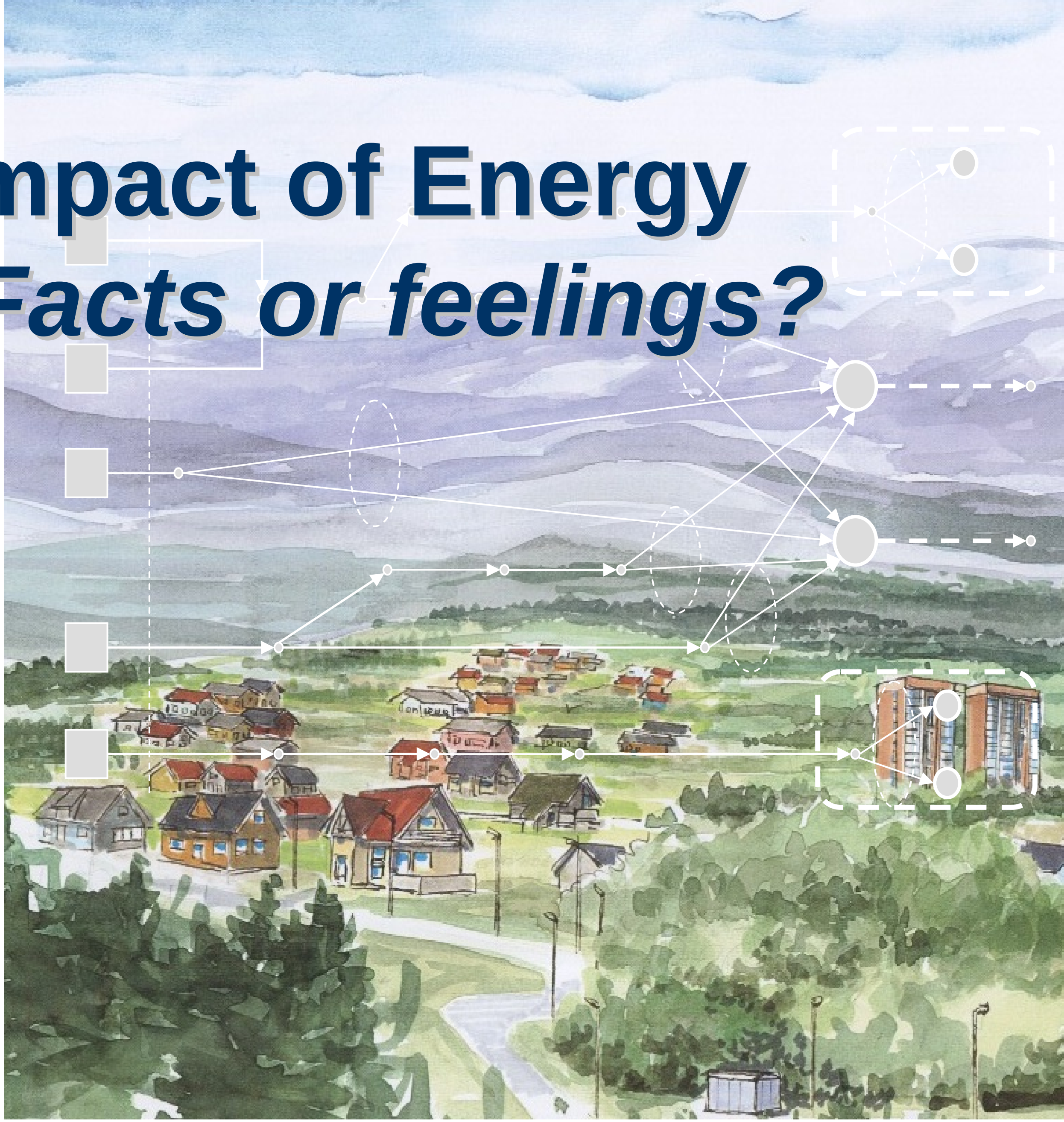
Practical impact of Energy planning: *Facts or feelings?*



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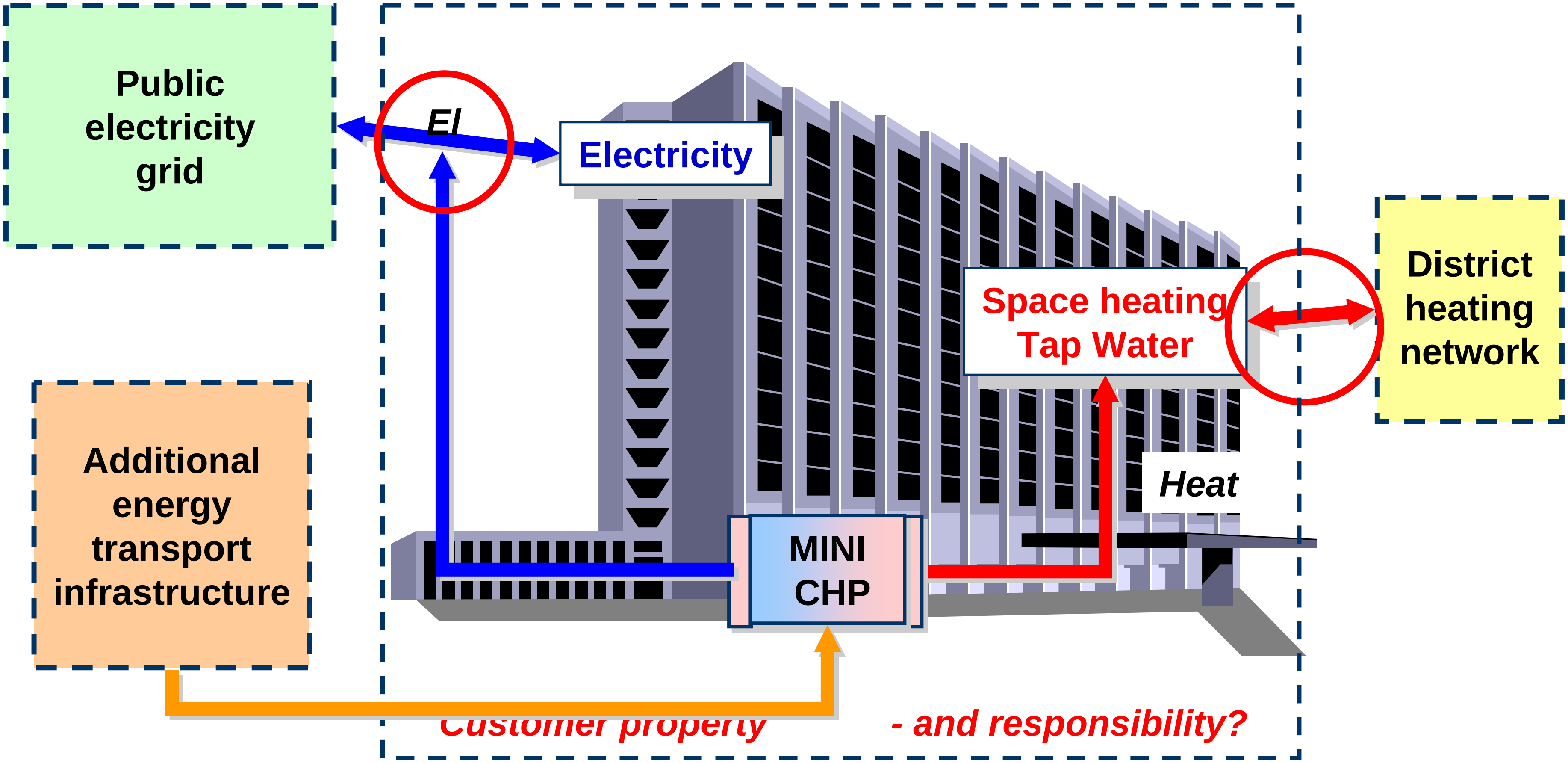
www.energy.sintef.no

