

# Engineering Education & Complex Decision Making

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# Content of the talk

- **Human deficiencies regarding Complex Decision-Making**
- **Engineers' Education to CDM – developing skills with students in Brussels**
- **Solution to deficiencies ?**

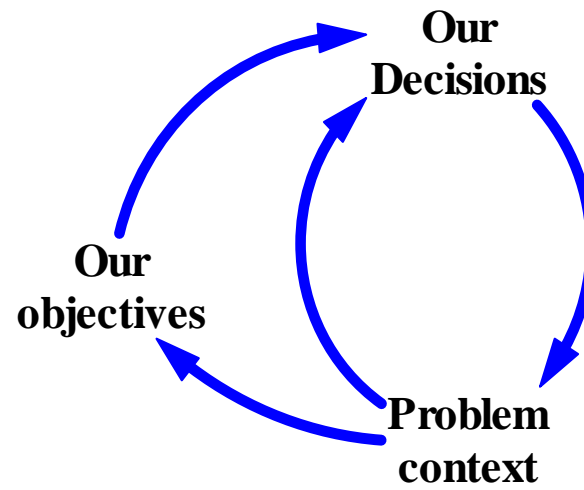
# Why engineers' education to CDM is important ... and difficult

- Engineers are future Decision-Makers BUT ...
- The human mind has difficulty to depart from linear thinking and linear extrapolation of past data
- Complex decisions imply loops permanently changing the context of the 'problem'
- Vicious side-loops often bring unexpected boomerang effects
- Decisions imply multiple players/stakeholders who have divergent priorities, bringing new loops into action

