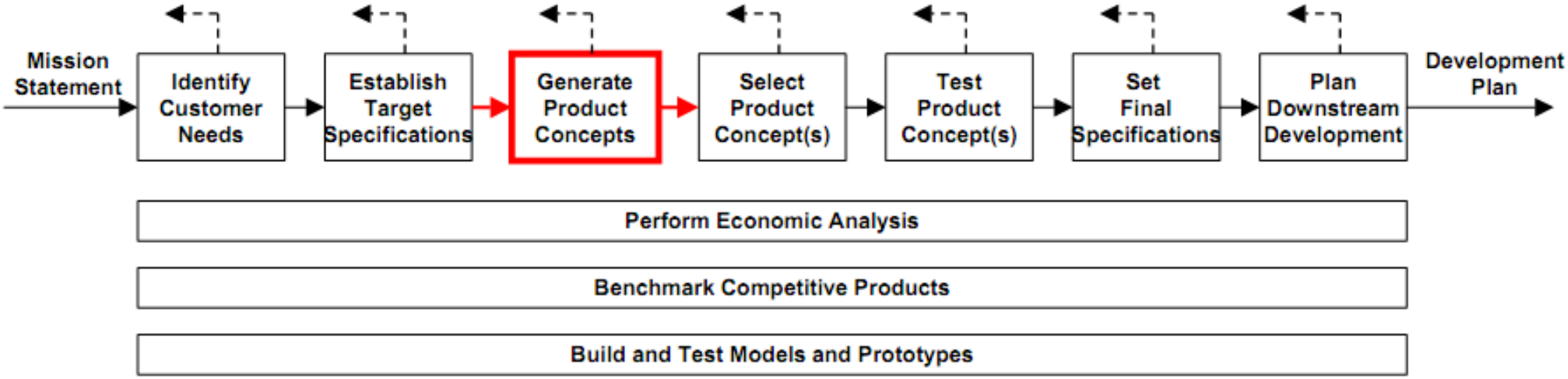
PRODUCT DESIGN & DEVELOPMENT

CHAPTER 7: Concept Generation

Tetuko Kurniawan

Coursebook:
Product Design and Development 5th edition.
Karl T. Ulrich & Steven D. Eppinger

CONCEPT GENERATION

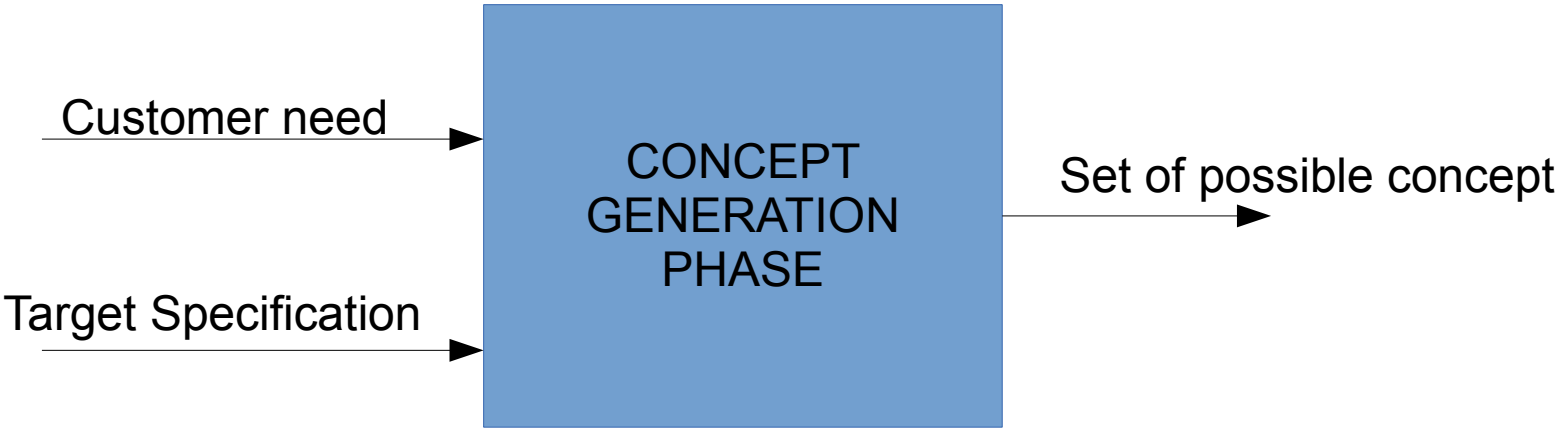


A product concept is an approximate description of the technology, working principles and form of the product.

Concise description of how the product will satisfy customer need

A concept is a sketch or rough 3D model with brief textual description

Objectives



Good concept generation → leaves the team with confidence that the full space of the alternatives has been explored

Thorough exploration of alternatives →
Reduces the likelihood that the team will stumble upon a superior concept late in the development process or that a competitor will introduce a product with dramatically better performance than the product under development

Common failure during concept generation

- Consider only one or two alternatives, proposed by the most assertive members of the team
- Involvement of only one or two people in the process, resulting in lack of confidence and commitment by the rest of the team
- Ineffective integration of promising partial solutions
- Failure to consider entire categories of solutions

5 steps

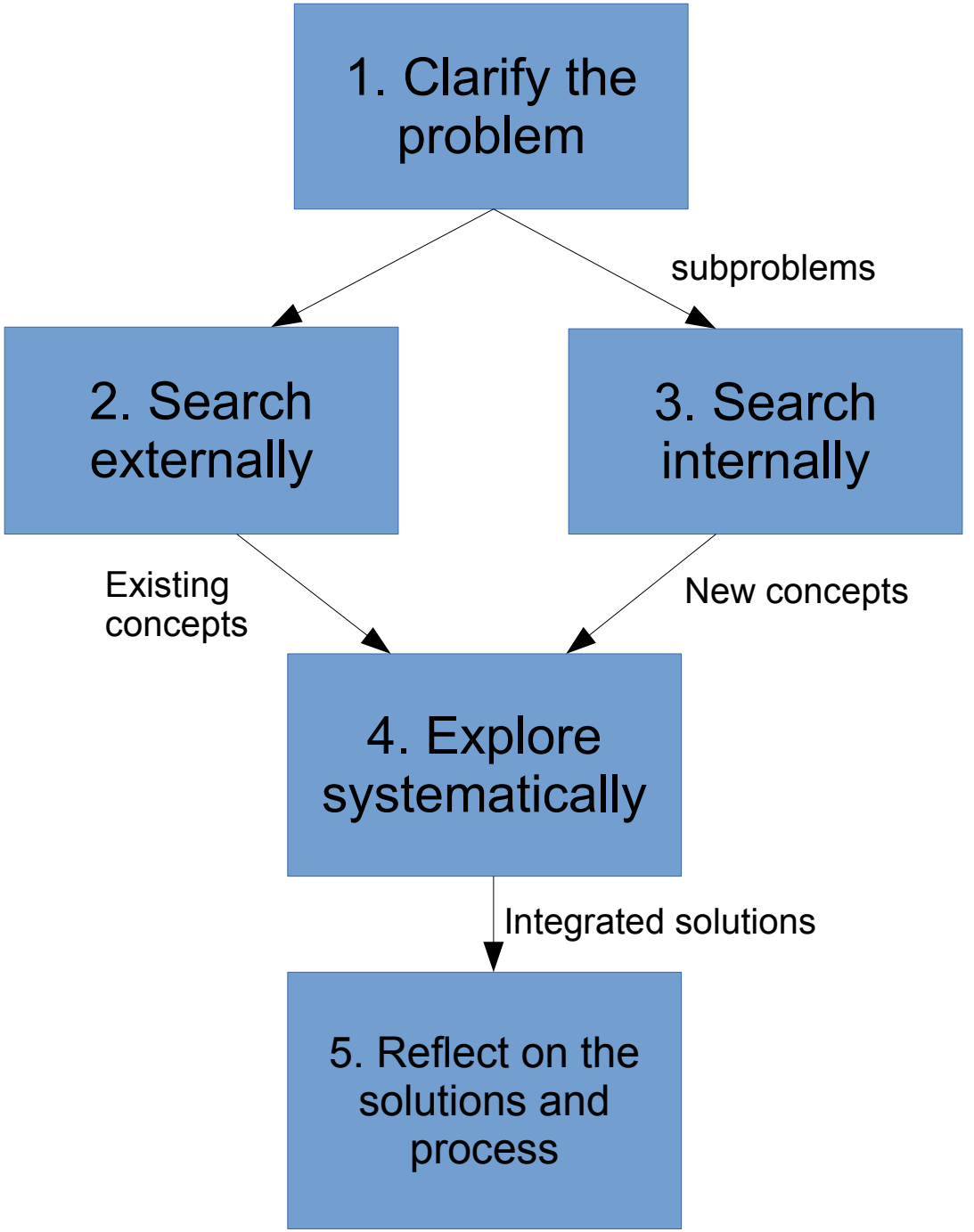
(1)problem decomposition, focus on critical sub problems

