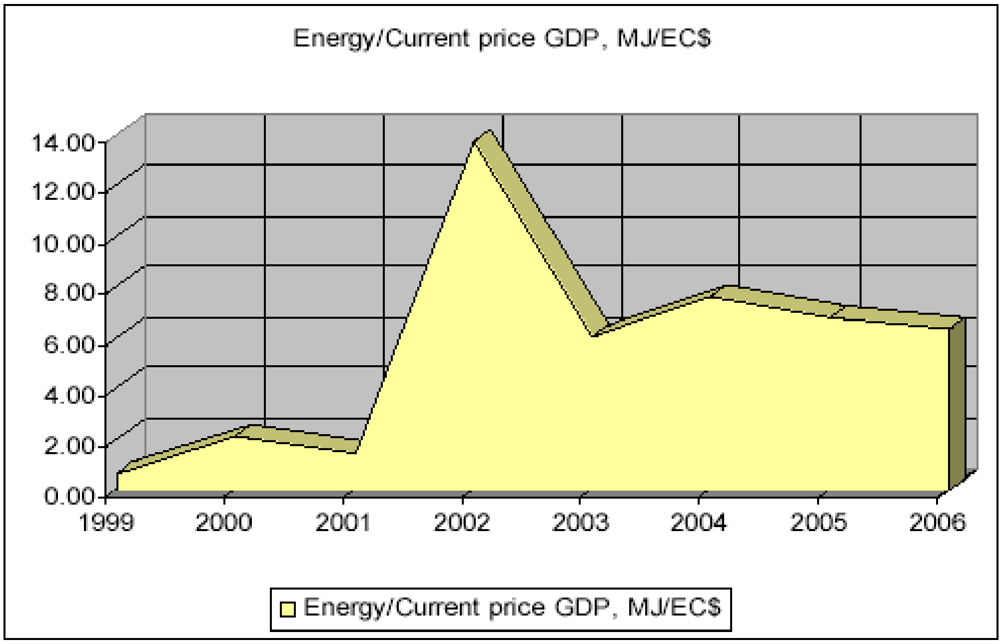


Fig G2.3 *Energy intensity of Montserrat's Economy, using GDP at current prices*

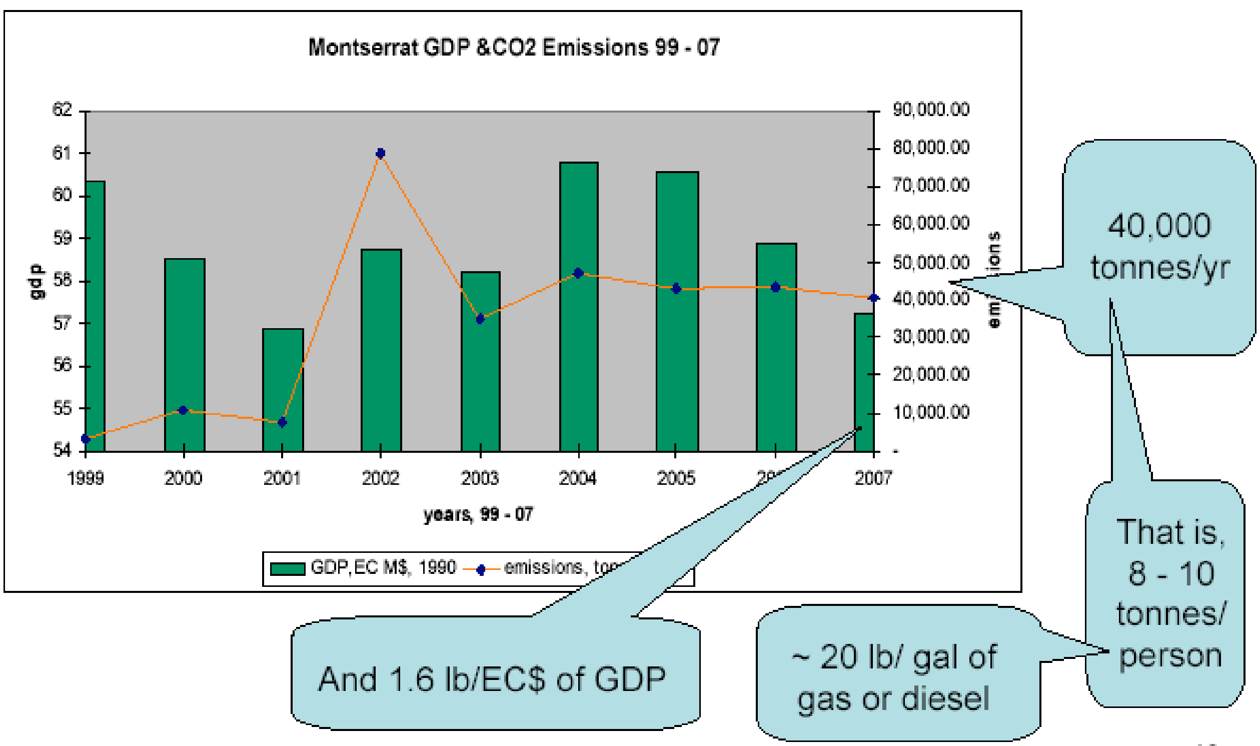


Fig G2.4 *Montserrat's Constant-dollar GDP vs. Carbon Dioxide emissions*

Table G2.1: Montserrat Fuel Import trends and related statistics, 1999 – 2007, as per initially supplied Statistics Dept Data circa January 2008, relative to data request 710 and associated calculations

M'rat fuel use trends 99 - 07					**YEARS**				
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
A: FUEL CONS. DATA									
gasoline, US Gal.	87,882	423,748	277,868	2,254,576	1,467,906	1,853,823	1,440,254	1,642,669	1,826,347
diesel, US gal.	72,527	591,519	430,906	5,858,182	2,209,469	2,753,643	2,438,496	2,298,164	2,281,725
LPG [Propane] US Gal	277,685	196,257	122,517	5,697	249	530,319	1,047,700	1,000,571	311,721
Kerosine, US Gal	3.11	29.53	664.78	0.31	1.86	434.17	131.78	35.43	72.10
Jet fuel, US Gal	1,411.92	493.54	332.55	33.25	555.07	6.84	89.51	15.23	9.32
energy from that fuel, GJ	49,631	166,283	115,215	1,204,535	535,563	721,398	667,639	668,036	623,720
Monlec gen, MW h	8408.4	8876.9	8990.9	9555.6	9741.2	10607.6	11302.4	11412.4	
Monlec fuel use, US gal diesel			590,737	619,486	644,283	669,396	712,071	729,577	740,835
gal diesel/MWhe			65.70	64.83	66.14	63.11	63.00	63.93	
Absolute energy Efficiency			0.354	0.359	0.352	0.368	0.369	0.364	
Tot fuel per req 710, US Gal	439,509	1,212,047	832,288	8,118,488	3,678,180	5,138,226	4,926,671.01	4,941,455	4,419,874.39
Fuel, per earlier data,[1] US Gal		1,796,000	2,025,000	2,043,000	2,251,000	2,373,000			
CIF value. Per req 710, EC$	1,837,659	6,168,400	3,441,394	12,771,112	10,493,362	14,449,697	19,010,042	23,281,800	22,688,849
Current price GDP, Mn EC$	80	79	83	88	89	95	99	106	
GDP, Mn EC$1990	60.32	58.51	56.85	58.74	58.2	60.79	60.58	58.86	57.26
Population, mid-year	3,392	3,894	4,517	4,563	4,482	4,681	4,785	4,655	
GDP EC$ 1990/capita	$17,783.02	$15,025.68	$12,585.79	$12,873.11	$12,985.27	$12,986.54	$12,660.40	$12,644.47	$11,882.13
energy/current price GDP, MJ/$	0.62	2.10	1.39	13.73	5.99	7.63	6.77	6.29	
CIF/Current GDP	2.3%	7.8%	4.2%	14.6%	11.7%	15.3%	19.3%	21.9%	n/a