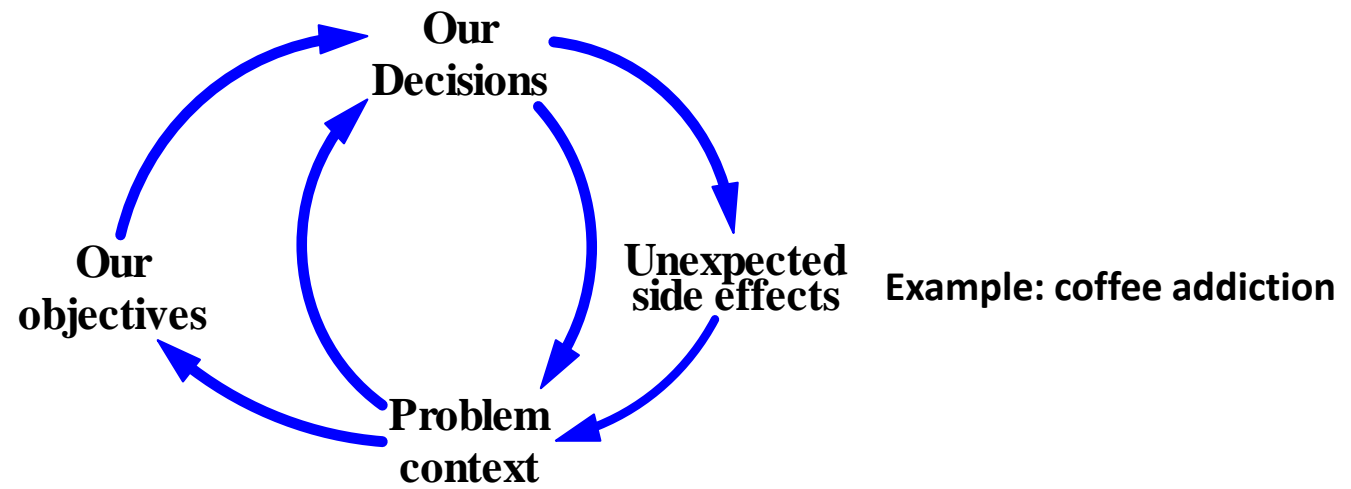
# The open-loop view on decision



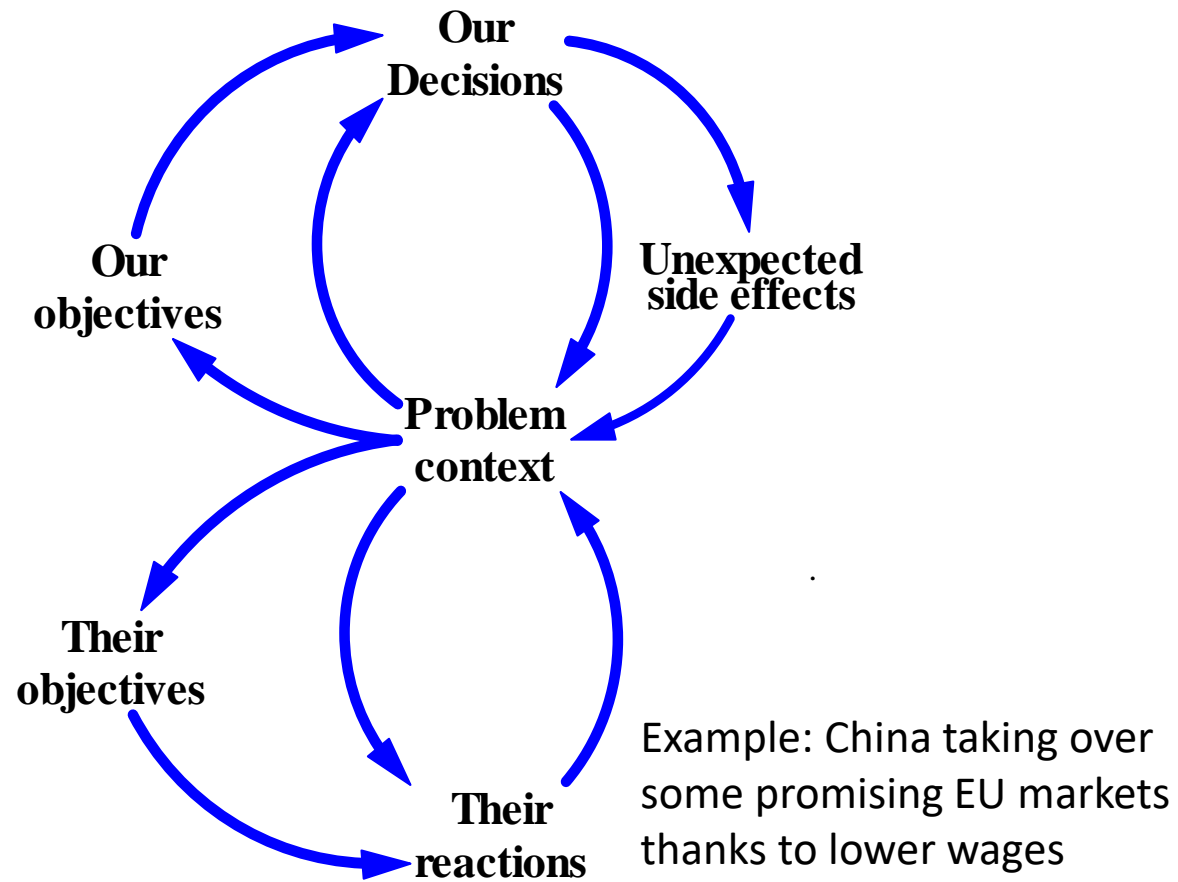
# First closed loops



## ... + boomerang sideloops



**... more loops from others !!**



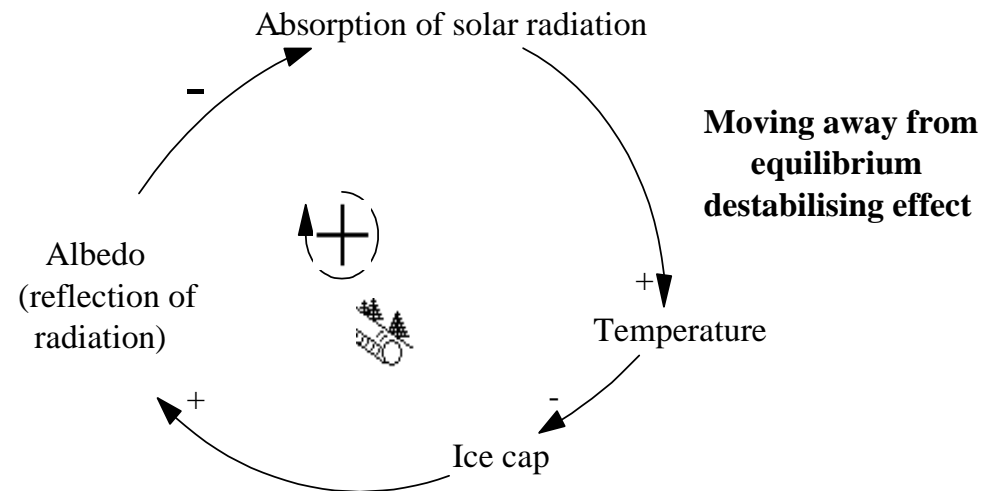
# A short tour on loops ...