Why do we need energy planning?

- **New technologies for distributed energy systems are emerging**
  - better possibilities to design sustainable energy systems for the future
  - more complex energy systems to design, operate and maintain
  - mutual influence and dependence between multiple infrastructures

Integrated energy systems

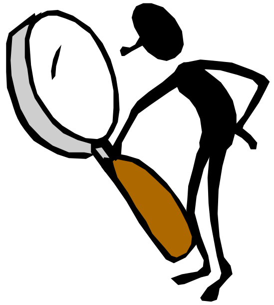


Natural gas / Biomass etc

New renewable energy sources
- some drawbacks…

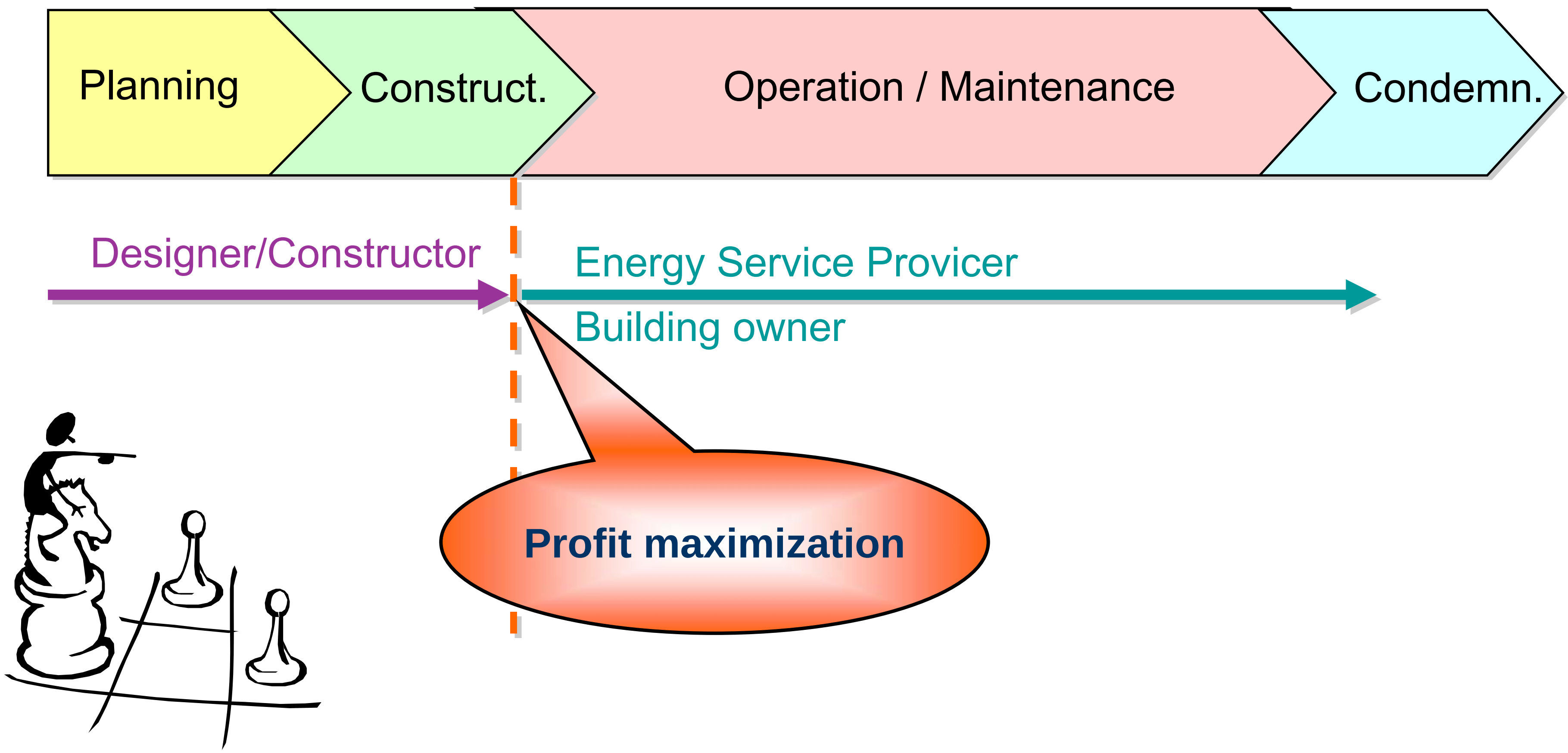
- **Ownership, operation and maintenance by private owners with low technical competence**
- **Fuel transportation often by road (biomass, waste, gas, fuel oil)**
  - Transport cost and environmental impact like exhaust, noise, dust and security must be considered
- **Often new immature technology**
  - ”Laboratory tested”
  - 95-98% availability (>175 h/year down-time ≈ 1 week!)
  - Electricity grid: 99,96% => 3.5 h/year down-time