(2)Lead users, experts, patents, literature, benchmarking

(3)Individual or group

(4) Classification tree, combination table

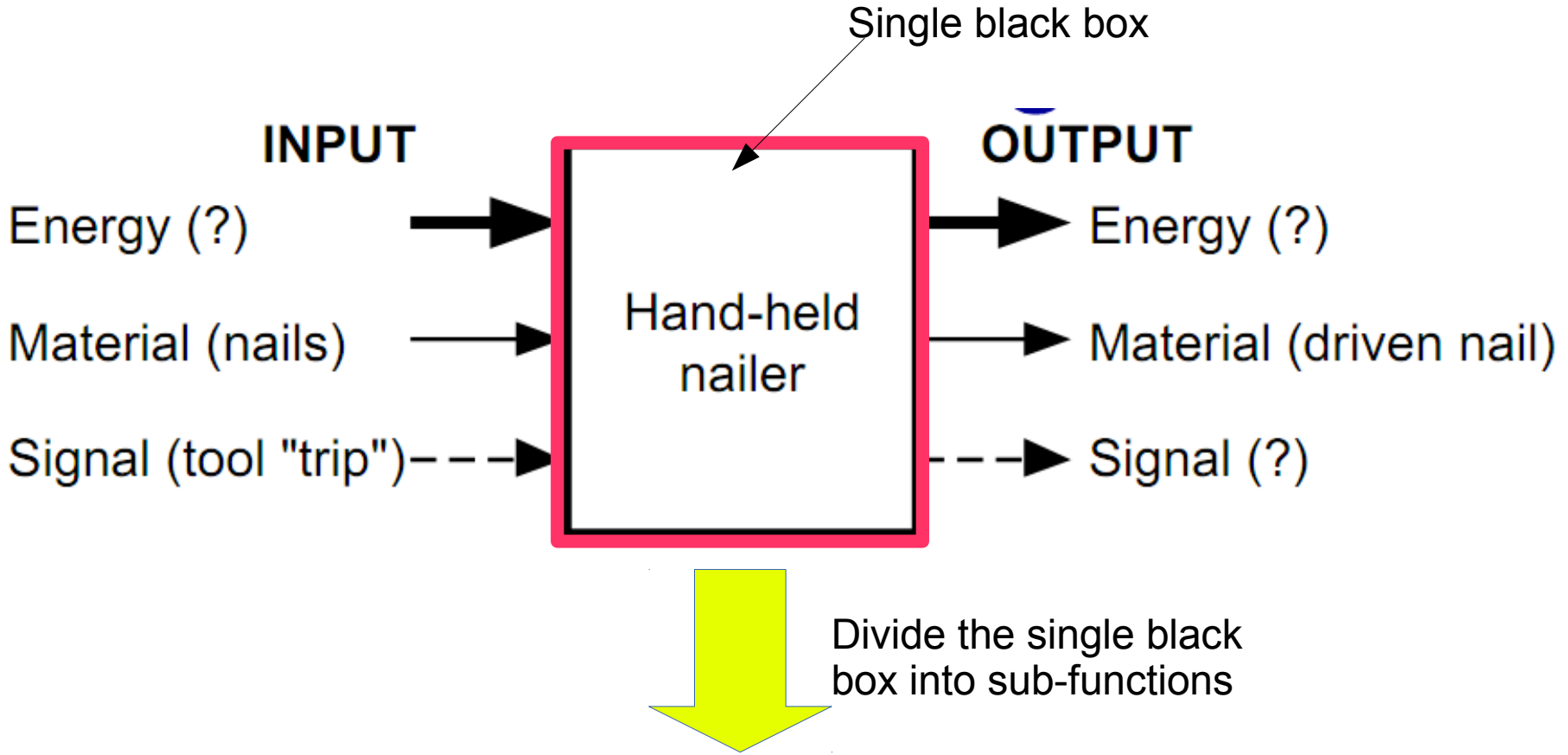
(5) Constructive feedback

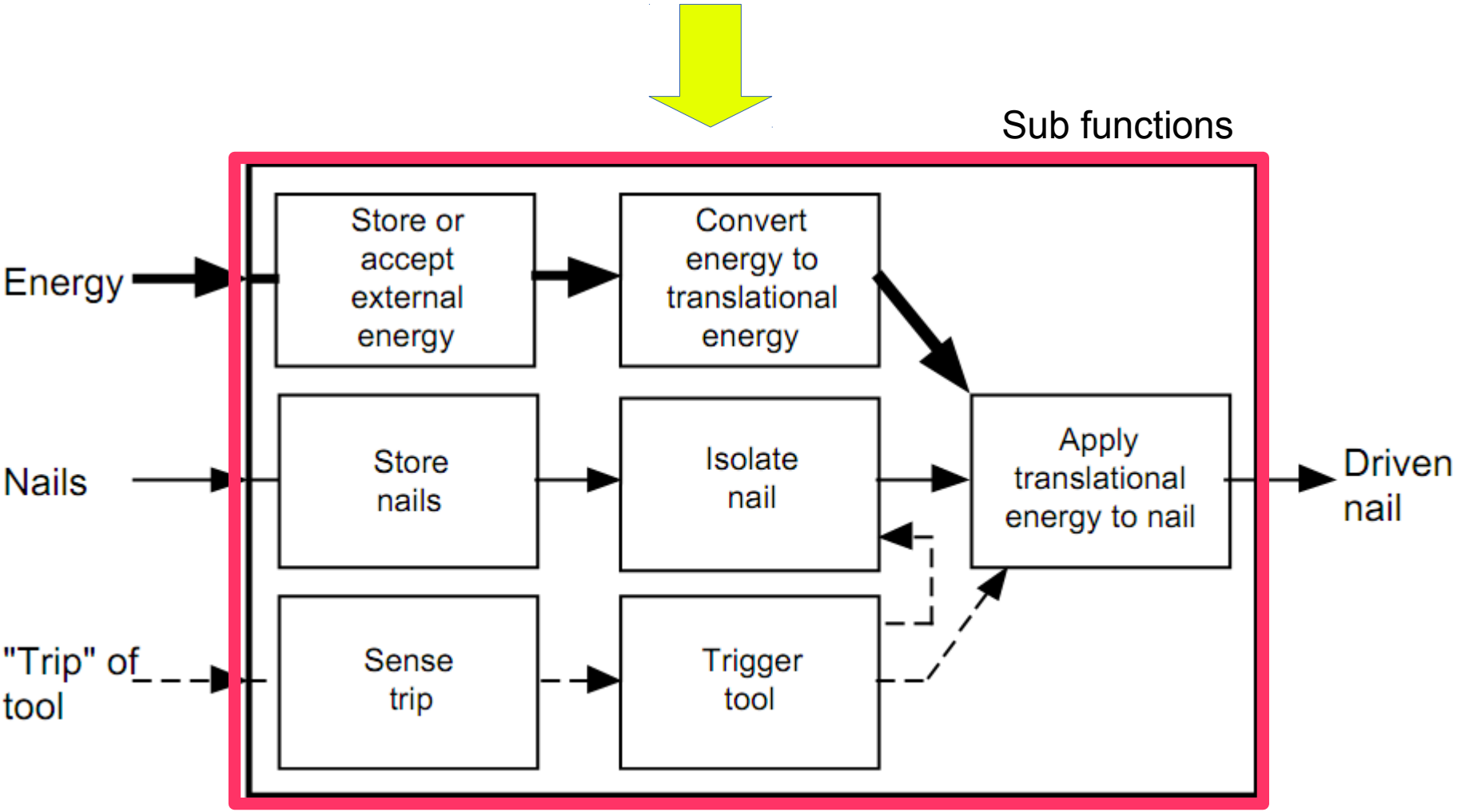


Step 1: clarify the problem

Problem decomposition: dividing a problem into simpler sub-problems

Example: functional decomposition





Some useful techniques creating a function diagram:

1. create a function diagram of an existing product
2. create a function diagram based on an arbitrary product concept already generated by the team
3. follow one of the flows (material, current, signal)

Other decomposition form

- Decomposition by sequence of user actions: useful for products with very simple technical functions involving a lot of user interaction
  - Nailer example: moving the tool to the gross nailing position, positioning the tool precisely, triggering the tool
- Decomposition by key customer need: for products in which form, and not working principles is the primary problem
  - Nailer example: fires nails in rapid succestions, is lightweight, has large nail capacity
  - Toothbrushes and storage containers

The goals are...

- Divide complex problem into simpler problems.
- The team chooses sub-problems that are most critical and tackled it first

Step 2: Search externally

- ***INTERVIEW LEAD USERS***

  Lead users → users of a products who experience needs months/years before the majority of the market and stand to benefit sustantially from product innovation

  Frequently, they have already invented solutions

- ***CONSULT EXPERTS***

  Experts: professionals af firms, professional consultant, university faculty, technical representatives of suppliers.

  - Finding them might be difficult but less time consuming than re-creating existing knowledge
  - They will expect to be paid

Step 2: Search externally

- ***Search Patents***
  - it is source of technical information containing detailed drawings and explanations of how a products work.
  - It is protected (generally for 20years), there may be a royalty if we use them → knowing which/what concepts must be avoided
- ***Search Published Literature***
  - Journal, conference proceedings, trade magazines, government reports; market, consumer and product information