- **Causal Loops (CL), also called feedback loops (FBL), are everywhere in complex decision systems**
- **The human mind is not trained to cope with Causal-loop diagrams, very often entangled bringing a lot of non-linear complexity**
- **There are two types of CL**
  - **(+), or (R) loops, are self-reinforcing and therefore destabilising, they are necessary for growth, can be virtuous but also vicious**
  - **(-), or (B) loops, are balancing and therefore stabilising, they are necessary to dampen growth and to bring system to equilibrium**



# Destabilising positive loop ...

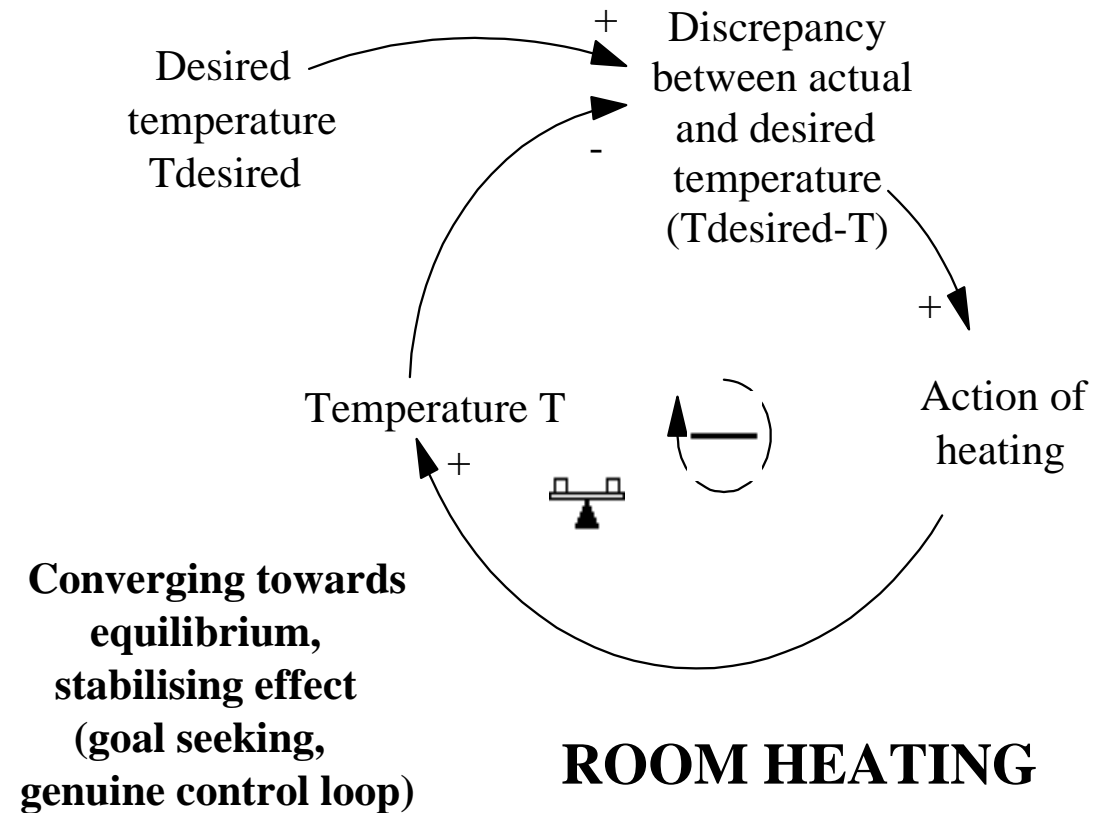
## positive loop



## GLOBAL CLIMATE CHANGE

# Stabilising negative loop= CONTROL LOOP

## negative loop



## Short tour on loops

- **Growth (+) loops are necessarily balanced by stabilising (-) loops**
- **Too many/too strong (+) or (-) may damage healthy systems**
- **Healthy systems must therefore have the right share of (+)/(-) loop numbers and strengths**

# Loss of (+) loop control THREATS ON

- Demography
  - Greenhouse Gases
  - Uncontrolled immigration
  - Plastic packages
  - Drugs
  - Public&Private debts
  - Big data
  - Mass tourism
  - AI algorithms
  - ....
- Welfare & Resources
  - Climate
  - Security&Values
  - Biodiversity in Earth&Oceans
  - Health & Security
  - Welfare & Jobs
  - Privacy & Free Speech
  - Quality of life of locals
  - Jobs, Autonomy ...??
  - ...

# Education is the remedy to loop illiteracy

## My proposition

- Add systemic course to engineers' curriculum in main-stream Operations Research and Decision Science
  - Soft modelling
    - Cognitive mapping
    - Soft system dynamics
    - ....
  - Hard modelling
    - System dynamics
    - Agent-Based modelling
    - Discrete-event simulation
    - ....