Some other concerns…



- Current concessions and regulations give few incentives to reduce the energy consumption
- Water-based (hydronic) space heating with electric boilers give NO energy saving
- Heat pumps increase the customers' dependence on electricity
- Hydronic space heating based on heat pumps is much more expensive than electric heaters - bank rate and VAT must be included for private investors!
- Change of energy system (e.g. from electrical to hydronic heating) difficult to implement during rehabilitation of existing buildings
- Building designers and constructors are mostly focused on construction cost, not operating cost

Planning and operation of buildings



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- **Public pressure to "do the right thing"**
  - an overall system perspective is necessary for planning and operation
  - multiple infrastructures and geographic distance must be considered
  - sufficient documentation and communication of complex decisions
  - ***NIMBY, NOMH, NOPE...***

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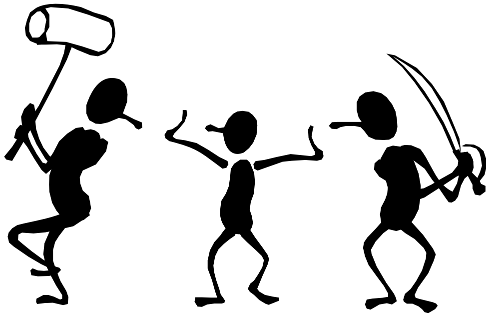
  - ***NIMBY, NOMH, NOPE...***
- **Liberalization**...
  - development from vertical integration to horizontal: *Multi-utilities*
  - Both complementarity and competition must be evaluated
- ***More comprehensive and flexible planning tools needed***

Planning of energy systems

- **The outcome of a *planning process* is a *plan***
  - Descriptive; what, where, when
  - Continuous process
  - May support decisions
- **The outcome of a *decision process* is a *choice***
  - Identifiable in time and space
- **Actors involved in planing (and decision making)**
  - Utilities and grid companies (concessionaires)
  - Local/regional authorities
  - Regulatory authorities
  - Environmental and other special interest groups
  - Local political groups
  - Industrial and domestic customers
  - Technology vendors
  - Commercial energy providers

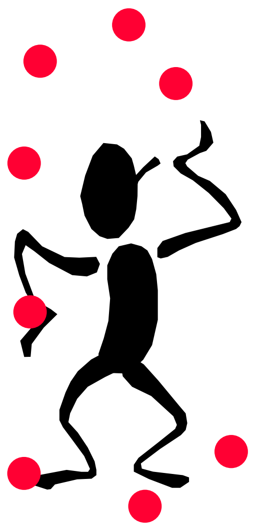
Different decision makers have different preferences...

- **Economy**
  - Maximize profit (corporate / micro-economic)
  - Minimize total cost (Socio-economic)
- **Environmental consequences**
  - Quantitative (measurable): Emissions, noice ...
  - Qualitative (not measurable): Esthetic, visual, experience of nature...
- **Quality**
  - Security of supply
  - Technical: Voltage, temperature, pressure ...
  - Use: Comfort, user friendliness, controllability ….
- **Public opinion**
  - Company reputation
  - Service level
- **etc...**



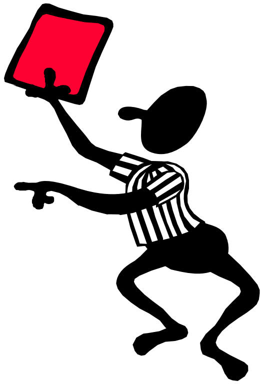
How to find the best expansion plan? An example...

- **If three investments A, B and C are mutually exclusive, the following investment alternatives exist:**
  - *None*, A, B, C, (A,B), (A,C), (B,C), (A,B,C) => 8 different
  - Expression: 2^N
    - N=10: 1024 combinations
    - N=20: 1.048.576 combinations
    - ....
- **Many alternatives will not be mutually exclusive**
  – but which ones?



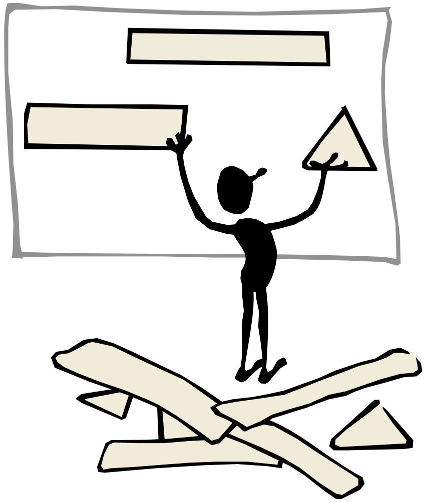
How to find the best expansion plan?

- **Manual calculations e.g. in Excel spreadsheets**
  - Each expansion alternative is analyzed one at a time
  - The alternatives are compared (NPV method)
  - Probably a good strategy in many cases
- **Time consuming if**
  - there are many investment alternatives
  - the investments can be made at different points in time
  - operating costs are dependent on the investments
- **A good investment analysis will often require many and complicated calculations**
- ***Without a formal optimization methodology, preferences, rules of thumb and gut feeling might easily become dominant***



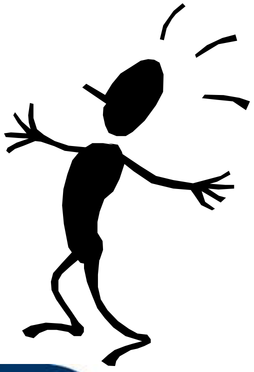
Models for energy planning

- **Main model classifications**
  - **Simulation** or **Optimization** (***Inform*** or ***Choose***)?
  - **Bottom-up** or **Top-down** (***Engineering*** or ***Econometric***)?
- **How to choose model(s)?**
  - Consider acceptable levels of detail, simplifications, abstraction, uncertainty, user-friendliness, time consumption etc
  - Presentation of results!
  - *Choose the right tool for the job!*
- **GIGO**
  - "Garbage In - Garbage Out"
  - "Guesses In - Guidance Out"
  - *"Garbage In - Gospel Out"*