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[1] Evidently, as used by D Edgecombe, circa 2004

APPENDIX G.3:

PROJECT CONCEPT PAPER FORMAT

GEM/TKI 2001, this rev. 2008

CONTEXT: Project concept papers are used to set out the key ideas for a project in a format that can be used for further development through the stages of the project cycle:

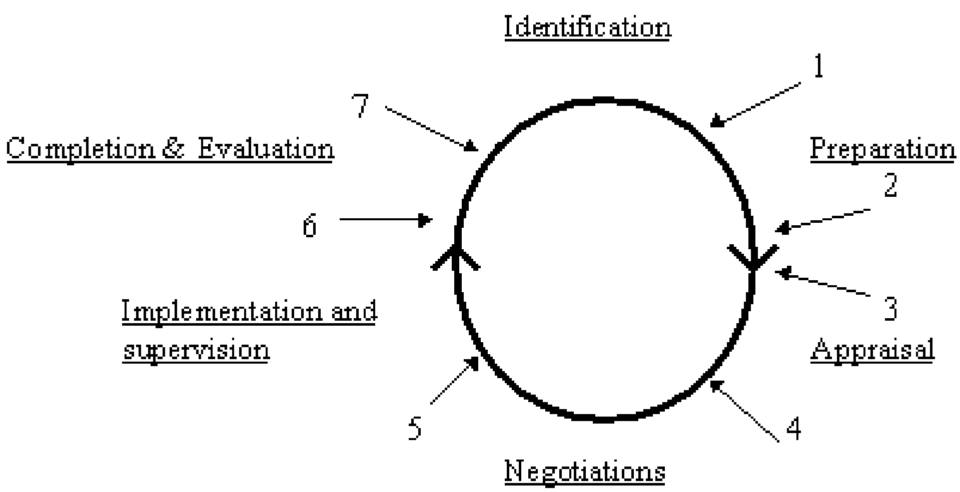

Fig G.3.1: *The World Bank's summary of the Project Cycle*[2]

In the case of small projects, the concept paper may be enough to serve as a proposal. More complex projects will use such a paper as the start-point for further development in a standard format.

Thus, being able to write such a paper, to capture an idea for a project in a format that can be used for discussion and development is a critical project management skill.

The concept paper should be of about 3- 5 pages in length [exclusive of the Log Frame and any other appendices you wish to add], and should be accompanied by a covering letter. The framework for such a paper should include:

OUTLINE OF A PROJECT CONCEPT PAPER

TITLE: Be brief, descriptive, and memorable.

---

[2] *(SOURCE: Project Cycle Manual,* http://www.mos.gov.pl/mos/publikac/Raporty_opracowania/manual/source_1.html#9.5 *)*

INTRODUCTION: A *brief* statement of the need for the project, why it is important/urgent to meet the need, and how it may be successfully and sustainably met through carrying out this project. What is the FIRST thing you want the reader to know about your project?

1. **Background and Rationale:** An exploration of the context for the project, in light of the underlying analysis, giving a bit more detail than the introduction on:

    - How the need for a project came to be;
    - A thumbnail sketch on the state of the art in knowledge on the matter: environmental factors, trends and dynamics, issues/controversies and perspectives, how interventions could give rise to the desired outcomes.
    - The existing/expected resources and stakeholder commitments that permit an effective response to be developed; and,
    - What factors could motivate a switch from business as usual to a more sustainable path through doing the project.

2. **Goals and Objectives:** Concisely state the overall goal to be achieved through doing the project. Then, break it down into a small list of more specific, brief, observable (and preferably quantitatively measurable) objectives that can be achieved by given times (to the day, week, or month, typically). When attained, these objectives should collectively indicate the achievement of the goal.

3. **Proposed Implementation:** Briefly outline how the project would be organised, managed and carried out using people, organisational, financial and material resources, across time. (It may be helpful to draw a chart that states the goal, then branches out to the objectives, then lists the required activities for each objective. This is called a **work break-down structure**. An organisational framework for making decisions about and managing the project will also be helpful.)

4. **Milestones and Deliverables:** Identify and list, stage by stage, what the project is to achieve and produce as outputs. (These will be used for monitoring, management, control and evaluation of the implementation process, so inception, interim ["progress/gap"] and final narrative and financial reports will be important deliverables.)

5. **Inputs:** Identify and list the inputs required for the project: people and skills, teams/work-groups, reporting linkages, equipment, space, materials, funds, permits required, etc.

6. **Estimated Budget:** A summary budget based on reasonable estimates of the costs for major activities, and on contributions from the different funding (and in-kind) sources. Perhaps, as an appendix, with a reference in the main text, as that allows easy exclusion in copies circulated to those who do not need to see a budget. (The log frame and work breakdown structure are very helpful in budget construction. It is often useful to include a contingency sum, to be

released under appropriate authorisation if/as contingencies are warranted or unforeseen opportunities arise.)

7. **Key Assumptions:** Identify and list critical environmental conditions that may affect the achievability of the project's goals. Some assessment of their risk and impacts on the project may prove helpful, with some brief reference to how they will be monitored and responded to as necessary.

8. **Outcomes, Benefits and Impacts:** A year or so after the project has been completed, what will it have changed for the good? What about five to ten (or more) years after? Who will directly benefit from these medium- to long- term changes? Who else may be affected by the project, for good or ill? [These groups are the *stakeholders*.] Also, if the project is likely to significantly affect the human or natural environment (e.g. gender issues, cultural heritage sites, stakeholder groups, economic prospects of stakeholders, rivers, watersheds, forests, coastal zones, threatened flora and fauna), favourably or adversely, this should be briefly noted and requirements for preparing an Environmental Impact Assessment (if one is needed) should be listed.

SUMMARY AND RECOMMENDATIONS: Summmarise the point of the project as briefly as you can, state your verdict on feasibility, importance and desirability, and invite participation. A respectful, professionally dignified tone is best.

APPENDICES: Logical Framework (which will provide the basis for many of the above sections of the paper), and contact information for the project implementers. Any other reference material that seems appropriate, such as a SWOT analysis chart, a budget, or a Gantt Chart or a Work Break-down Structure chart.)

APPENDIX G.4:

CONFIDENTIAL:

Stakeholder review and response form

As a stakeholder of a green energy future for Montserrat, you are kindly invited to fill in then submit the following, to the Environment Department of the Ministry of Agriculture, Lands, Housing and the Environment [MALHE], Brades, Montserrat, or at other locations as announced:

1] General response:

a) I see the following as *three major good points* for this proposed energy policy:

GOOD POINTS	WHY THEY ARE GOOD
1:	
2:	
3:	

b) I found the following to be *three major bad points* about this energy policy:

BAD POINTS	WHY THEY ARE BAD
1:	
2:	
3:	

/Please turn over . . .