I now show an example of system dynamics education at the VUB Solvay Business school

# Developing loop literacy with System Dynamics at the VUB Solvay Business School

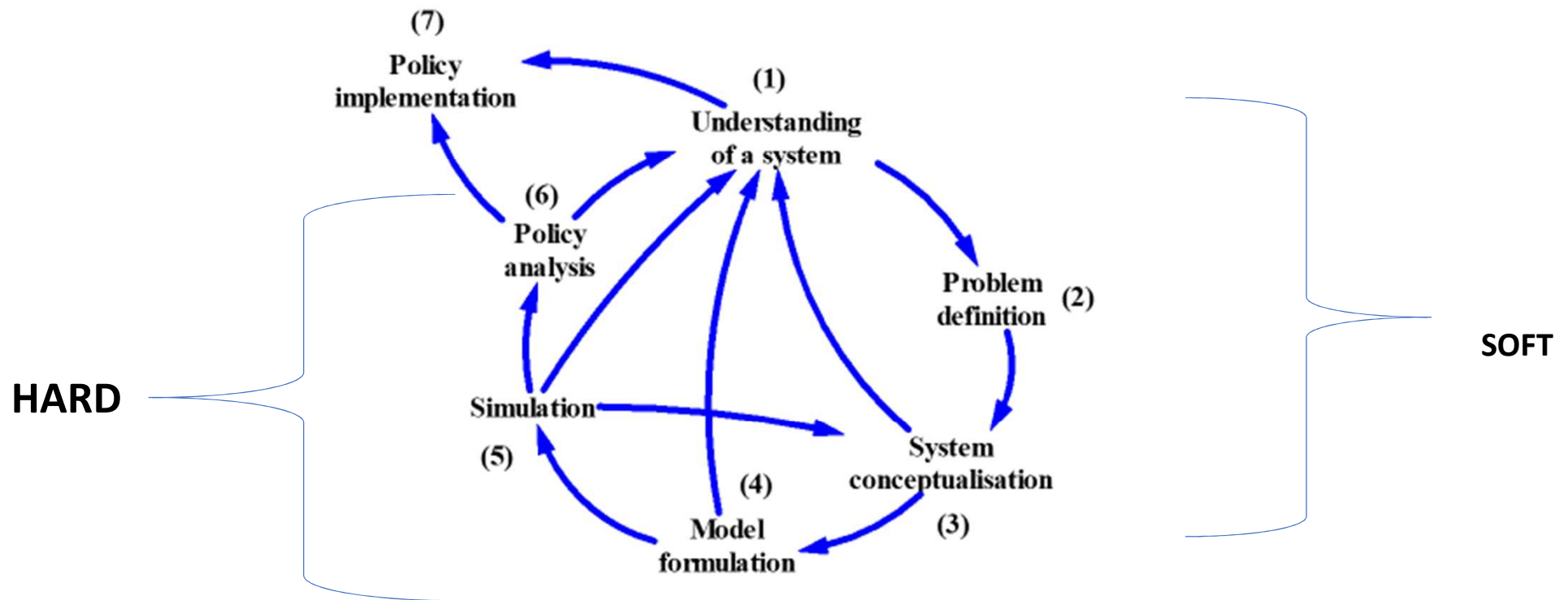
## □ Going through the 6 (7) phases of SD modelling for a contemporaneous problem

1. Understanding a system bringing a 'problem'
  2. Problem definition with indication of clients and boundaries in space and time
  3. System conceptualisation with setting up a causal-loop diagram
  4. Model formulation with simulation package VENSIM PLE<sup>®</sup>
  5. Simulation to check the model validity
  6. **Policy analysis to solve the problem**
  7. (Policy implementation is out of reach)
- 
- The diagram uses blue brackets to group the phases. A large bracket on the right side groups phases 1, 2, and 3 under the label 'SOFT'. A smaller bracket on the left side groups phases 4, 5, 6, and 7 under the label 'HARD'.

## □ Write a detailed report for the 'clients' on the findings/solutions

## □ Defend the whole in front of the class room with a PPT presentation

# Developing loop literacy with System Dynamics at the VUB Solvay Business School



# Education to loop literacy

## Examples of 'problems' handled by VUB students

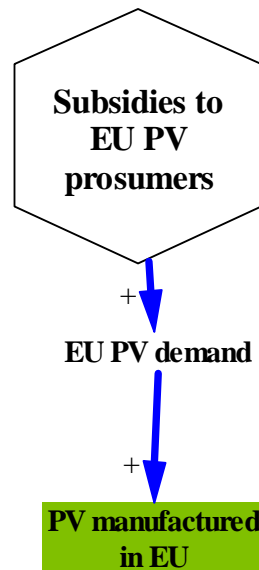
- **Aids epidemic**
- **Traffic congestion on roads**
- **Subprime crisis**
- **Greek crisis**
- **Euro construction&crisis**
- **The Belgian legal-pension system**
- **Wages indexation**
- **Phasing-out Belgian nuclear energy & energy transition**
- **Carbon trading & Climate Change**
- **Plastic dumping in the Mediterranean sea**
- **The green bubble of photovoltaic panels**
- **Delocalisation of enterprises**
- **Extremist political parties**
- ....



