Session 1:
Methodological challenges in modelling « Efficiency First »

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enefirst.

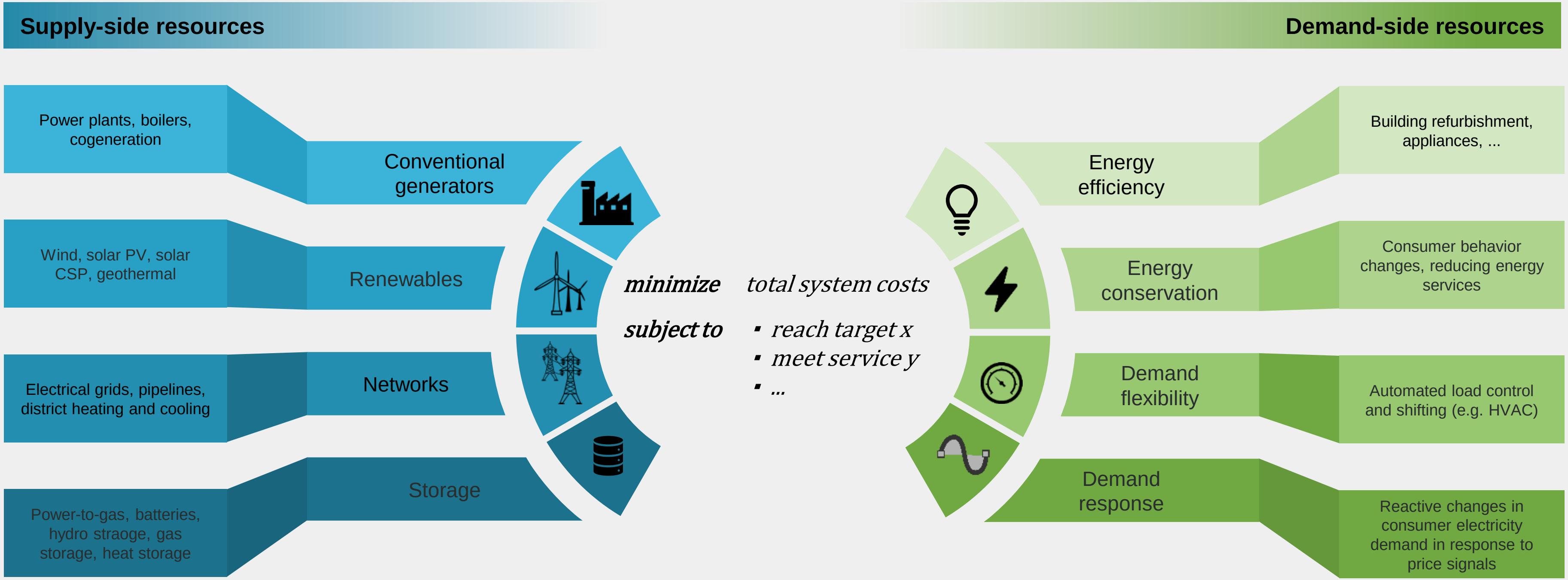
Introduction

The ENEFIRST project defines « Efficiency First » (E1st) as follows

> **‘Efficiency First’** gives priority to demand-side resources whenever they are more cost effective from a societal perspective than investments in energy infrastructure in meeting planning and policy objectives. It is a decision principle that is applied systematically at any level to energy-related investment planning and enabled by an ‘equal opportunity’ policy design.

Introduction

Modelling E1st comes down to determining the least-cost mix of resources



Introduction

Different model types can be used for different E1st research questions

Model types	Energy system optimization models	Energy system simulation models	Power system and electricity market models
Primary focus	Normative scenarios	Forecasts, predictions	Operational decisions, business planning
Model examples	MARKAL, TIMES, MESSAGE	PRIMES, LEAP, NEMS	PLEXOS, ENERTILE, WASP
E1st research questions	*« What are least-cost technology pathways for the EU buildings sector with a view to the 2050 climate targets? »*	« How is the EU energy system likely going to evolve under the given policy framework and what system costs does this entail? »	*« What is the economic potential of demand response and to what extent can it contribute to peak shaving and delaying capital investment? »*
Research examples	ENEFIRST Project	EU Reference Scenario 2016 (Capros et al.)	Neme et al. (2015): Energy Efficiency as a T&D Resource. Lexington. NEEP.