  - Handbooks: Standard Handbook of Mechanical Engineering, Perry's Chemical Engineers' Handbook, Mechanisms and Mechanical Devices Handbook
- ***Benchmark Related Products***
  - Study of existing products with functionality similar to that of the product under development or to the sub-problems on which the team is focused.

Step 3: Search Internally

- Brainstorming! (we did this last week)
- It can be personal or group
- Important guidelines:
  - Suspend Judgment
  - Generate a lot of ideas
  - Welcome ideas that may seem infeasible
  - Use graphical and physical media

Hints for Generating Concepts...

- ***Make Analogies***: what other device solve a related problem, natural/biology analogy, analogy in other scale
- ***Wish and wonder***: stimulate oneself or the group to consider new possibilities
- ***Use related stimuli***: brainstorming of idea that related to the problem
- ***Use unrelated stimuli***: randomly generated object can related to the problem, example: individuals can be sent out on the streets with digital camera to capture random images for us in stimulating new ideas.
- ***Set quantitative goals***: the more concepts the better
- ***Use the gallery method***: gallery to show large number of concept (maybe picture of concept), other group must give suggestion.

Pile driver: analogy to the nailer (larger scale)

Example
Nailer problem
concepts searching

Solutions to Subproblem of Storing or Accepting Energy

- Self-regulating chemical reaction emitting high-pressure gas
- Carbide (as for lanterns)
- Combusting sawdust from job site
- Gun powder
- Sodium azide (air bag explosive)
- Fuel-air combustion (butane, propane, acetylene, etc.)
- Compressed air (in tank or from compressor)
- Carbon dioxide in tank
- Electric wall outlet and cord
- High-pressure oil line (hydraulics)
- Flywheel with charging (spin-up)
- Battery pack on tool, belt, or floor
- Fuel cell
- Human power: arms or legs
- Methane from decomposing organic materials
- "Burning" like that of chemical hand warmers
- Nuclear reactions
- Cold fusion
- Solar electric cells
- Solar-steam conversion
- Steam supply line
- Wind
- Geothermal

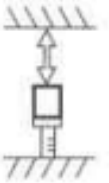
Solutions to Subproblem of Applying Translational Energy to Nail

Single impact

Multiple impacts (tens or hundreds)

Multiple impacts (hundreds or thousands)