# Two (very) important cases for the Belgian economy

Or how open-loop view of political policymakers can be damageable for  
our economy

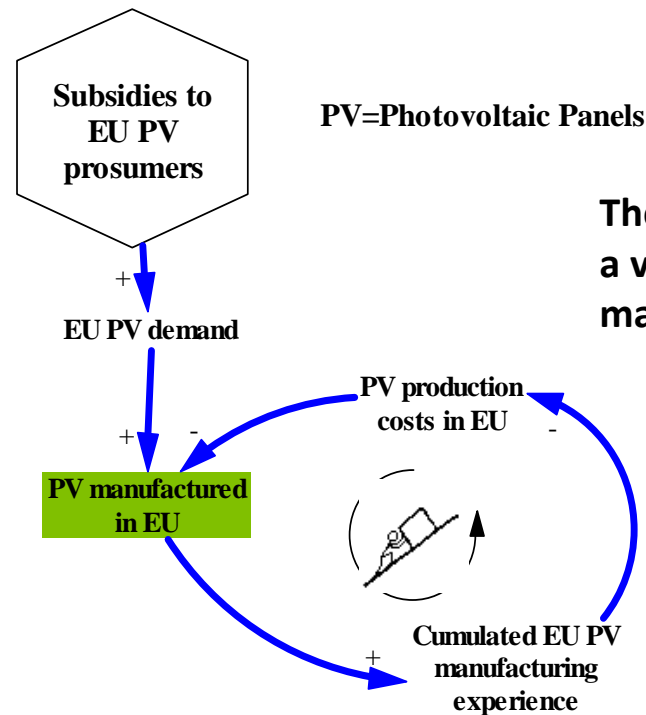
# Open-loop approach to more photovoltaic panels in EU



**PV=Photovoltaic Panels**

**In order to promote solar energy several EU governments have given generous incentives to private PV investors**

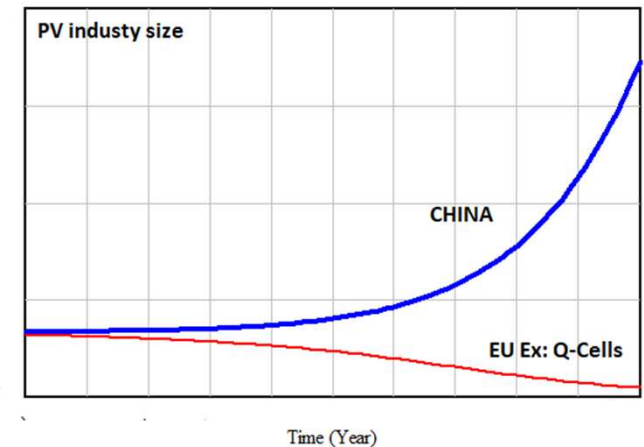
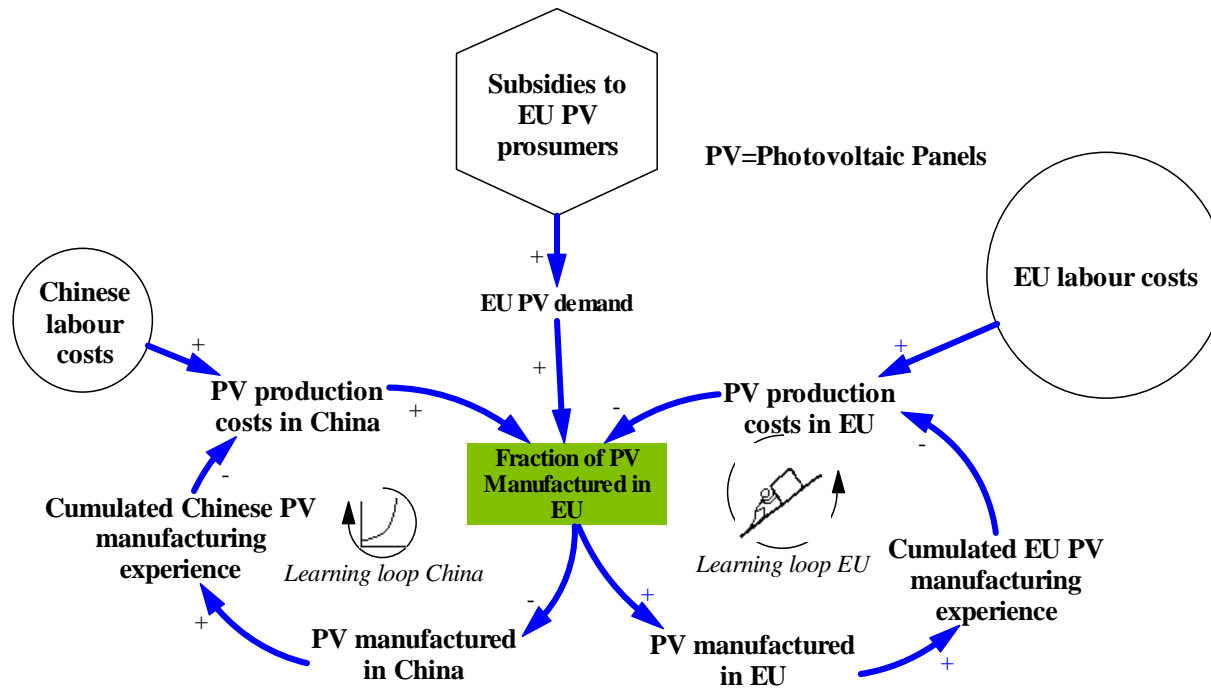
# But insufficient loop intelligence: too many EU green subsidies...