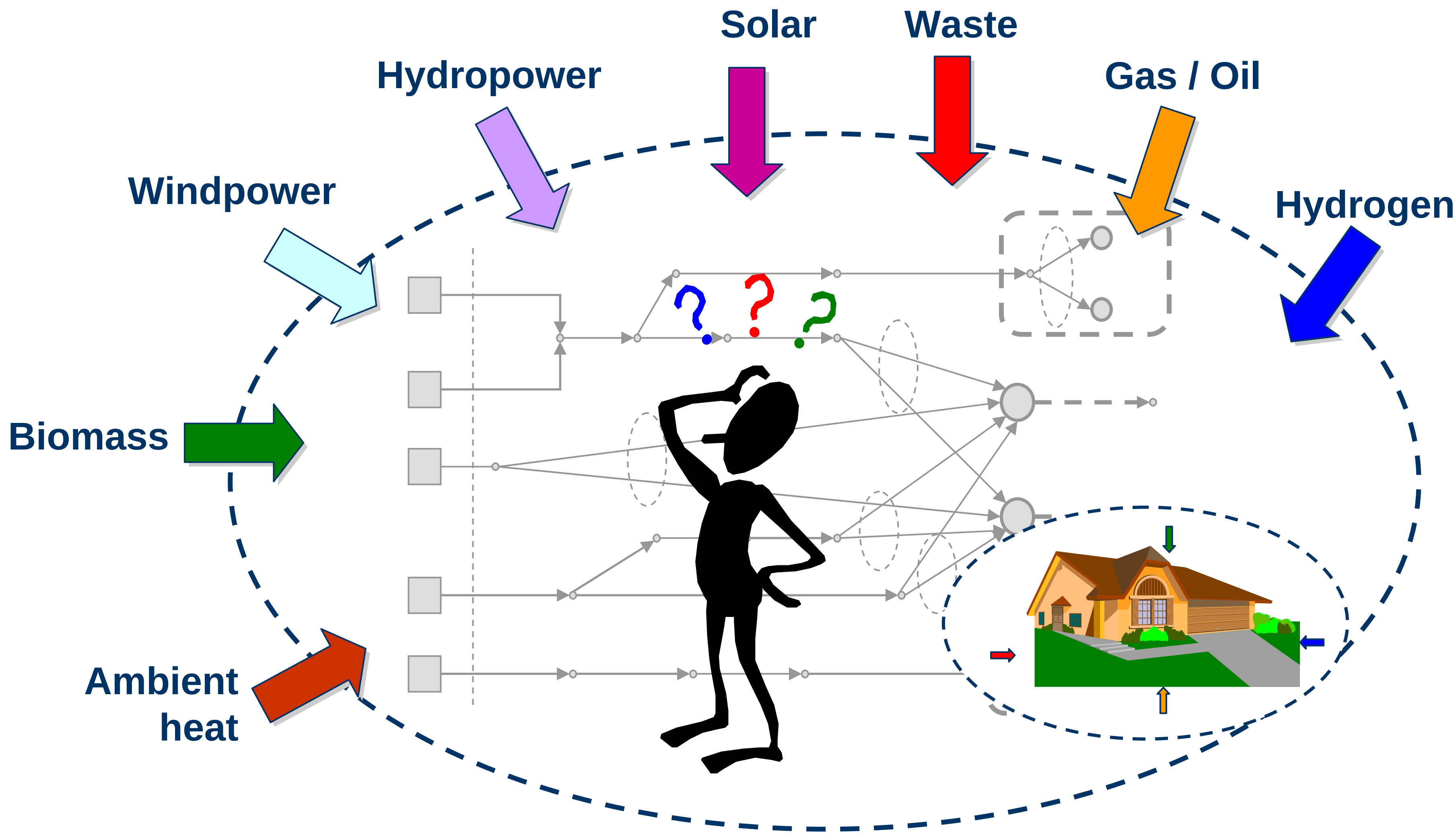
eTransport model at SINTEF Energy Research

- **Developed with external funding after internal pilot studies (1998-2005)**
- **Formal optimization model with several types of energy carriers, sources, transmission, conversion and demand**
  - Expansion planning of local energy systems
  - Optimize construction of new DER power plants subject to multiple infrastructures
  - Evaluate up-stream infrastructure for DER fuels (including road, rail or keel)
  - Identify mutual influence and dependence between energy systems
  - Evaluate ”threats” from other DER and suppliers in the same area
  - Visualize the conclusion of complex problems