2] Points for improvement:

This draft energy policy would be *improved* if . . .	
1:	Because . . .
2:	Because . . .
3:	Because . . .

3] Any other suggestions or comments . . .

I also suggest that . . .

4] *If* you wish to do so, you <u>may</u> contact the Department of the Environment, Brades, for further communication. You do not need to do so, but it might be helpful.

-- THANK YOU --

APPENDIX G.5:

Remarks on Stakeholder & Partner Consultations and Contributions

The stakeholder and partner consultation process for this consultancy began on an informal basis with the UNECLAC expert visit in September 2007; that is, in the preparatory phase before the actual contract was signed in mid-December.

During that visit, an informal circle of key partners and stakeholders was consulted with, subsequently becoming the nucleus of the formal Energy Policy Consultation Group. This group has played a vital, shaping role across the life of the project. The devotion of focus, time and effort by Mr Peter White of MUL has been of particularly noteworthy importance. Likewise, major concerns raised by CRM/MGPC have also played a key shaping role in the policy drafting process. Mr Albert Daley of the Development Unit has repeatedly contributed significant insights and information. Many officers in departments and units across the government have given significant inputs and comments, especially through providing key documents and data; the Development Unit, the Finance Department, the Statistics Department and the Customs Department being particularly noteworthy. Mr Royden Greaves' 2007 Engineering summer study for his M.Eng at Imperial College, London, was graciously made available to the consultancy.

Beyond this, many individuals and groups across Montserrat also contributed insights and inputs in various ways, especially following the circulation of a draft overview with attachments starting December 17, 2007; the date of contract signing. Members of groups and the public who participated in individual discussions, in group meetings and in public meetings and media appearances are also to be recognised.

Similarly, wider electronic consultations and meetings with visiting experts have brought in insights from various stakeholders and development partners overseas. Especially notable among these overseas contributions are:

- The many, varied and beyond-the call-of-duty contributions of UNECLAC through Mr Manlio Coviello,
- Technical insights, observations and comments by visiting experts from GeothermEx and IGG,
- Dr Simon Young's general suggestions and his comments in response to questions on certain technical geological issues,
- OAS and the Government of Dominica [who have kindly supplied a copy of the GeoCaraibes project draft geothermal development law and associated legal commentary],
- Concerns on possibilities for exploitive foreign investment voiced by Dr Sharon Romeo Fivel Demoret in a series of transatlantic telephone conversations, and
- Former energy officer and PS Mr Joseph Daniel's contribution on electric vehicles.

Discussions with representatives of CRM [Committee for the Redevelopment of Montserrat] on the energy policy and on Geothermal Energy development proved very important from December 2007 on, as this NGO became the focus for expression of critical concerns and challenges. It is important to document their perspective, as expressed in a series of meetings with principals of both

CRM and Montserrat Geothermal Power Company (MGPC, the spun-off proposed geothermal developer based on CRM), from December to January-February:

1] CRM/MGPC considers that the key issue is to move forward on geothermal energy development through granting a license to the *local,* community-based initiative, MGPC, without further undue delay. For MGPC, in their stated opinion, has identified and sourced adequate funding to initially explore and then lay a basis for developing geothermal energy. (There was a strong concern that questionable overseas interests might hold significant equity in or manage any geothermal development, leading to a risk of inappropriate exploitation of Montserrat's resources and people. The unfortunate circumstances of the 2006 attempted signing of a geothermal exploration and development license contract with West Indies Power Limited and resulting public protests and controversies were cited as a key evidential basis for this concern.)

2] On learning that the GOM wished to develop an energy policy as a framework before carrying out geothermal development, one of CRM's members prepared and submitted a draft for such a policy based on the CARICOM draft policy as cut down to what was deemed appropriate to Montserrat's circumstances. So, in their opinion, there was no need for any further elaborate policy development process. (NB: At the consultant's request (and as offered by CRM), a copy of the document was communicated; the CARICOM and OECS policy drafts having already been a part of the process to date. It was consulted in the drafting of the policy document, but proved to be of somewhat limited utility relative to the broader terms of the remit for the policy as set by our democratically elected government and its duly appointed officials.)

3] Most of the alternative and renewable energy ideas in the CARICOM policy document were viewed as being irrelevant to Montserrat and so what in CRM's view is the key issue was identified and highlighted, *geothermal energy development.* In that context, the remit of the policy development consultancy was therefore seen by this NGO as far too broad. The policy development project was seen as effectively a delaying tactic, perhaps linked to concerns identified at 1 just above.

4] The group then claimed that GoM had given an undertaking to CRM/MGPC that no action would be taken on geothermal energy until the policy was in place. Further, they had been to DfID about helping to fund geothermal exploration and development through MGPC, only to be rebuffed on DfID policy grounds. So, on learning that *DfID* (nb: as opposed to GOM) had initiated a project with UNECLAC to bring to Montserrat an American company and an Italian "company" to undertake a low-budget initial survey, it was viewed as not transparent and thus most likely a step towards injection of exploitative overseas interests. This, CRM would publicly protest. (Indeed this set of concerns formed the framework for subsequent radio broadcasts.)

5] The technical competence of the proposed company, GeothermEx and that of the Italian *research institute*, IGG, were questioned. So was the initial costing and projected risk for geothermal exploration and development: especially, the Coviello-NREL estimates that on basic probability analysis suggest ~ 50-50 odds on initial exploration up to and including exploratory wells; at a cost probably in the ball park of up to about US$2 millions.

6] Dr Paul Younger's 2006 estimates for the probable overall project costs and timelines were viewed as too high, relative to quotations CRM had. Dr Simon Young's observation that early commercial development had repeatedly been stymied in the Caribbean and his associated recommendation on the strength of the Guadeloupe success story and the then emergent GeoCaraibes project, that aid-funded exploration was more likely to succeed was also objected to. So were the observations of ADEME on the key success factors of the Guadeloupe geothermal developments; namely, the injection of aid funding to undertake the high-risk, relatively high-cost exploratory phase that had repeatedly been a roadblock to strictly commercial development. Similarly NREL of the USA's observations that exploratory geothermal wells credibly tend to cost up to or more than US$1 mn, and have an industry average success rate of 1 in 5, was dismissed as irrelevant to our case.