Introduction

The following modelling-related challenges will be discussed in detail

Challenge 1	Capture the broad array of **multiple impacts** to provide a complete assessment of total system costs
Challenge 2	Select appropriate **discount rates** to enable a fair comparison of demand- vs. supply-side resources
Challenge 3	Represent **VRE variability** to account for the true costs of supply-side resources

Challenge 1 | Capturing multiple impacts | What’s the buzz?

Neglecting multiple impacts provides an incomplete picture of total system costs

Why capture multiple impacts (MI)?

a) More complete and balanced indication of externalities

b) Help achieve policy objectives

c) Reflect consumer preferences

Effect in modelling « Efficiency First »

- Inclusion of MIs can substantially alter results of cost-benefit analyses; omission can reduce cost-effectiveness of demand-side resources below their actual value and thus sub-optimal levels from a societal perspective
- e.g. *Thema et al. (2019)*: for residential building refurbishment in the EU, multiple impacts in 2030 amount to 13.6 bn€ (plus 19.2 bn€ of energy cost savings)

Challenge 1 | Capturing multiple impacts | Practical applications

The H2020 project COMBI introduces a total of 32 multiple impact indicators

COMBI	Air pollution	Macro-economy	Energy poverty	Resource	Energy security
Impact indicators	○ Human health ○ Ecosystem acidification ○ Ecosystem eutrophication ○ Emissions	○ GDP increase ○ Employment ○ Public budget ○ Fossil fuel prices ○ Abatement costs ○ Trade effects ○ Sectoral shifts	○ Thermal comfort/winter mortality ○ Asthma burden ○ Active days ○ Workforce performance	○ Material footprint ○ Fossil fuels ○ Minerals ○ Metal ores ○ Biotic raw materials ○ Unused extraction ○ Direct carbon emissions ○ Carbon footprint	○ Energy intensity ○ Import dependency ○ Aggregated energy security ○ Avoided power investment costs ○ Reserve capacity rate
Quantification methodology	GAINS model	General equilibrium modelling	COMBI model	Material flow accounting (MFA)	Energy balance model

Thema, Johannes; Suerkemper, Felix; Couder, Johan; Mzavanadze, Nora; Chatterjee, Souran; Teubler, Jens et al. (2019): The Multiple Benefits of the 2030 EU Energy Efficiency Potential. In Energies 12 (14), p. 2798.

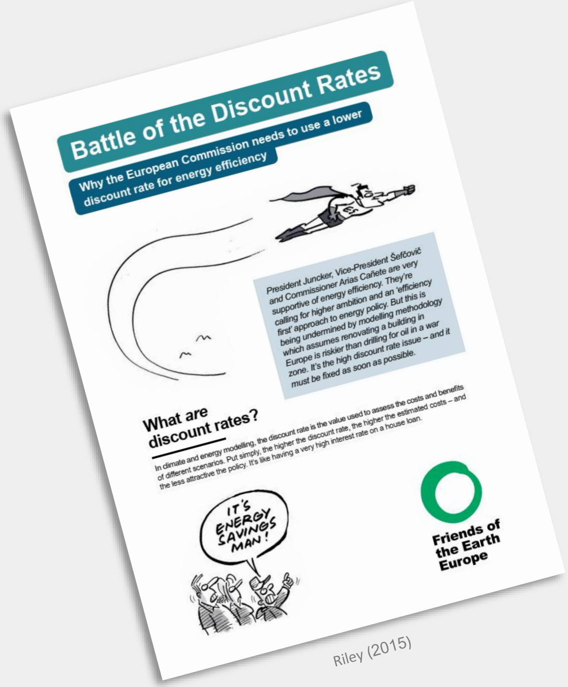
Challenge 1 | Capturing multiple impacts | Recommendations

The inclusion of multiple impacts is an essential to reflect a societal perspective

Challenge 1	Capture the broad array of multiple impacts to provide a complete assessment of total system costs	▪ provide comprehensive assessment of positive and negative impacts of demand- and supply-side resources ▪ where possible, monetize impacts for cost-benefit analysis
Challenge 2	Select appropriate discount rates to enable a fair comparison of demand- vs. supply-side resources	
Challenge 3	Represent VRE variability to account for the true costs of supply-side resources	

Challenge 2 | Selecting discount rates | What's the buzz?