The hope was that incentives would initiate a virtuous loop leading to lower manufacturing costs and therefore a growing market

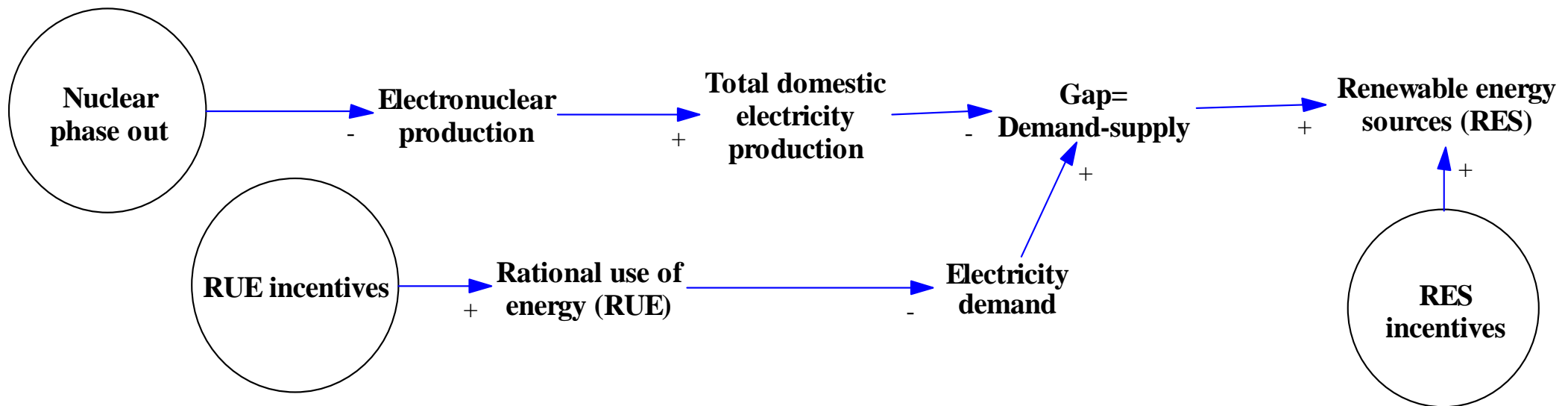
# ... have ruined the EU PV industries and jeopardised the PV development in EU