7] The solution offered by CRM/MGPC was to in effect adopt the CRM draft policy document without further delay, rapidly thereafter grant an exploration-development licence to MGPC, and let the development of geothermal energy move ahead based on Montserratian ownership and already identified financing. Where external technical expertise was needed, it would be hired, management would be in experienced hands as present in the leadership of MGPC, and the required plant would be more or less available at low cost off the shelf. [xlviii]

These themes, issues and arguments have subsequently come up from time to time across the life of the consultancy, in public meetings and in some group or individual consultations. Doubtless, this reflects the public relations and public education activities of CRM and MGPC over the two-year interval since 2006. It is therefore appropriate to note on a few points, observing how the above concerns have been reflected in the drafted policy, especially on points where the policy addresses geothermal energy as a major -- albeit fairly risky and likely high cost -- opportunity for a green energy future:

a] Geothermal energy is just one of several renewable and energy efficiency opportunities we need to address to transition Montserrat to a more robust, secure and sustainable energy base. So, while the GOM-DfID-UN aid-funded project to carry out exploration and if successful identification and characterisation of a resource is an ongoing project, so is a wind initiative, and steps are being considered to move ahead on other renewables. Energy efficiency initiatives and demand side management are also under consideration, and more futuristic possibilities like hydrogen [through UNIDO's Hydrogen Islands initiative] and bio-fuels [through the regional initiative] are also under consideration.

b] Through applying the legal principle that mineral, water and treasure rights are public resources, any development of geothermal energy will be through a transparent, legally mandated Tenders Board process with bidder pre-qualification. Also, geothermal energy is generally viewed as a complex, capital-intensive, fairly high risk form of energy to develop; which hinders commercial development. Consequently the global circle of experienced, successful, credible developers is fairly narrow. This led to the proposed aid-funded exploration process, which is now ongoing. Then, if a commercially viable geothermal energy resource is successfully identified, the prospective development partnership will have to demonstrate financial and technical credibility, and will have to incorporate a Montserratian component, towards technology, management and [if relevant] ownership transfer.

c] This reflects not only the need for us to develop our own capacity, but also the history–driven balance of forces, views and sensitivities in our community and region on ownership of key national assets. For, we cannot forget that the Caribbean's first experiences of foreign investment were associated with conquest, enslavement, slavery–based plantations and colonialism. In more recent times, there have been too many occasions in the region where major investment deals were not carried out in the interests of the people at large, and in some cases were not only not transparent, but sometimes outright corrupt. It is this backdrop that lends plausibility and sting to CRM's expressed concern that geothermal development here might fall victim to similar destructive patterns.

d] Having noted that, given the need to move ahead without undue delay on energy developments, it is actually an early payoff of the energy policy discussion and development process that it has helped trigger aid-funded geothermal exploration, as well as a similar project through MUL and DfID to bring modern wind energy back into Montserrat's electricity grid. So, the policy development process is plainly not a cause of undue delays on green energy development.

e] Similarly, as soon as a link was seen between the established Tenders Board financial transparency regulations and the principle of public ownership of the potential geothermal resource, leading to a pre-qualified bid process for commercial development, the GOM would have been irresponsible to reject or postpone such an aid-funded exploration process. Not least, such a process takes the observed major commercial development roadblock [high-cost, high-risk exploration] off the table. If successful, it would at once put Montserrat's people and elected government in the position of inviting bids against a known, valued resource, not an unknown, risky possibility. That should put us in a position of negotiating from a position of known strength.

At the same time, as a part of the inception process, a stakeholder identification, impact analysis and consultation strategy matrix was prepared in collaboration with the DOE and was presented at the first meeting of the EPCG, early in February. Public and group consultations have been undertaken in its light, electronically, through individual and group meetings, and the media appearances and public meetings, with somewhat mixed results. Low attendance at public meetings, and repeated delays and difficulties with making initial contacts and with follow up to firm up meetings for group sessions were particularly noteworthy as challenges. Having noted that, the energy policy consultation group was a particularly noteworthy point of success, and several significant inputs have come in electronically. Also, in many cases, observed patterns of interaction, issues and discussion indicate that most of the issues and concerns stem from the clear impact of the CRM concerns just noted above.

One key issue was that many stakeholders are more concerned to see practical reductions in bills and costs, if possible and wish to know how soon. The timeline is that energy efficiency can make a difference right away. Wind power can be online within a year or so. Geothermal if successful may credibly take about three years. Biofuels and the like are probably 5 – 10 years off for major impacts. Solar PV will take several years to be really cost-competitive and affordable. An energy audits, credits and efficiency promotion scheme could in parts start right away, but would take some months to organise, before initial implementation which would take some months beyond that.

Already, wind development is underway, and the geothermal exploration has reached the initial phase, a preliminary scoping field visit in February with initial reports currently being peer reviewed.

A further noteworthy concern is that some see the development of Geothermal energy as liable to dislocate jobs among Monlec's staff, as was for instance highlighted in a Labour Speaks presentation on ZJB radio. (This probably interacts with the ongoing concerns regarding the merger between Monlec and the Water Authority, to form MUL.) When this concern came up in a public meeting [in St Peters], it was observed that the staff of Monlec constitute the sole concentration of relevant technical capacity for energy transformation. So, while dislocations, discomfort and risks are likely, this has to do more with retraining and retooling, not so much with a rise in unemployment.

An interesting issue raised in Lookout was that of whether bio-fuels are cost-competitive with fossil fuels, once subsidies are removed.

Of course, fuel and transportation prices have always reflected many direct and indirect subsidies and taxes; e.g. to support the national road network, ports etc – all the way up to the multiple hundreds of billions invested in the oceanic power navies that secure the world's oil trade routes. And, it has been evident since the days of classical empires across the world that such subsidies often return such large benefits that their cost is well worth undertaking.

More directly, we are exploring an opportunity for the future; one that would make fuels a far more indigenous product, thus significantly improving robustness, stability and security of energy supply. Further, for bio-fuels, this is in a context where the processing requirements to transform bio-mass into fuels are often fairly simple. This means that the most significant question typically becomes feedstock costs, which – apart from recovered wastes – are in the end driven by the requisites of farming. Of the various bio-fuels alternatives, alcohol fuels and bio diesel are particularly promising. Algae oil, as is discussed in the rationale section, is a high risk, but particularly high potential payoff initiative.

Similarly, there was some concern over the driving forces behind food price jumps, in light of recent international media concerns on food to fuel, in effect taking food out of the mouths of the world's poor. (This concern has been expressed in public consultations, dating back at least to the radio appearance on April 26th.) While indeed there is a legitimate concern that such may happen [which makes non-food feedstocks such as algae or cellulosic biomass particularly valuable], we must reckon with the implications of the sharp price rise of oil. This is multiplied by the growth in demand for food and animal feeds in places like China, and impacts of now prolonged drought in Australia. Indeed, corn production in the USA has more than doubled across the past twelve years, with more food available for food consumption, not less; even after the ethanol production has been subtracted.

It was also requested in the same meeting that an estimate for consumer cost savings from implementing say 15% grid penetration of wind be given. Now of course we should not bind Monlec by putting up ill-founded public expectations, but wind typically costs US$ 1,100 – 1,700/kW nominal capacity, with a realistic estimate of actual output being about 1/3 of nominal, as wind is intermittent. That intermittency limits grid penetration percentage, and so 15% is a reasonable first target; which in light of our current peak of about 2 MW would be 300 kW effective, or about 900 kW nominal. The immediate savings potential would be more or less elimination of fuel for 15% of our electricity, and that within about a year if there are no delays. So we may make a simple, indicative calculation of how wind on the grid might help us save on energy costs:

> Taking Wigton Jamaica as a cost model, wind could be about US$1300 or so per kW of capacity, as a for illustration point estimate, so a 900 kW rated plant would cost about US$ 1.2 millions
>
> Cost of wind energy may be US 5 – 10c/kWhr, leading to a rough consumer price estimate of maybe EC 60c/kWhr [at the upper end], without fuel surcharge. A recent typical bill for 300 kWhr went like ~ EC$200 for direct cost, and EC$ 300 for fuel additional, averaging about EC$1.67/kWhr.
>
> For such a consumer with 85% diesel and 15% wind, that yields a weighted average of:
>
> $300 * [(0.60 * 0.15) + (1.67 * 0.85)] = 300 * [0.09 + 1.42] = EC\$ 453$
>
> This "10% reduction" is of course only a simplistic estimate, to give an idea of how wind could help us save on energy costs. Full scale calculations would be a lot more sophisticated, and would have to reflect changes in circumstances, but would reflect generally similar patterns.