Push

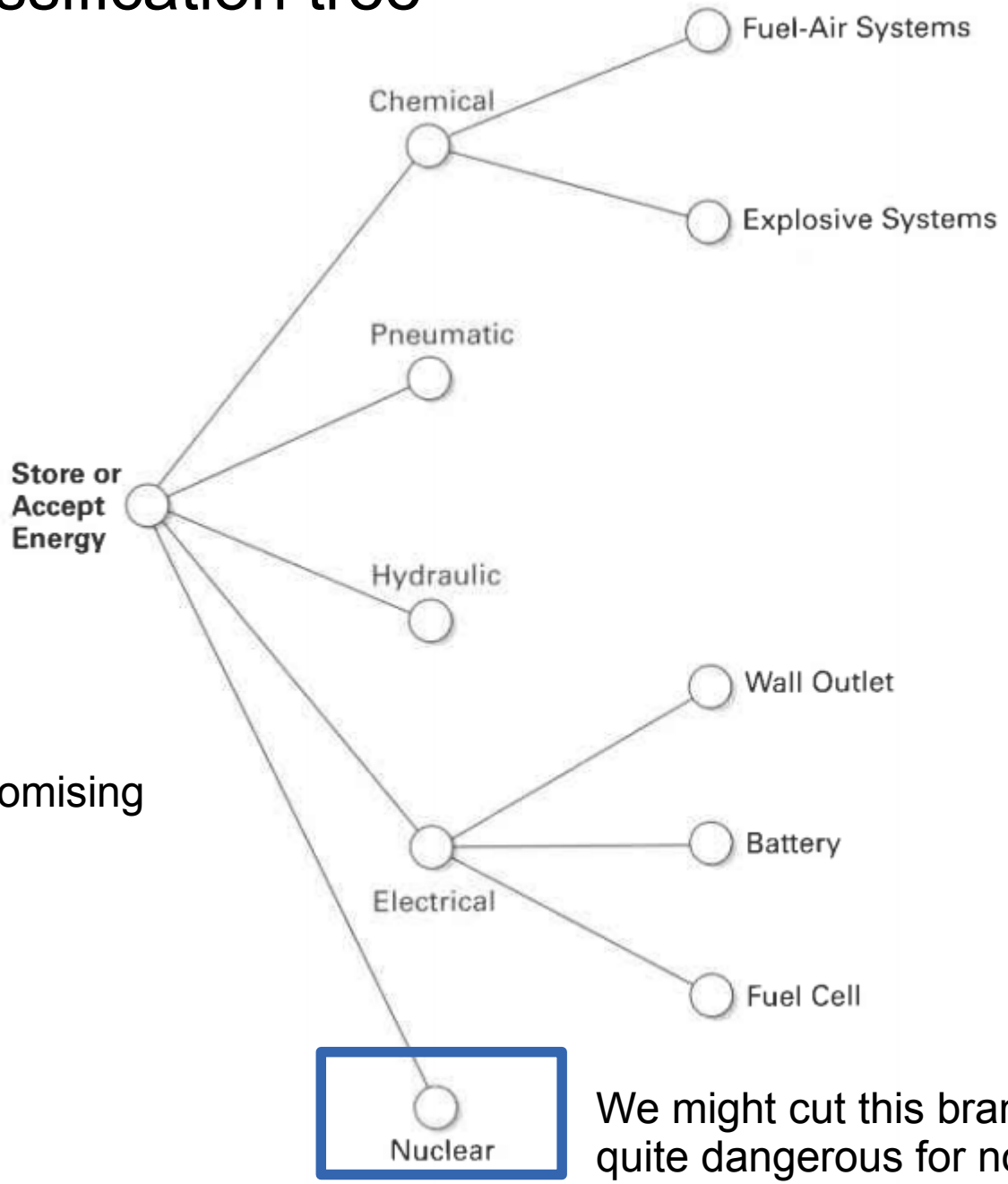


Twist-push

Step 4: Explore Systematically

- As a result of the external and internal search activities, the team will have collected ten or hundreds of concept fragments: solutions of subproblems
- Imagine the team have 15 fragment for each subproblem, and have 3 subproblems. The combination would be (15x15x15).
- Two specific tools: ***concept classification tree*** and ***concept combination table***

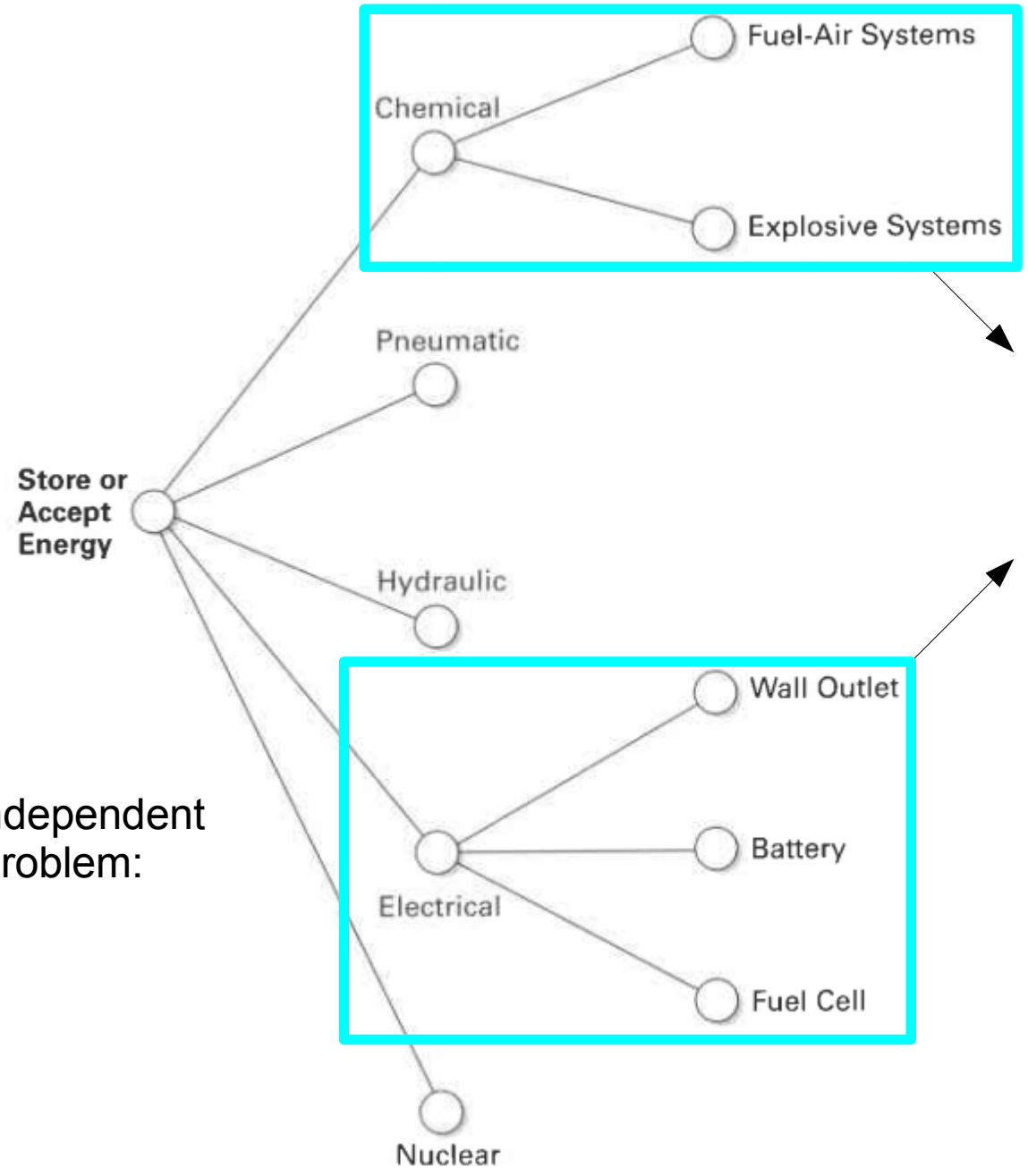
Concept Classification tree



1. Pruning of less promising branches.

We might cut this branch because it is quite dangerous for now.