Chinese labour costs are much lower than EU's

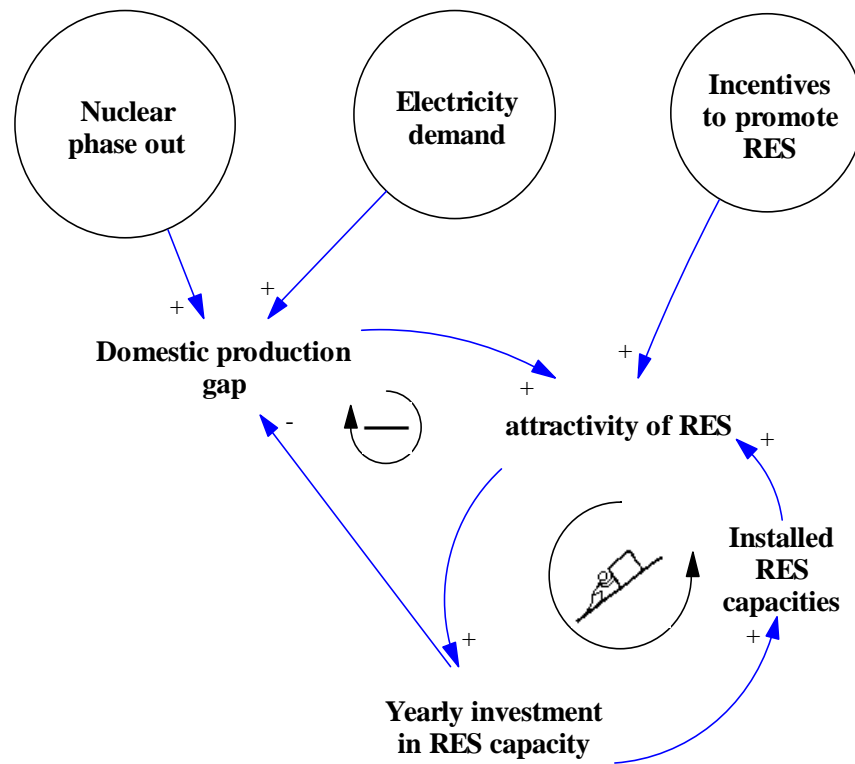


## Success to Successful

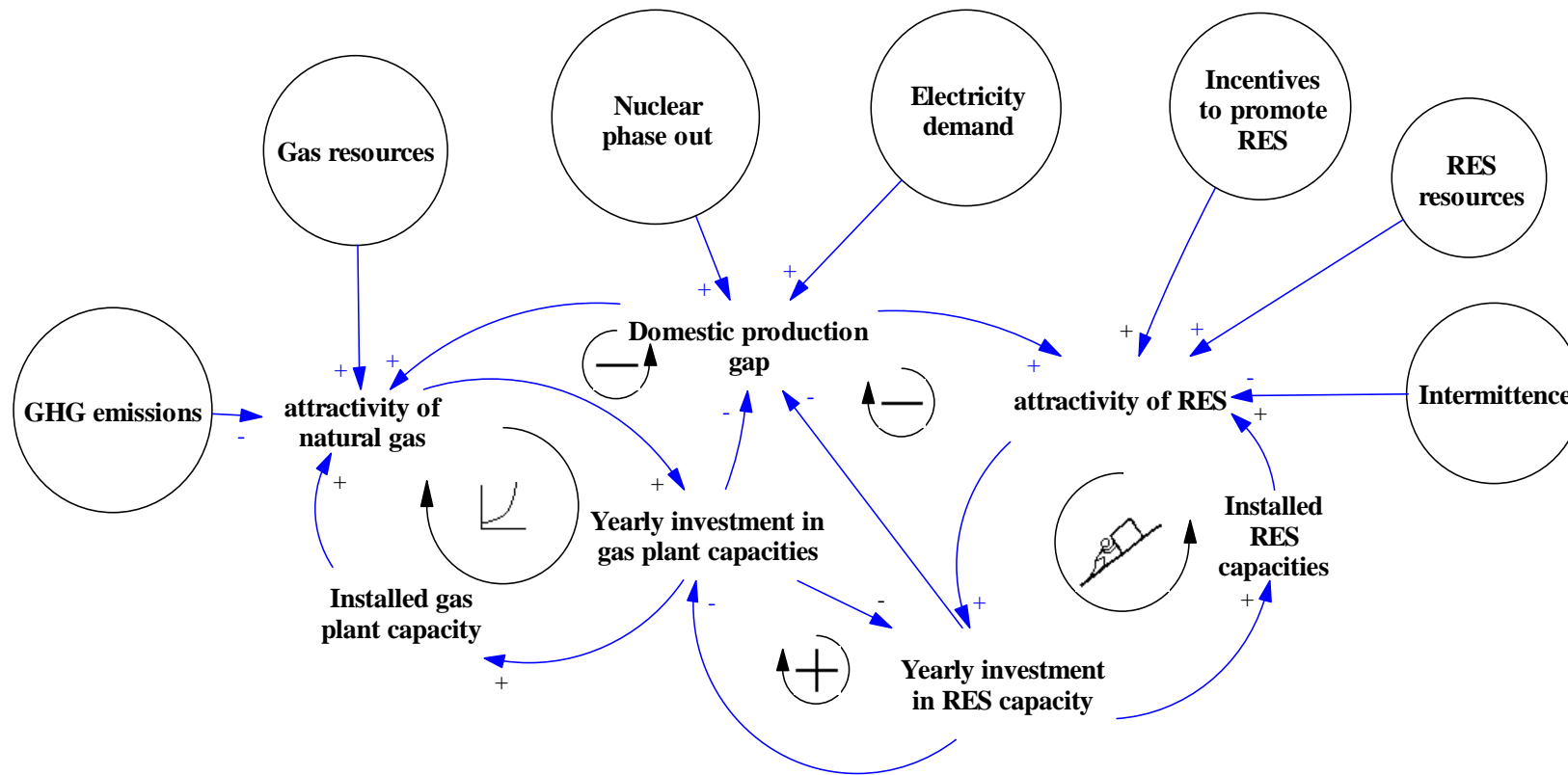
# The open-loop view on the electricity transition in Belgium