Perhaps the most significant point that came out in the Brades public meeting was triggered by the observation that many members of the public do not understand the meaning of the high fuel surcharge that now appears on our electricity bills. We learned that the fuel surcharge is just that, and goes to fuel suppliers to pay for fuel used in electricity generation. So, it does not form a proper part of Monlec's actual income from electricity generation.

Further to this, there is increased cost pressure on Monlec, so that the utility is being squeezed between costs to provide services and the sharp increase due to fuel price rises. When this is multiplied by proposed energy conservation and shifts off-grid for energy sources, Monlec comes under not just costs but also revenues pressure. Thus, tariff structures have to be revised, and Monlec may have to look at its costs, maintenance requirements, overheads and range of services, in the context of the rise of alternative energy systems based on renewable energy, more efficient uses of energy, and substitution of local generation [e.g. solar PV] for grid connexion.

Thus, while stakeholder consultations were somewhat of a mixed outcome [with public meeting attendance being a particular disappointment, and some of the tone that developed surrounding concerns was quite painful], in aggregate they made a major and positive impact on the policy development process, and have shaped the draft in many significant ways.

Onward, given the required submission and review process, further consultations will be continued, with an intent to incorporate any additional significant stakeholder inputs in the finalised document.

Finally, in about a year, the policy as initially implemented should be reviewed in light of experience, fresh opportunities and challenges, and further stakeholder inputs.

APPENDIX G.6

Electrical Energy Consumption Patterns and Conservation Issues:

Energy conservation must begin with an appreciation of how much energy we are using, and for what. Then, we may reflect and act on our alternatives.

For this, we may begin with the Monlec load curve for a "typical" week:

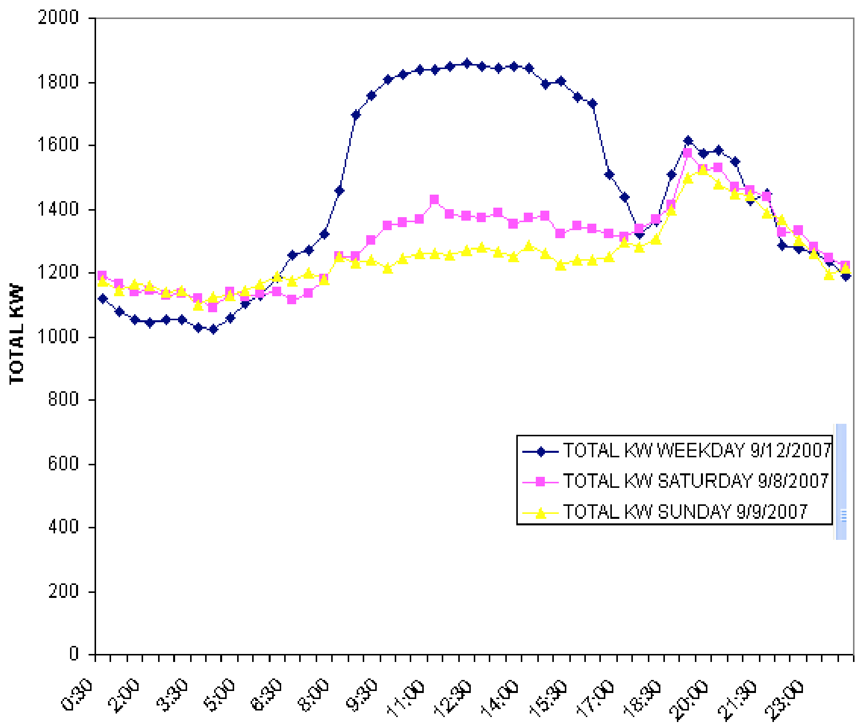

Fig. G6.1: *Monlec Load Curve, for a "typical" week in September 2007.* [Source: Greaves, 2007.]

An examination of the load curve shows a weekday time peak of just under 2 MW, corresponding to office hours. There is a secondary evening peak at about 1.6 MW. There is a base load of ~ 1 MW. These may be explained, tentatively [per "educated guess" to be confirmed through formal energy audits], as probably due to:

1] A workday load with a significant use of computers, similar office equipment and especially air conditioners. [Several savings opportunities.]

2] Evening loads due to lighting, some cooking and entertainment, especially television.

3] A base load that is probably in significant part shaped by refrigeration. [Note how the base trend line shifts a bit lower during the cooler hours of the day.]

This suggests that an appreciation of the load patterns posed by typical equipment will be helpful in improving consumption and reducing costs for consumers. For that, EERE of the US Department of Energy has prepared a useful summary:

> . . . examples of the range of nameplate wattages for various household appliances[3] [excerpted and highlighted for a tropical situation]:
>
> [ADDED: **Air Conditioning** – *consult a professional!* Energy consumption is a function of EER (10 – 14 is better) and right sizing relative to the load. A **1-ton** [12,000 BTU/hr], **EER = 10** unit produces ~ 3,500 W of cooling, and *by definition* requires **1,200 W** electrical to operate it. *It may cool 400 – 700 sq feet of indoor space.* If the air temperature drops by 15 – 20 °F across the evaporator coil, it is "acceptable" performance.]
>
> Aquarium = 50–1210 Watts
> Clock radio = 10
> Coffee maker = 900–1200
> ***Clothes washer = 350–500***
> Clothes dryer = 1800–5000
> Dishwasher = 1200–2400 (using the drying feature greatly increases energy consumption)
> Fans
>   ***Ceiling = 65–175***
>   Window = 55–250
>   Whole house = 240–750
> Hair dryer = 1200–1875
> ***Clothes iron = 1000–1800***
> Microwave oven = 750–1100
> Personal computer
>   **CPU - awake / asleep = 120 / 30 or less**
>   **Monitor [CRT] - awake / asleep = 150 / 30 or less**
>   ***Laptop = 50***
> Radio (stereo) = 70–400
> ***Refrigerator (frost-free, 16 cubic feet) = 725 [current values may be ~ 400 W]***
> Televisions (color)
>   ***19" = 65–110***
>   27" = 113
>   36" = 133
>   53"-61" Projection = 170
>   Flat screen = 120
> Toaster = 800–1400
> Toaster oven = 1225
> VCR/DVD = 17–21 / 20–25
> Vacuum cleaner = 1000–1440
> ***Water heater (40 gallon) = 4500–5500***
> Water pump (deep well) = 250–1100

The above numbers give "typical" power consumed when an appliance is actually running; one would need to examine and perhaps monitor actual equipment to see the actual energy usage. (For instance, a basic 9 cu ft refrigerator may be rated at 130 W.) However, some reasonable calculations based on the above are instructive. First, to get estimated energy usage we will need to multiply power by the time of use (in seconds), and then divide by 3.6 millions [to get kWh]:

> Consider a 100 W 19" TV burning for 6 hours per day (not unusual . . .) across a month:
>
> Energy per month = [100 W x 6 h/day x 30 d/month]/[1,000 W/kW]
> = 18 kWh/month

[3] http://www.eere.energy.gov/consumer/your_home/appliances/index.cfm/mytopic=10040

Cost at ~ EC$ 1.4/kWh, including fuel surcharge:

Cost = 18 kWh/Month x $1.40 = EC$ 25/month

This is a significant cost; especially for an appliance that, strictly, is not a necessity.