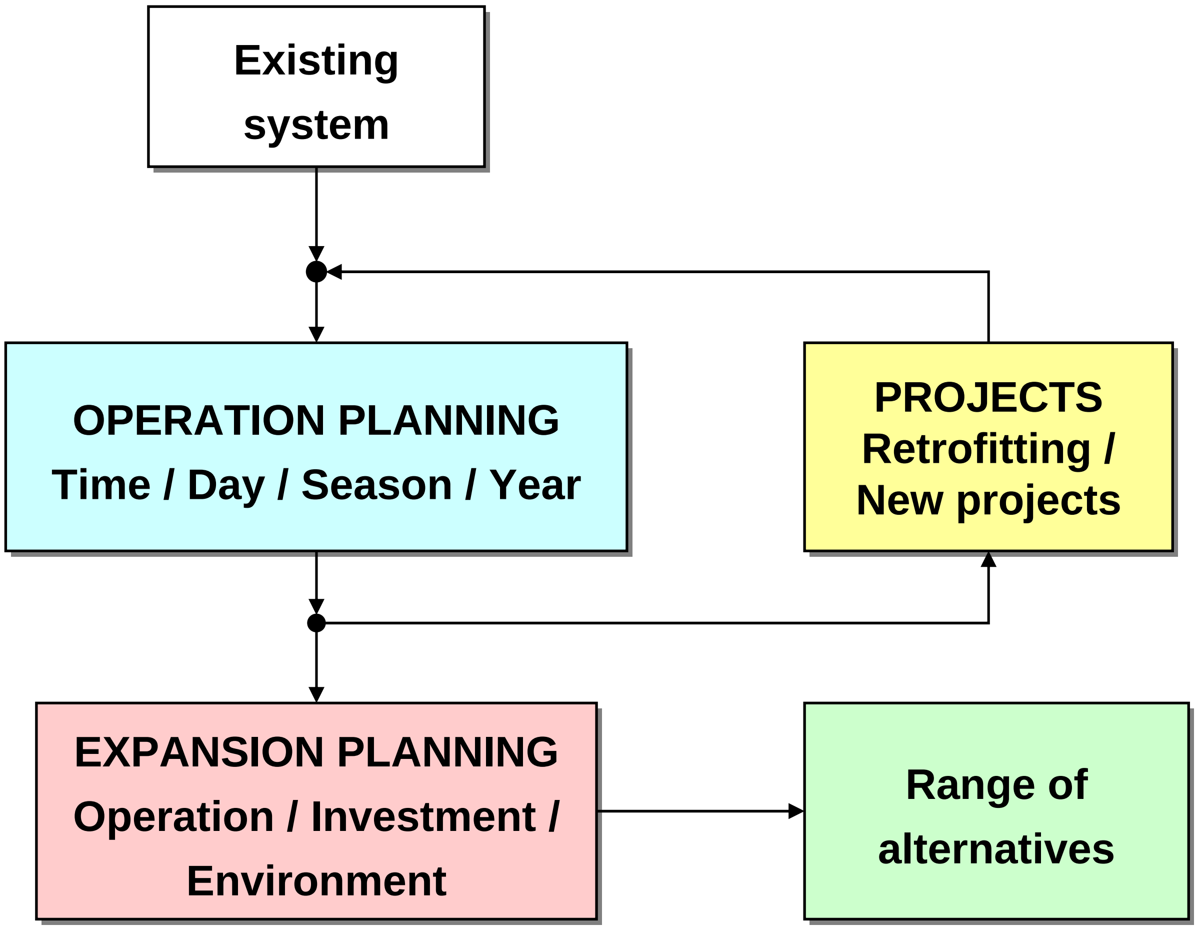


eTransport

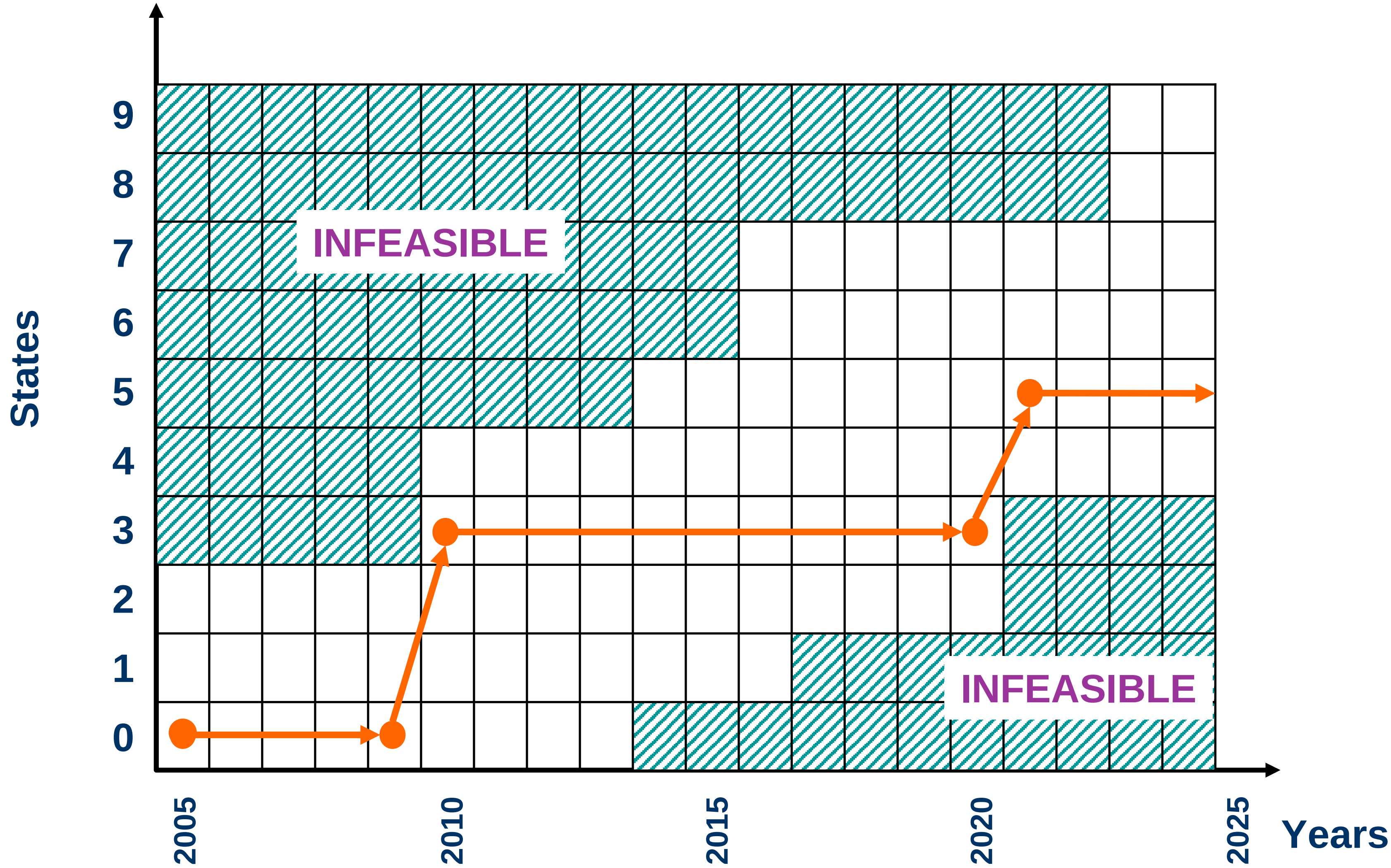
Planning of local energy supply



Operation and expansion planning combined

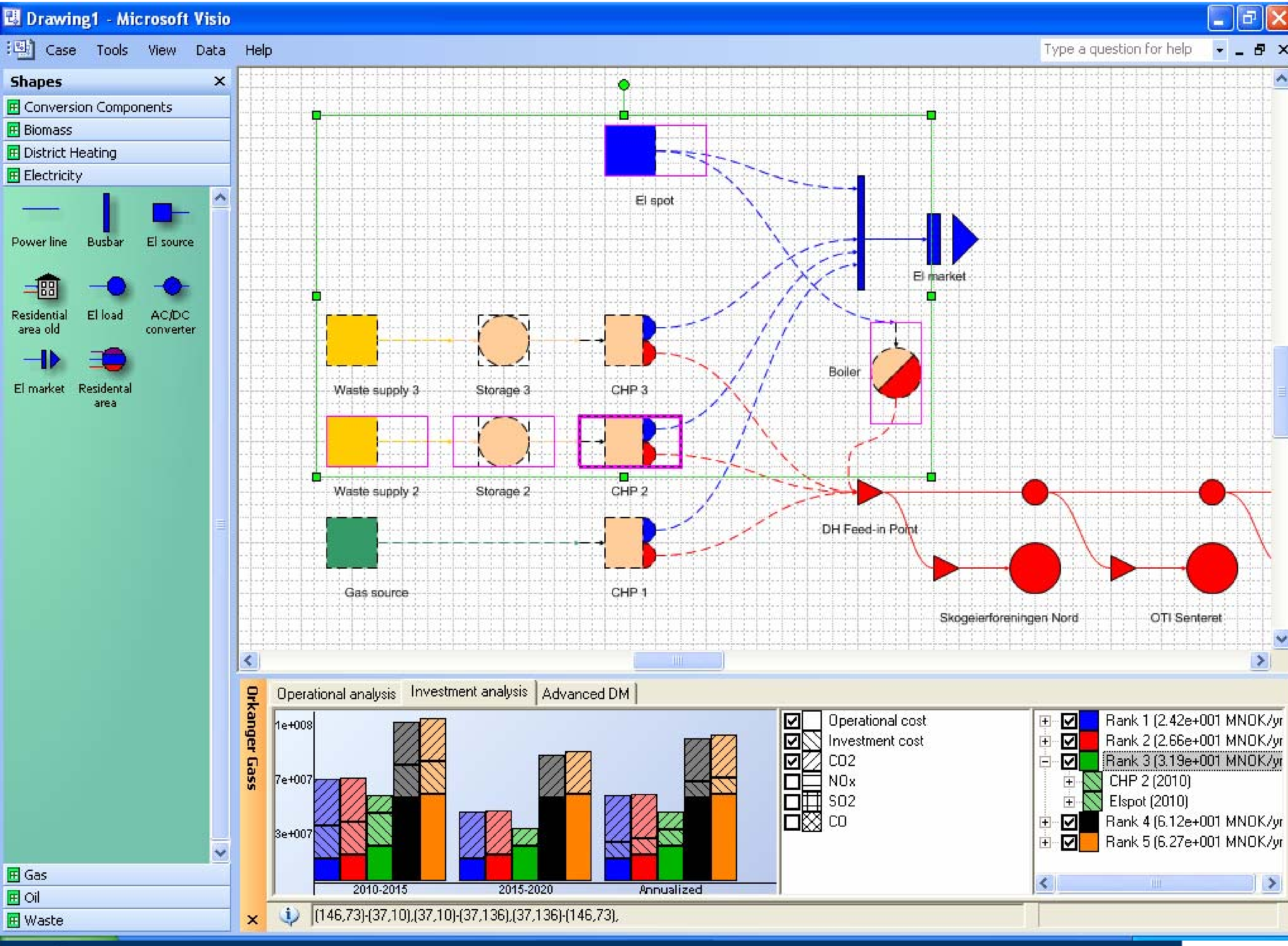


Optimal expansion plan

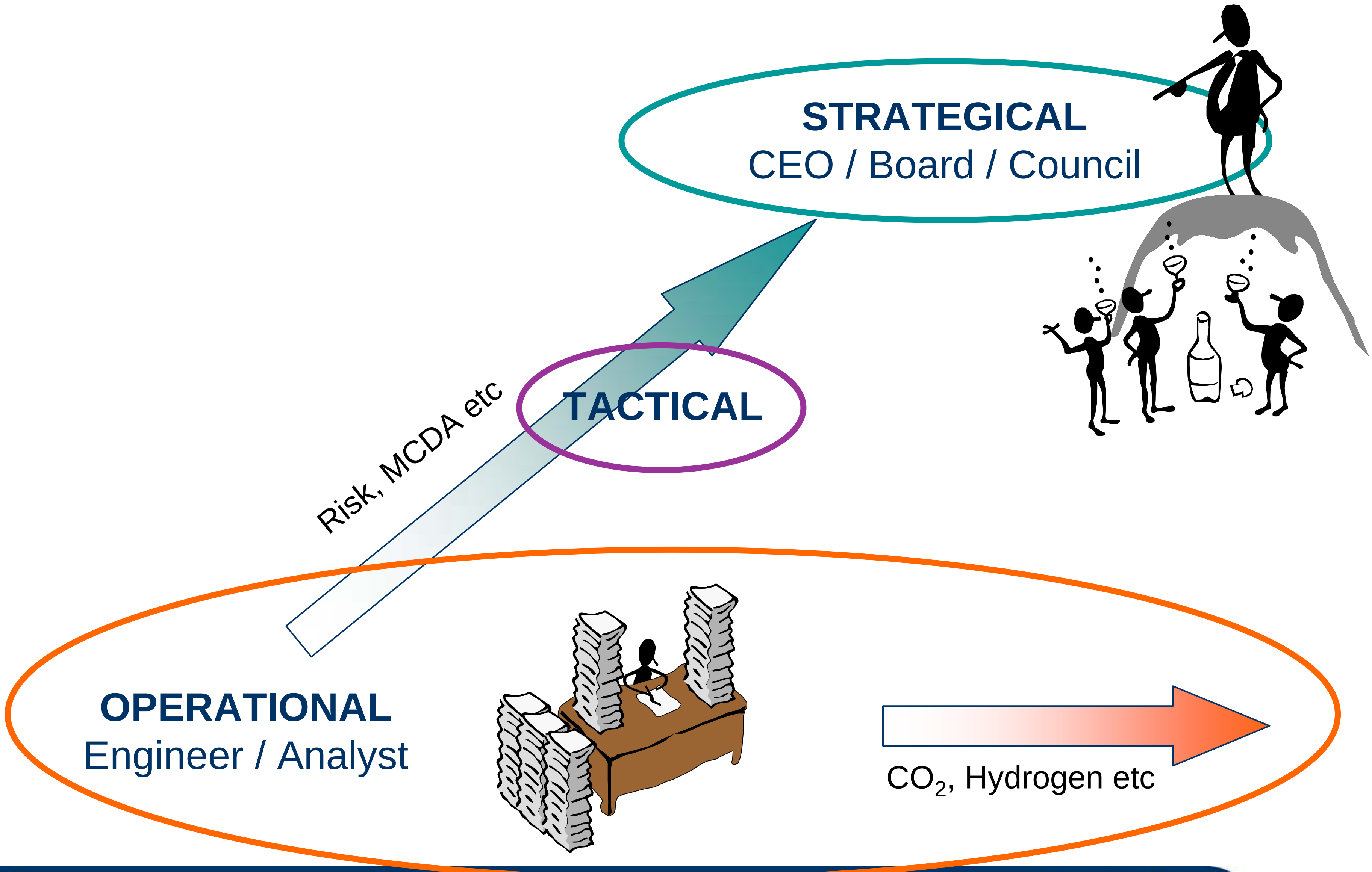


Current modules

- Electricity networks (DC power flow)
- District heating networks
- Gas pipeline with compressor
- Discrete transport (LNG ship and biomass by car)
- CO_2 transport (ship or pipeline) *– Mass transport!*
- Boilers: Gas, oil, electricity, biomass
- CHP: Gas (engine + turbine), biomass, special waste
- Heat pump
- Storage: Heat, biomass, gas
- CCGT model w/CO_2 capture
- LNG factory and reformer
- End user models by function (work, lighting, heating …)
- Markets for el, heat, gas and CO2
- Investment analysis / expansion planning incl. emissions