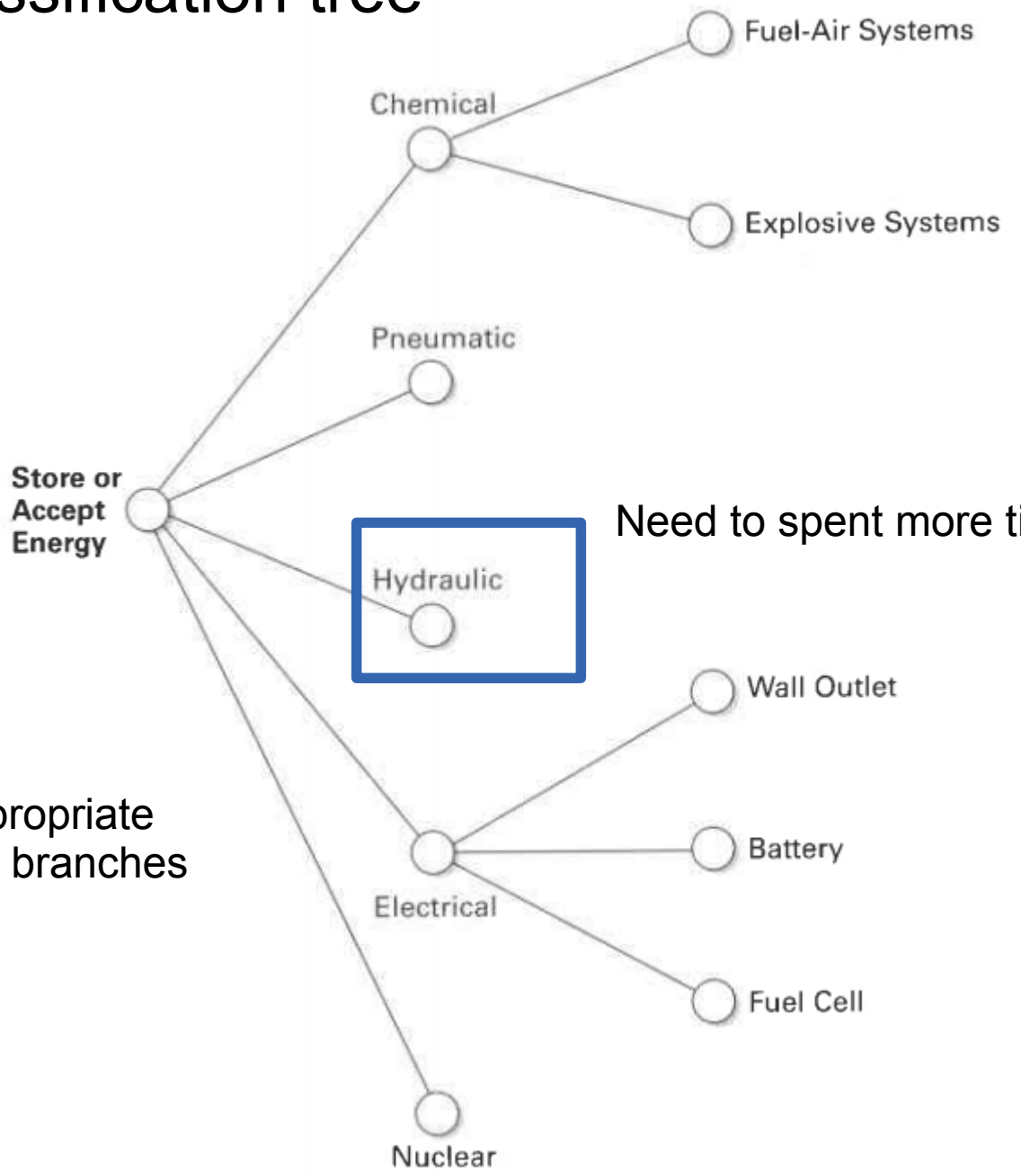
Concept Classification tree



-Completely independent,
-Assign different team
- healthy competition

2. Identification of independent approaches to the problem:

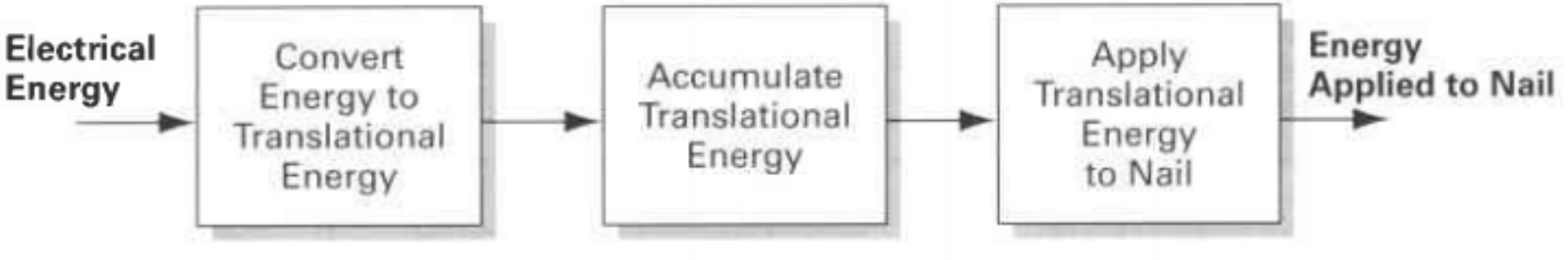
Concept Classification tree



Need to spent more time on this branch!

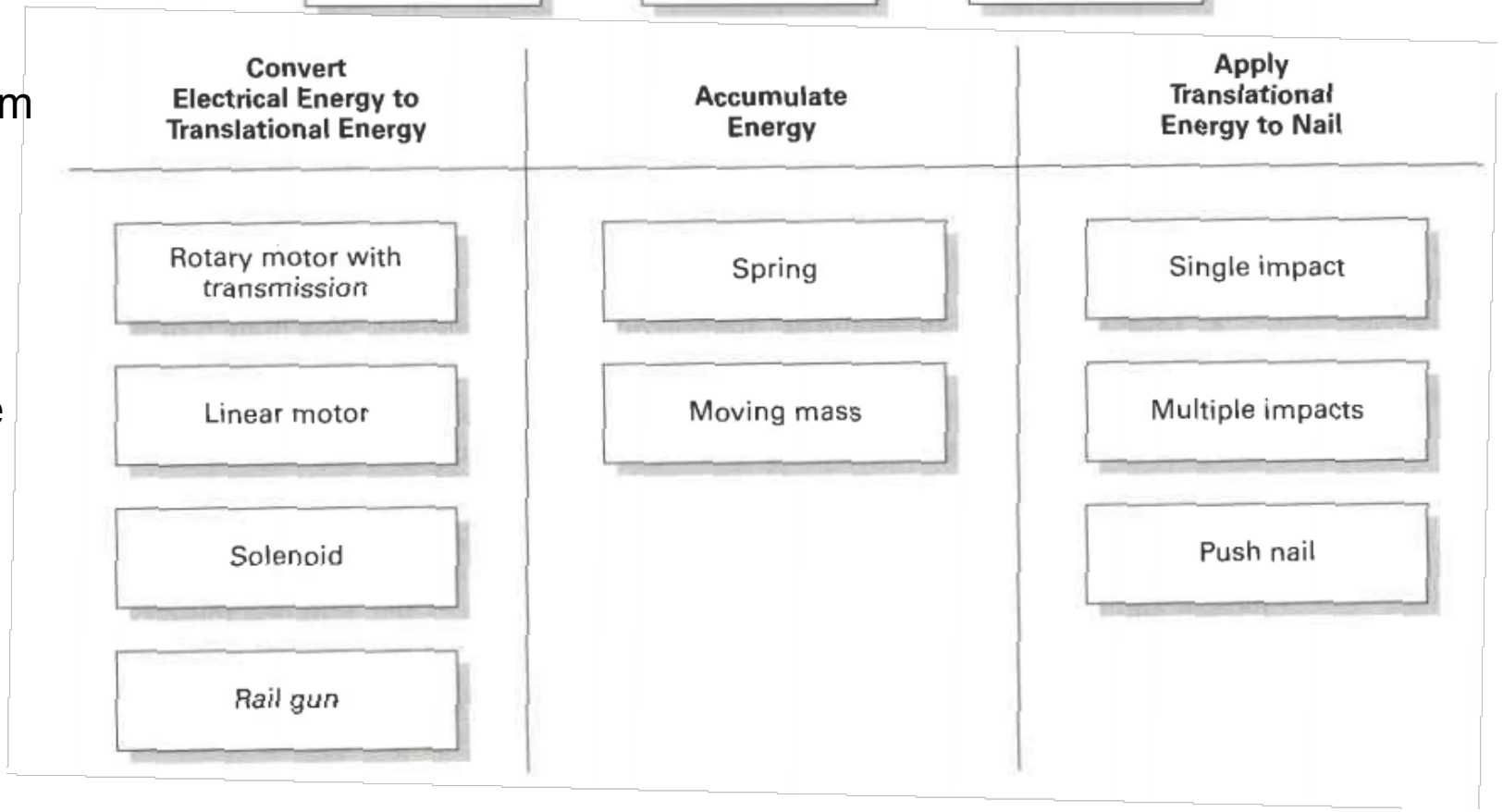
3. Exposure of inappropriate emphasis on certain branches