There may also be more to the TV's energy cost. If a 60 W bulb is going while one is watching TV (and watching modern high-brightness TVs in the dark poses eyestrain challenges), that adds an extra $ 15. *If the TV is an instant-on, remote controlled TV, it may have a parasitic load of 10 W for the other 18 hrs/day as it monitors for a remote's "turn on" signal;* which would cost an additional $ 7/month. Thus, the TV could be costing nearly EC$ 50/month all told; just for electricity.

Moreover, if one's 400 W, 16 cu ft refrigerator burns the equivalent of 8 hours per day (think of how often one hears it humming away, especially after opening and standing in the doorway to decide what to take out . . .), it would use 96 kWh in a 30-day month. That would, on the same estimated total electricity rates, cost about EC$ 134. (The 9 cu ft, 130 W unit would use about 31 kWh, costing about EC$ 44.) *Thus, we see how a monthly electricity bill of EC$ 200 - 300 can be arrived at without obviously "excessive" consumption, and how using adequately functional, lower power appliances can cut this.*

Such numbers also open up room for savings, first of all though self-monitoring and energy use changes. That is, *if there is an energy use awareness campaign, consumers could be sensitised to what is using up now increasingly expensive electrical energy, and can thus be motivated to change habits.* (Small, consumer level energy use monitoring devices such as the Energy Detective, may be a worthwhile investment.)

However, such changes would often be relatively small. *To get bigger reductions, consumers, offices and businesses would need to undertake more formal audits, leading to significant changes in equipment: replacing over-sized equipment with adequate size, but smaller units.* Or, if there is a need for the larger size, specially designed, energy efficient appliances and equipment may save up to 20 – 40%; e.g. Energy Star-compliant equipment.

Such audits would therefore need to be coupled to a credits [and possibly savings monitoring] scheme, as is envisioned in the main body of the policy. In turn, *this could be part of the redeployments of skilled energy sector workers to Demand Side Management [DSM] programmes.*

Consequently, such projects will also have to address possible implications for long term utility viability – especially in a context where benefits of postponed major capital investments on the part of the utility are not a countervailing benefit. *This will require a very careful assessment of relevant factors on undertaking such green energy projects, so that steps may be taken to preserve the long-term viability of the utility.*

Endnotes:

[i] That is, *"do to others as you would have them do to you,"* entailing that *"[neighbour-] love does no harm."* The Sustainable Development principle is, in effect, an application of this rule through intra and inter-generational equity: *better and more fairly meeting needs, while not compromising the ability of posterity to meet its needs* [i.e. through averting or minimising environmental, socio-cultural and/or economic degradation].

[ii] As a comparison, the UN-, OAS- and GTZ- sponsored Geo Caraibes project's standard form draft geothermal law of 2005, duly footnoting on the balance to be struck between royalties and taxes, proposes that:

> 61. (3) Geothermal Resources Concessions shall be fully exempted from income taxes . . .
>
> (a) for fifteen (15) years from the commencement of Commercial Operations for Pioneer Firms; and
>
> (b) for ten (10) years from the commencement of Commercial Operations for Non-Pioneer Firms

[iii] Similarly, in the Geo Caraibes draft geothermal law, it is recommended that royalties be assessed as follows:

> 50. (1). . . royalties shall serve to cover the cost of administration and inspection and shall serve to recompense the State for the use of Geothermal Resources. The holders of Geothermal Resources Concessions shall pay a royalty for each Geothermal Resources Concession as a function of the production from such Concession's Geothermal Resources Area.
>
> (2) The royalty shall be considered as an expense for tax purposes.
>
> (3) The royalty for each Geothermal Resources Concession shall be determined as a function of the gross annual sales from such Geothermal Resources Area and shall be paid in the manner agreed in each Geothermal Concession.
>
> (4) For Geothermal Energy used domestically such royalties may be zero but shall not be more than Three Percent (3%) of the gross annual sales of the Concession.
>
> (5) For Geothermal Energy exported, such royalties may be zero but shall not be more than Five Percent (5%) of the gross annual sales value of the Concession.

[iv] Communication, Mr Mark Lambrides of OAS [Manager, Geo Caraibes project], March 13 2008.

[v] The Geo Caraibes draft law of 2005 is drawn to the attention of the Government of Montserrat as a suitable model, should it be deemed necessary to draft a Law.

[vi] This may be a consequence of current fieldwork being carried out through the aid of UN ECLAC and DFID.

[vii] It is helpful to make a comparison of the Geo Caraibes draft geothermal law for sister OECS territories, clause 33. (3) on **due diligence** investigation before awarding a licence for exploration or development of geothermal energy:

> Upon receipt of an Application, the Geothermal Resources Promotion Manager shall initiate due diligence inquiries. *Due diligence, at a minimum, shall include* ***verification by knowledgeable third parties of the applicant's financial status, technical competence and experience as a geothermal developer***. [Source: Gov't of Dominica. Emphases added.]

[viii] In addition, it is noted from similar preliminary technical reviews and credible expert opinion, that on global averages, the initial geophysical-geochemical exploratory phase identifies potential sites for drilling but, even so, on global experience, a "typical" cluster of three initial exploratory boreholes may face cumulative odds of failing to identify a commercially successful resource, of about 50%. While it is hoped that the local situation may improve these odds somewhat, it remains clear that the exploratory phases are expensive and fairly high-risk.

[ix] Including environmental.

[x] Note that the SAC's current identification that the volcano is probably ~ 10 months into a 20 – 24 month or so pause is relevant, as is their suggestion that it may continue dome building eruptions for decades as that shifts project lifetime risk estimates. SAC will need to be specifically instructed to identify zones of hazard and associated probabilities for prospective Geothermal fields.

[xi] It is noteworthy that, even though the 1980s British Electricity International [BEI] study identified four sites in the N: Drummond, Lookout, Geralds, Blakes; of these, two have been used for building various entities, and Drummond and Blakes are associated with proposals for building projects. Zoning regulations and plans could be used to protect key wind assets as national resources.

[xii] In addition, it is noted from similar preliminary technical reviews and credible expert opinion, that on global averages, the initial geophysical-geochemical exploratory phase identifies potential sites for drilling but, even so, on global experience, a "typical" cluster of three initial exploratory boreholes may face cumulative odds of failing to identify a commercially successful resource, of about 50%. While it is hoped that the local situation may improve these odds somewhat, it remains clear that the exploratory phases are expensive and relatively high-risk.

[xiii] **policy** *noun* (pl. -ies) a course or principle of action adopted or proposed by a government, party, business, or individual. [*Oxford Concise English Dictionary,* CD, 2001.]