Drawing1 - Microsoft Visio
Case
Tools
View
Data
Help
Type a question for help
Shapes
Conversion Components
Biomass
District Heating
Electricity
Power line
Busbar
El source
Residential area old
El load
AC/DC converter
El market
Residental area
Gas
Oil
Waste
El spot
El market
Waste supply 3
Storage 3
CHP 3
Boiler
Waste supply 2
Storage 2
CHP 2
DH Feed-in Point
Gas source
CHP 1
Skogeierforeningen Nord
OTI Senteret
Orkanger Gass
Operational analysis
Investment analysis
Advanced DM
1e+008
7e+007
3e+007
2010-2015
2015-2020
Annualized
Operational cost
Investment cost
CO2
NOx
SO2
CO
Rank 1 (2.42e+001 MNOK/yr
Rank 2 (2.66e+001 MNOK/yr
Rank 3 (3.19e+001 MNOK/yr
CHP 2 (2010)
Elspot (2010)
Rank 4 (6.12e+001 MNOK/yr
Rank 5 (6.27e+001 MNOK/yr
(146,73)-(37,10),(37,10)-(37,136),(37,136)-(146,73),

Next step: Bridging different decision levels...

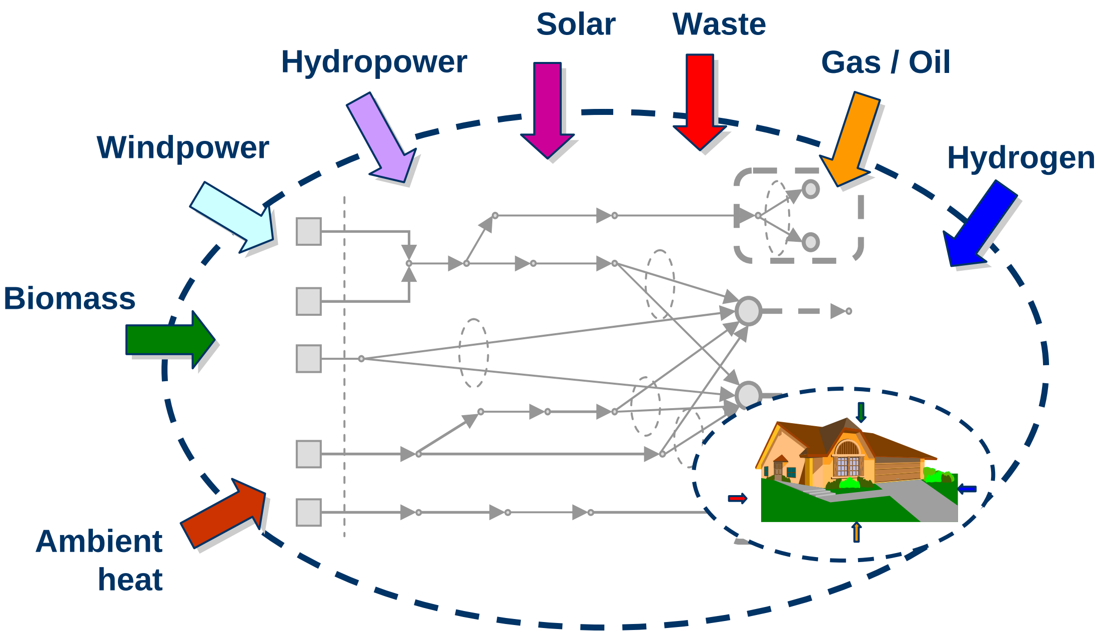


Multiple decision levels

DECISION LEVELS		
	Main actions	Main factors influencing the decision(s)
STRATEGIC	Building new energy infrastructure – for gas	Political and social implications • national energy policy / regulations • local social impacts: jobs, etc..
TACTICAL	Create premises for a gas market • attract local consumers: households, municipality, industry • convince other stakeholders	• % of the estimated gas market • expected consumer's costs and their willigness to pay • compliance with possible new rules and regulations
OPERATIONAL	• assess all possibilities/alternatives • assess the main uncertainties and the possible timing of investments • construct scenarios: prices, demands, emission taxes, etc.	• costs • emissions • system's reliability • quality of service, etc.