4. Refinement of the problem decomposition for a particular branch

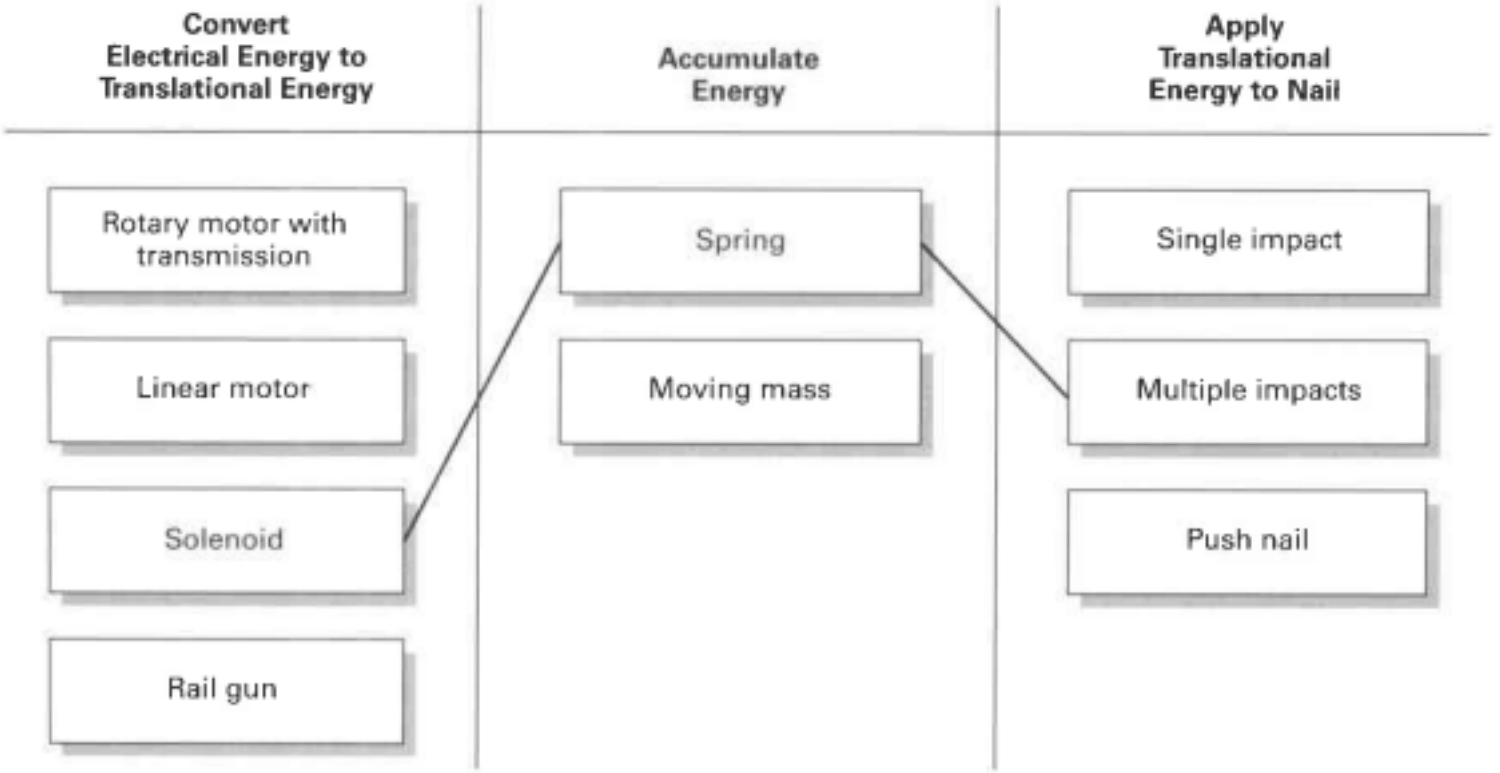


Power is not large enough → Need kind of accumulator over substantial period of nailing cycle → Need 10.000 watt in milliseconds To drive the nail

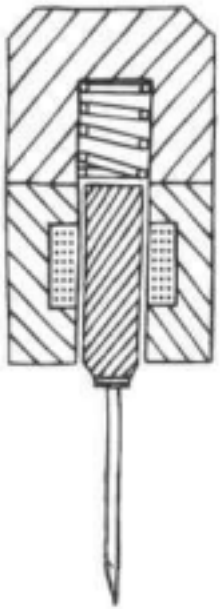
Concept Combination Table



Purpose: consider combination of solution fragments systematically
In this example: 4x2x3 = 24 possible combinations