[xiv] The SD principle in effect applies the Kantian *Categorical Imperative* to ethics of development. In turn, its underlying themes can be traced to the Golden Rule and its Judaeo-Christian context, as stated by Moses, Jesus of Nazareth and Paul of Tarsus: cf. Deut. 6:1 – 18, Lev. 19:15 – 19, Matt. 7:12 & 22:37 – 40, and Rom. 13:1 – 10, esp. 8 – 10. Deut. 6:3 is noteworthy for explicitly linking the ethical-legal framework of a culture to their prosperous well-being and that of their land: *"Hear, O Israel, and be careful to obey* [the Mosaic law] *so that it may go well with you and that you may increase greatly in a land flowing with milk and honey."*

[xv] Edgecombe, D, 2004. *Elements of an Energy Policy for Montserrat.*

[xvi] Presented in a column for the blog, *American Thinker*, May 14, 2008: http://www.americanthinker.com/2008/05/the_bum_rap_on_biofuels.html. It is also probably not irrelevant to observe that this is an American election year, and bioethanol has been a major green energy initiative by the current administration.

[xvii] Admittedly, in a trough of production, but within the general variability.

[xviii] Certain difficulties have showed up in the available statistics, as is discussed in Appendix G2.

[xix] The "bump" in CIF fuels imports in 2002 seems to be associated with a hard to account for jump in importation of diesel fuels. [Cf. discussion on fuel import data in Appendix G.2.] Perhaps, in part at least, it reflects a real phenomenon; such as a large transaction in the fuels market that was not associated with any obvious local project or event.

[xx] As industry experts pointed out on being consulted on this point, there is a wide scatter [reflective of the fairly high degree of risk], so the averages cited are to be seen as part of a wide range of possible outcomes, not as precise one-point estimates. For instance in some projects, exploration has turned out to require up to 50% of overall initial investment costs, and the actual profitability of any given investment is a specific outcome based on its own actual circumstances and the quality of management involved. But, the averages summarised here give us a balancing note which should be borne in mind.

[xxi] Experts cautioned that it is likely that coring bits will tend to bind here, and advance slower, so even though they seem to be cheaper on a per diem basis, it is unwise to use that as a sole deciding criterion when it comes to exploratory drilling.

[xxii] Holtzapple, Mark, Dept. of Chemical Engineering, Texas A & M University (2005), *MixAlco: Biofuels and Chemicals from Biomass*, URL: http://www.epa.gov/Region6/6pd/pd-u-sw/wte_ftworth/cafo/holtzapple.pdf

[xxiii] PetroAlgae of Florida, circa 2007, has showed on a 4-acre test farm that fast-growing CO_2-bubbled micro-algae (a potential match for power plant emissions) give about a two-day crop cycle, and through centrifuge techniques, the oil [50+% of biomass, comparable to oil seed yields] may be separated from the remaining biomass, with up to 98 - 99% recovery of water. Annual yields are projected at up to about 14,000 gal/acre-year [4.3 mn acres to supply the US diesel fuels market]. XL TechGroup, the parent company, holds that algae are the only commercially viable near-term solution to bio-fuels, and have evidently initially targetted the fuel additive market, at a target price of US$ 0.26/lb. (A January 2007 estimate at US$ 0.22/lb yields a raw oil cost of US$1.73/gal, or a processed biodiesel cost of US$ 2.25/gal; suitable for use as an additive. [Learning curve effects would reasonably push that cost level down over time.] URL: http://www.xltg.com/archive/PetroAlgae_Overview.pdf.) Scaling an estimate by John Sheehan of NREL to a more Caribbean-sized power plant, a 200-acre algae farm using the emissions of a 100 MW power plant would produce up to 4 mn gallons of bio-diesel and 5 mn gallons of cellulosic ethanol fuels, per year. In so doing, it would extract 40% of emitted CO_2 and 86% of emitted N_2O.

[xxiv] Neste Oil, of Finland (along with others) has pioneered an alkane-based bio-fuel alternative to typical biodiesels comprising methanol or ethanol based long-chain fatty acid esters. (The process also converts the glycerol side-chain to propane.) The alternative biodiesel is termed by them *NexBTL*. As at 2008, a 550 million Euro, 800 ktonne/annum plant is prospective for Singapore, and onward plans include development of a gasification- and - Fischer-Tropsch synthesis based third generation biofuels process that would easily use any biomass as a feedstock.

[xxv] If the price of algae-derived vegetable oil per barrel would target US$ 50 or so, at a productivity of about 100 bbl/acre, the annual prospective sales of raw oil would be of order US$ 500,000 for a farm of 100 acres; which shows that the economics probably favours a regional sector based on clusters of fairly large estates, with contract algae farmers to gain additional feed-stocks once the main capital costs and capacity development to set up an algae-oil processing agro-industry have been met.

[xxvi] Volcanic ash is a potential source of micronutrients also; cf. *Azomite*.

[xxvii] Going to global level, the US DOE's *2007 World Energy Outlook*, Ch. 3, projects that "In the IEO2007 reference case, world consumption of petroleum and other liquid fuels grows from 83 million barrels oil equivalent per day in 2004 to 97 million in 2015 and 118 million in 2030 . . .

liquids production is projected to increase by 14 million barrels per day from 2004 to 2015 and by an additional 20 million barrels per day from 2015 to 2030. OPEC producers are expected to provide more than one-half of the additional production in 2015 (8 million barrels per day) and more than two thirds in 2030 (23 million barrels per day)." That translates to a baseline of some 1.27 trillion gallons of fuel per year, or some 100 – 400,000 sq. miles of potential algae production, equivalent to [for the lower productivity figure] a square of land 631 miles on the side, growing to 753 miles on the side by 2030.

[xxviii] Above about 20%, there are increasing technical challenges. These usually make Caribbean utility engineers less than comfortable with a higher proportion of the electricity than 20% being from wind.

[xxix] Bio-fuels are of course currently as a rule more expensive than fossil fuels. That is a big part of why the fossil fuels have dominated the markets for so long; even given their volatility on price, and the unstable politics and resulting geostrategic security challenges an oil-based economy imposes on the world. However, the conversion process for many bio-fuels is relatively simple – e.g. the well-known Appleseed reactor, made from an old water heater, is used for many basement biodiesel "plants" that convert waste oil recovered "free" or for nominal cost from fast-food franchises and similar sources. *Thus, the principal cost-drivers for bio-fuels are tied to feedstocks costs, so if feedstocks can be brought down in price through say cost-effective provision of algae and cellulosic biomass, joined to low-cost transformation processes, this picture can change dramatically.* (It is also worth noting that methanol [formerly known as "wood alcohol"] can be made from almost any biomass by pyrolysis. Some then argue that coal can be used as a feedstock for methanol, and may be comparable to oil at ~ US$ 50/bbl. They go on to propose – on energy independence, strategic grounds -- that gasoline engines for cars sold in the USA should, by law, be converted to a flexible fuel basis [any blend from 100% methanol or ethanol to 100% gasoline] through additions costing US$ 100. Already, it is credible that butanol will work in many ordinary, unmodified gasoline engines. If battery technologies come down sufficiently in price, this may lead to the rise of plug-in-hybrid, flexible-fuel vehicles getting perhaps up to 100 mpg, as a major segment of future transportation. With such vehicles, the battery [recharged by being plugged in overnight] would handle short-range, low speed trips, and the gasoline engine would in the main serve to extend range and provide for spurts of high performance. Once batteries come down in price, mains electricity will prove a very attractive energy source for short range transportation.)

[xxx] Such a high-pressure breakdown is comparable to a well-known industrial process of gasification and synthesis into longer chain hydrocarbons. These industrial hydrocarbon syntheses, from the 1920's on, have been shown to be able to make oil out of just about any form of organic matter, in a few hours. Unfortunately, *such processes tend to be capital-intensive and the plants typically have high operating costs.* However, it is a known, relatively high *material* efficiency process for making "synthetic" oil from say garbage or woody/herbaceous biomass or even coal.