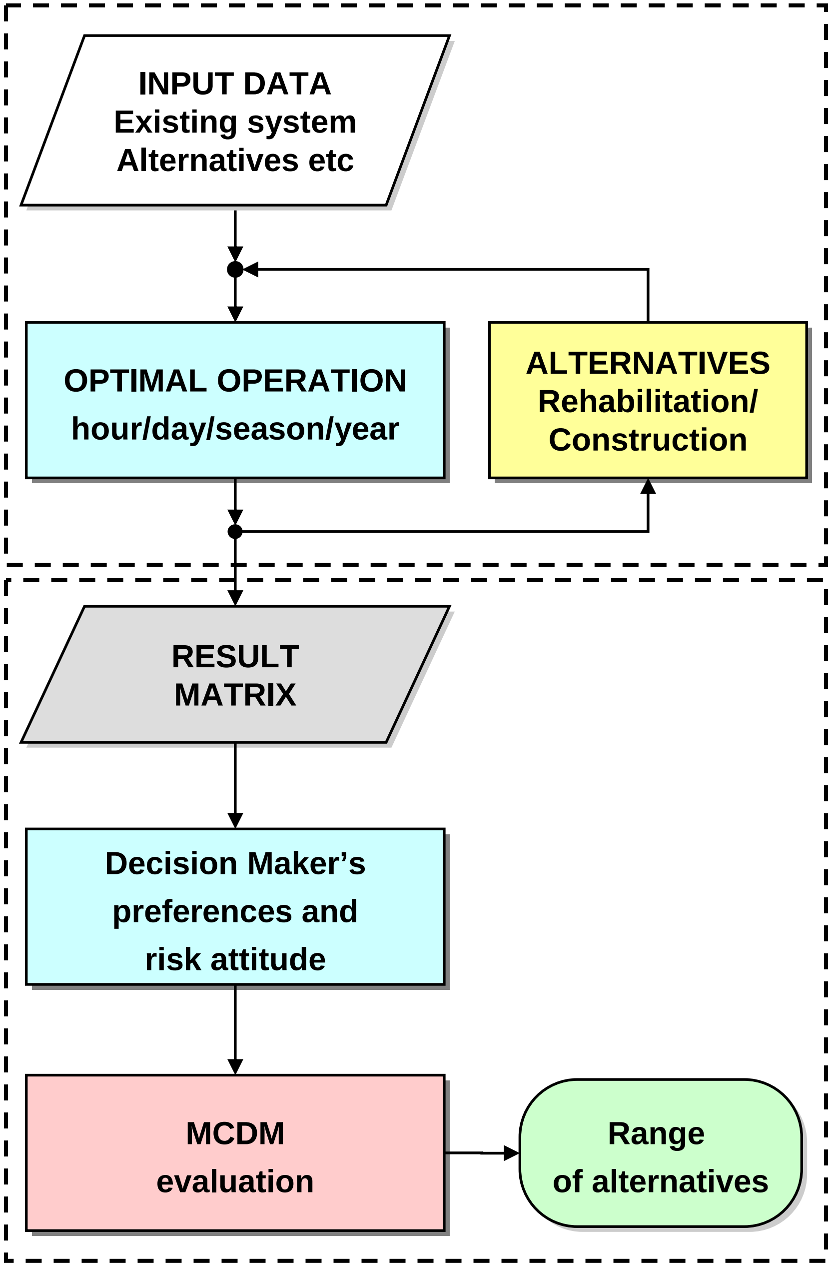
Multiple system boundaries

- **Physical boundary =>**
  - geography, technology ....
- **Impact boundary**
  - economy, environment....
- **Political boundary**
  - laws, regulations, guidelines...



Multi-Criteria Decision Making (MCDM)

- **Impact model**
  - Use optimization model (eTransport)
- **Preference model**
  - E.g. Multi-Attribute Utility Theory (MAUT)



Conclusions

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  - better possibilities to design sustainable energy systems for the future
  - more complex systems to design, operate and maintain
- **Public pressure to “do the right thing”**
  - overall system perspective is necessary for planning and operation
  - multiple infrastructures and geographic distance must be considered
  - complex decisions must be sufficiently documented
  - communication across scientific and organizational barriers is important
- **A good investment analysis will often require many and complicated calculations**
  - Without a formal optimization methodology preferences, rules of thumb and gut feeling might easily become dominant
- ***More comprehensive and flexible planning tool is needed***

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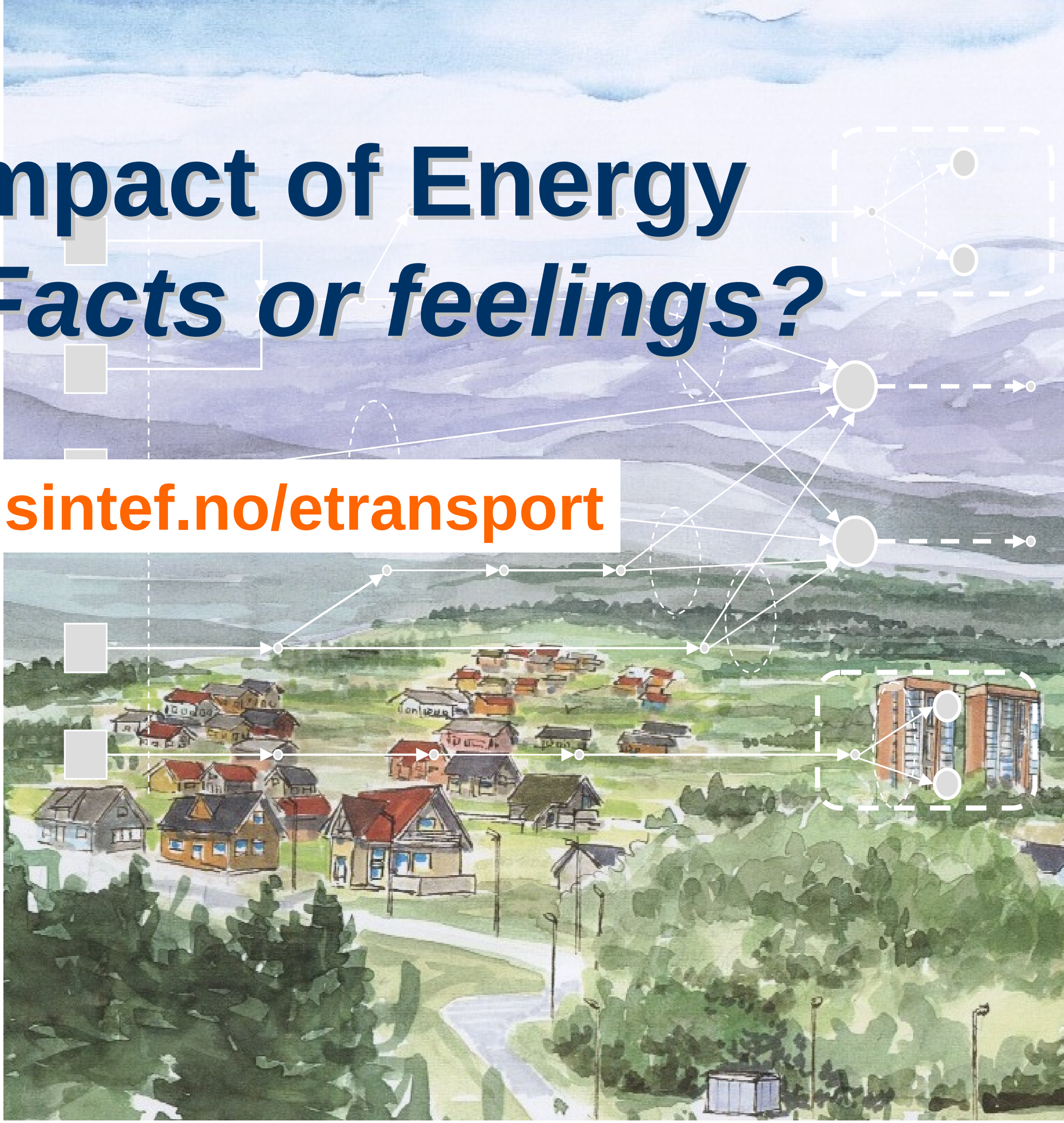

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