**The message that NPP's are an obstacle to developing RES ...**

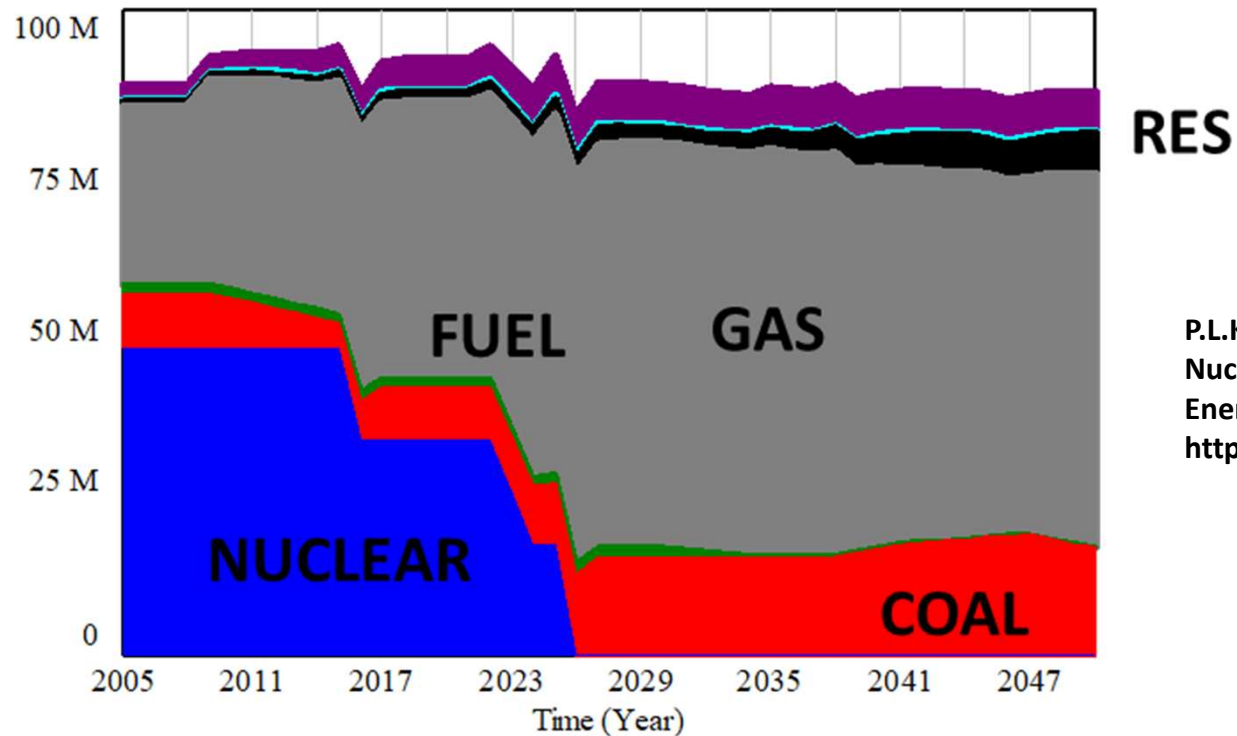


.... has created hopes for a successful virtuous Renewable Energy Sources (RES) loop ...



## Success to Successful!

... but it is rather to be expected that natural gas will fill most of the 50% nuclear gap in the short term



P.L.Kunsch & J.Friesewinkel  
 Nuclear energy policy in Belgium after Fukushima  
 Energy Policy, 66,462-474, 2014  
<https://doi.org/10.1016/j.enpol.2013.11.035>

Result: more gas or more electricity imports (from the French 75% nuclear program!) for the Belgian production



## Final Observation ...

***Operations Research curricula in engineers' faculties* have so far very much concentrated on Optimising**

**They have largely ignored *systemic multi-criteria, multi-stakeholder decision engineering* (at least in this country)**

✓ **What happens in other countries?**

✓ **Could we start developing soft-modelling skills in Kindergarten?**

Thank you for your kind attention!

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