[xxxi] There was and continues to be a debate among the relevant scientists on the precise linkages and mechanisms involved in climate and weather trends, and on the degree of human responsibility for current and projected trends. In observing such debates, it is wise to bear in mind that [1] science is inherently and inescapably provisional on its major findings,and [2] computer models are just that – models, not experiential reality.

[xxxii] The BTU, or British Thermal Unit, is a traditional engineer's unit of heat. 1 BTU = 1055 J. Similarly, the kW h or kilo-Watt hour, is a traditional unit of electrical energy: 1 kWh = 3.6 million J,

the energy to burn a 100 W light bulb for 10 hours. The Joule is roughly the energy required to lift a 4-oz weight [~ 100 g] through 3 ft. It also takes ~ 4.2 J to heat 1 g of water (~ 1/5 teaspoon) through 1°C.

[xxxiii] The upper end of the price range does not create an arbitrage, as a rough calculation of the "substitute" of buying and shipping wood [pulp] to locations where it can be sequestered "permanently" comes to roughly the same level.

[xxxiv] An initial, crude estimate could be *the cost to make steam of comparable quality from fossil fuels.* However, one would normally generate higher pressure, cleaner steam and would thus save considerably on the capital investment required for the more standardised type of steam-plant one would use with such higher quality steam. Then, too, at the initial ~ 5 MW power level, diesel [perhaps with combined cycle] would probably be a better "standard" option. So *in the end a royalty calculation would probably be based on negotiated splitting of the presumable cost savings per kWh of electrical energy produced due to shifting to geothermal, across: [1] reduced cost per kWh to the consumer, [2] profit-enhancing cost savings to the electricity generator, [3] some take-up on the loss in Government revenues due to no longer importing the fossil fuel.* However, the economic dynamism of shifting away from fossil fuels and opening up a potentially large energy resource could then trigger growth that leads to a much bigger national income pie, so that a narrower slice of a bigger pie gives enhanced income, opportunities and prosperity. Further to this, as [especially for prospective electricity exports] we are in a competitive regional situation when it comes to attracting investors, we should reckon with the UN-, OAS- and GTZ- sponsored Geo Caraibes standard form draft geothermal law for sister OECS territories, *which proposes royalties in the range* ***3 – 5% of gross electricity sales****, the latter being for export sales.* (NB: This range brackets the earlier, consultancy-based proposed level of 4% for a commercial developer in 2006; which was strongly disputed at that time by some local stakeholders as being plainly too small.)

[xxxv] Thus, royalties would apply even where there is a tax holiday or another similar incentive scheme.

[xxxvi] Hance [p. 12] cites a circa 2005 GeothermEx regression model; in effect:

$$\textbf{Cost, US\$} = \textbf{240,000} + \textbf{689*depth in metres} + \textbf{0.205*depth}^2$$

(This directly applies to full bore wells, giving ~ US$ 1.13 Mn for 1,000 m. Slim-hole wells may cost half that. [p. 7.] Current high oil prices and associated competition for drill rigs will probbaly bid up the price relative to this regression-line summary datum.)

[xxxvii] It is noteworthy that, on questioning the WIPL initiative in March 2006, in the context of public protests over an attempt to undertake geothermal development on the "early commercialisation" model, former Chief Minister (and member of the well-known local NGO, CRM) Mr P. Austin Bramble, remarked: *"Any dealing with any developer should be transparent and subject to public accountability…. The investors must have an established and proven track record and should be well known throughout the geothermal industry."* In the same context, then prospective Chief Minister Dr Lowell Lewis observed: *"It was in Britain's natural interest to finance geothermal exploration in Montserrat."* [Allen, K, March 20, 2006, in a *Caribbean Net News* article: "Montserrat's government cited as a 'criminal sellout'."]

[xxxviii] Wild-catting, given the relatively high risks involved, understandably requires a correspondingly high profit rate for successful projects (in part to compensate for unsuccessful ones). Cf. a news report on related local perceptions, issues and challenges in the case of WIPL: http://www.caribbeannetnews.com/cgi-script/csArticles/articles/000009/000916.htm.

[xxxix] As electronic device decay processes are quantum-based activation-level stochastic ones, the relevant thermodynamics shows that cooling by ~ 8 °C at typical room temperatures *in principle* roughly doubles the expected lifetime of solid state electronics based systems. Air conditioning also reduces exposure to dust and grit, which can also cause damage.

[xl] Electric cells ["batteries"] that use a fuel such as hydrogen or a hydrogen-rich alcohol.

[xli] Cf. *Nanosolar* [http://www.nanosolar.com/technology.htm] and the *Popular Science Magazine* 2007 innovation of the year award.

[xlii] Currently reported as US$ 40,600/km [~ EC$ 180,000/mile], according to Monlec. [Cf Greaves, 2007, p. 63.]

[xliii] It requires more energy to make hydrogen gas than the energy extracted from it in a fuel cell or engine. But it is a portable energy source.

[xliv] Both ethanol and methanol can be trans-esterified with vegetable oils to make biodiesel.

[xlv] It has been suggested (Bell, 2008) that one tonne of woody/herbaceous biomass may be bio-digested to methane then transformed into some two barrels (84 US gallons) of oil.

[xlvi] First president of Israel. *The ABE, corn starch fermentation process he pioneered to make acetone produces twice as much* ***butanol*** *as acetone.* That acetone helped Britain make *cordite*, the British army and navy propellant for rifles and artillery; which was desperately needed for the fighting in World War I. Weizmann refused to accept any *personal* reward for his war-winning success, but instead asked for the restoration of the historic national homeland of his people, the Jews. This was the underlying context of the Balfour declaration, and the associated 1919 Weizmann-Feisal Hussein (later, King of Iraq) side-agreement to the Versailles treaty; on joint mutually supportive development of the Arab and Jewish nations in the Middle East. (This parallels the underlying Versailles principle of national self-determination, which underlies the subsequent rise of independent states globally out of former colonies and provinces of various empires.) Onward, the Balfour Declaration based process issued in the League of Nations and United Nations mandates and resolutions that resulted in the partitioning of Palestine, the launching of an invasion by Arab armies to destroy the nascent Jewish state, the resulting victory and established independence of modern Israel, and an exchange of alienated refugee populations: initially ~ 400 – 600,00+ Arabs and ~ 820,000 Oriental Jews. *Thus, we can see some of the complex roots of the so far irresolvable tensions in the Middle East, which in turn is a major exogenous, accelerating driver of the deep instability in the global oil markets.*

[xlvii] Cf. WND report by Jerome Corsi, March 20, 2008.

[xlviii] Contrast NREL's observation:

> Because the temperatures of most geothermal resources are low relative to the combustion temperatures of fossil fuel, the size and cost of surface plant equipment are greater . . . **Almost all geothermal plants to date have been built specifically for individual sites.** While this may permit optimal energy capture, it also prevents the economic gains from mass production . . . Furthermore, the chemically reactive nature of typical geothermal fluids requires protective measures to prevent equipment damage from scaling and corrosion. Mitigating these problems can be expensive . . ."
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> [NREL, *Geothermal Technologies Program Strategic Plan*, 2004, p. 10. Emphasis added.]