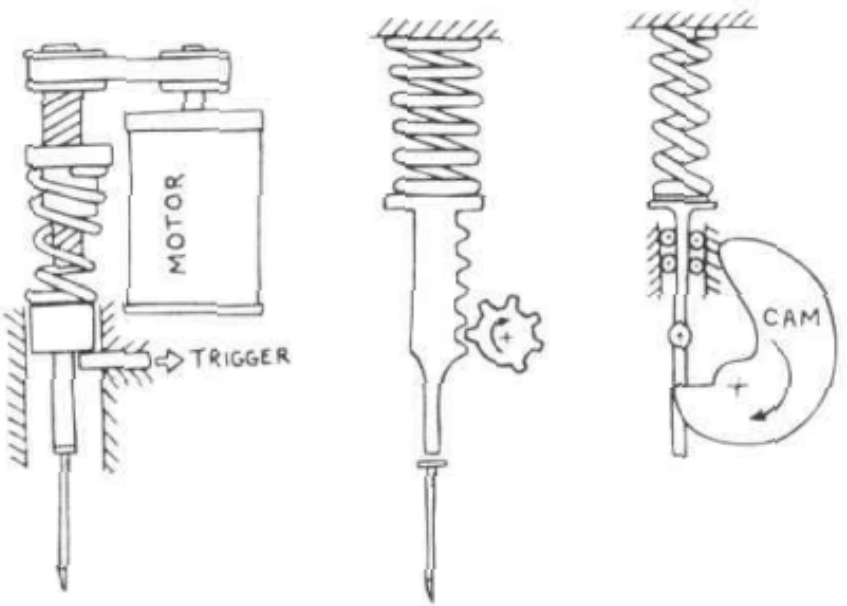
First example
Solenoid → spring → multiple impacts



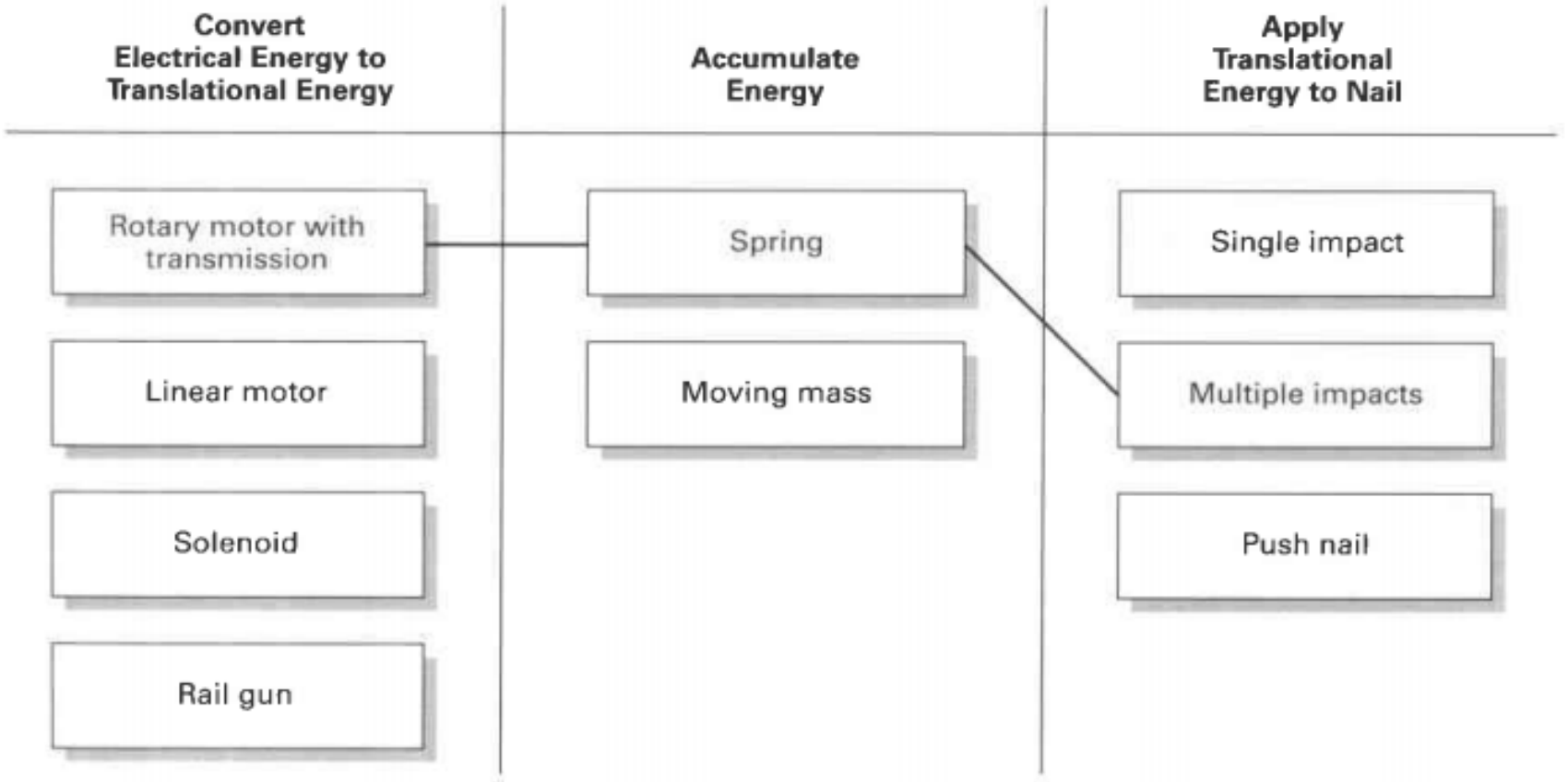
* if a fragment can be eliminated as being infeasible before combining it with other fragment.

* focus on subproblems that are coupled to other subproblems
Example: source of electrical energy is independent to the conversion method

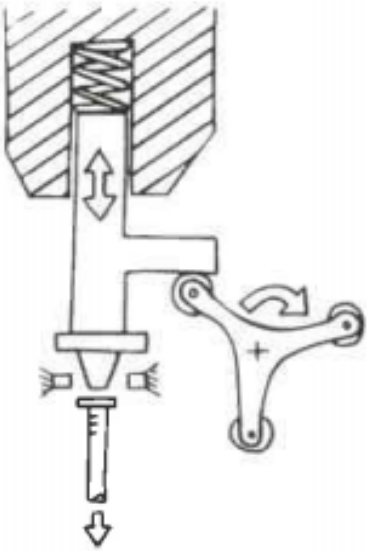
Convert *Electrical Energy to* Translational Energy	Accumulate Energy	Apply Translational Energy to Nail
Rotary motor with transmission	Spring	Single impact
Linear motor	Moving mass	Multiple impacts
Solenoid		*Push nail*
Rail gun		



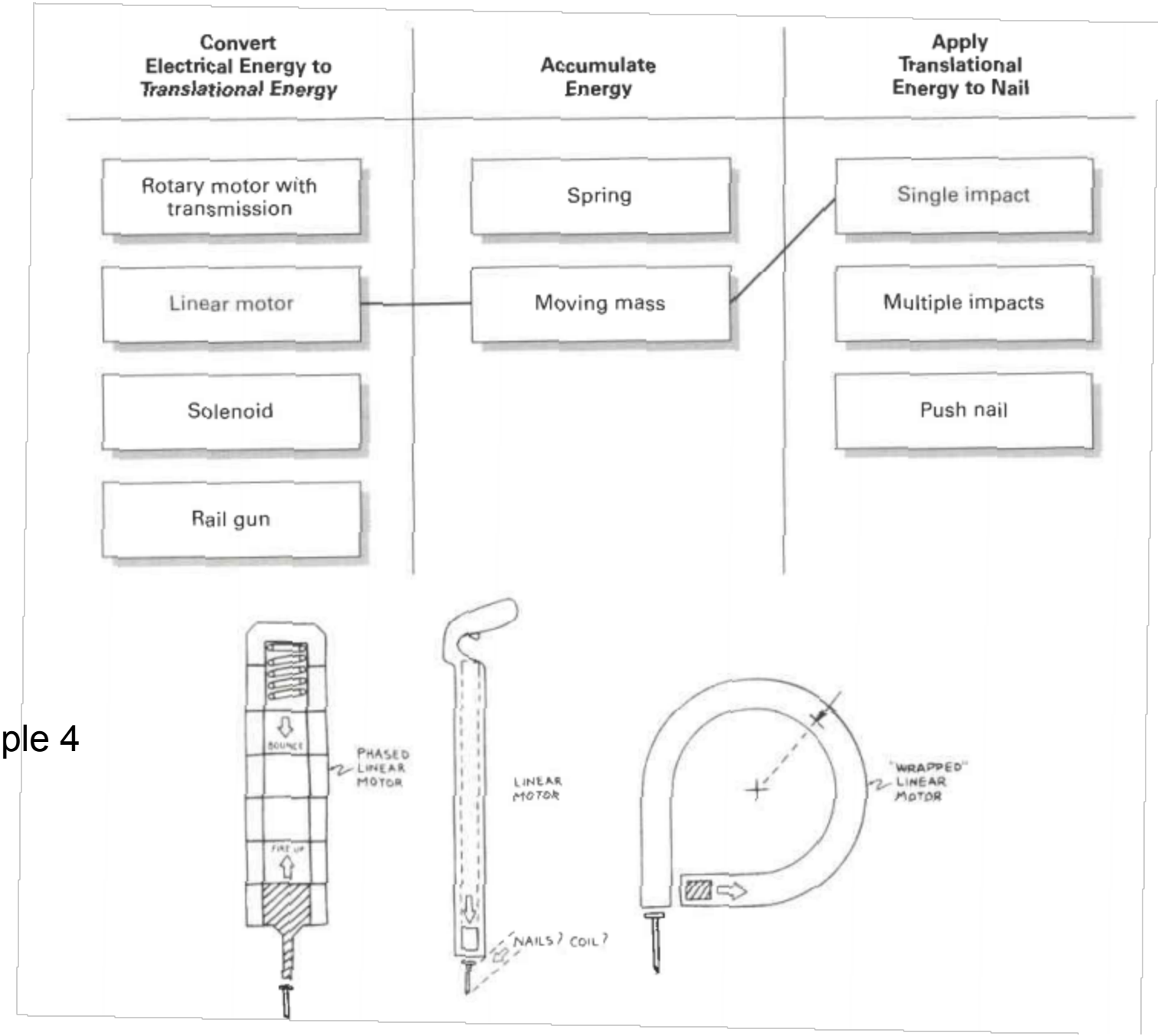
Example 2
* Maximum three column, otherwise it would not be effective

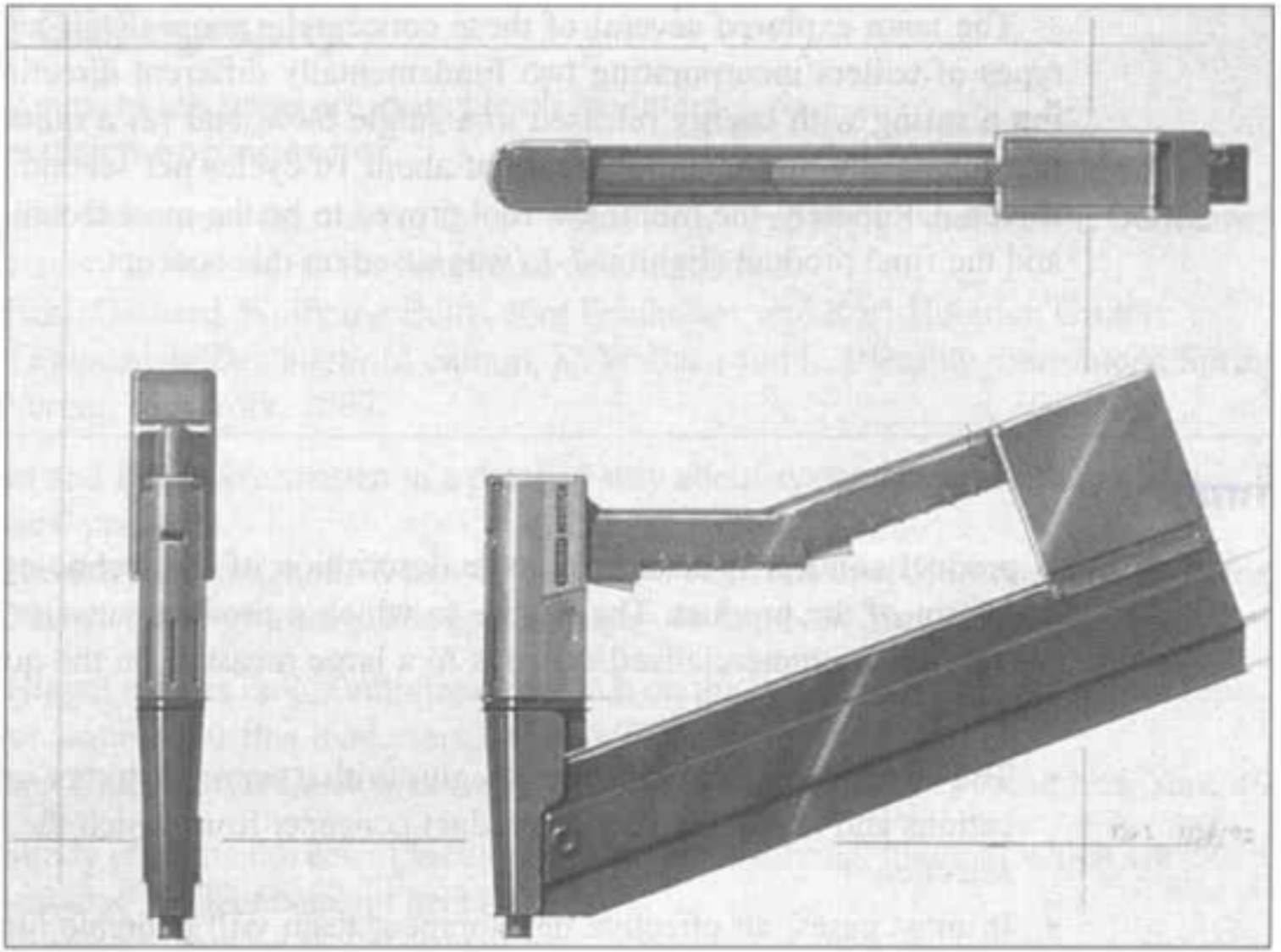

Convert Electrical Energy to Translational Energy
Accumulate Energy
Apply Translational Energy to Nail
Rotary motor with transmission
Linear motor
Solenoid
Rail gun
Spring
Moving mass
Single impact
Multiple impacts
Push nail

Example 3



Example 4


Convert Electrical Energy to Translational Energy
Accumulate Energy
Apply Translational Energy to Nail
Rotary motor with transmission
Linear motor
Solenoid
Rail gun
Spring
Moving mass
Single impact
Multiple impacts
Push nail
BOUNCE
FIRE UP
PHASED LINEAR MOTOR
LINEAR MOTOR
NAILS? COIL?
"WRAPPED" LINEAR MOTOR



One of several refined solutions concept