The higher the discount rate, the less attractive capital-intensive investments (e.g. efficiency)



Riley (2015)

Why discount rates

- discount rates attribute a weight to future cash flows
- major reasons for applying discounting are:
  (i) inflation, **(ii)** time preference, **(iii)** risk

Clusters in the discussion on discount rates

- Implicit / behavioural discount rates
- Market discount rates
- Social discount rates

Effect in modelling « Efficiency First »

➢ skewed selection of discount rates can significantly alter results of cost-benefit analyses to the detriment of demand-side resources

Challenge 2 | Selecting discount rates | Practical applications

In bottom-up systems modelling, discount rates are typically applied in 2 stages

	Stage 1: Modeling individual decision-making	Stage 2: Accounting total system costs
Rationale	▪ mimic decision making of private/corporate actors about investment choices ▪ take into account actors' bounded rationality	▪ allows adding annuities for capital with variable and fixed annual costs to report on total costs ▪ may create disadvantage for capital-intensive EE
Typical discount rates	see Table A	see Table B
Method. issues	a) Adjust discount rates in response to policies b) Use different discount rates for different actors	a) Enhance theoretical foundation b) ...

Table A. Definition of residential discount rates in PRIMES-2016 (Capros et al. 2016)

Context	Default [real] discount rates	Mod. [real] discount rates due to EE policies
Private cars	11.0%	11.0%
Building renovation / heating equipment	14.75%	12.0%
Electrical appliances	13.5%	9.5%

Table B. Definition of discount rates for system cost accounting in different studies.

Reference	[Real] discount rate
EU Reference Scenario 2016 (PRIMES)	10.0%
EC Better Regulation Guidelines	4.0%
EC Guide to Cost-Benefit Analysis	3.0 – 5.0%
Steinbach et al. (2015)	1.0 – 7.0%
Langenheld et al. (2015)	1.5%

Challenge 2 | Selecting discount rates | Recommendations

Be critical on what discount rates are used for modelling demand- vs. supply-side resources

Challenge 1	Capture the broad array of multiple impacts to provide a complete assessment of total system costs	▪ provide comprehensive assessment of positive and negative impacts of demand- and supply-side resources ▪ where possible, monetize impacts for cost-benefit analysis
Challenge 2	Select appropriate discount rates to enable a fair comparison of demand- vs. supply-side resources	▪ apply higher ‘Stage 1’ discount rate to model actors’ decision-making, and lower ‘Stage 2’ rate (social rate) to evaluate total system costs ▪ carry out sensitivity analyses to ensure transparency
Challenge 3	Represent VRE variability to account for the true costs of supply-side resources	

Challenge 3 | Representing VRE variability | What's the buzz?

Neglecting VRE variability may substantially over- or underestimate supply system costs.

Why represent VREs?

- Long-term energy planning models typically characterized by **coarse spatiotemporal resolution**
- Ongoing deployment **of variable renewable energies** (VRE) requires detailed consideration of variations in power demand and supply

Effect in modelling « Efficiency First »

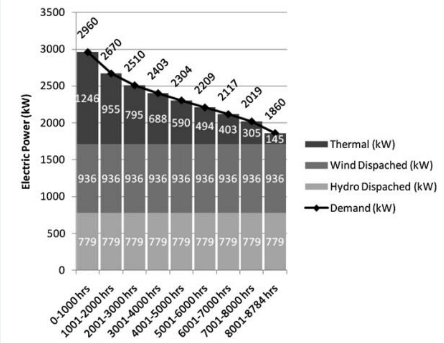
- Too coarse spatial and temporal resolution can give **poor estimation of supply operation & costs**
- Example *Welsch et al. (2014)*: 21.4% of dispatch allocated to wrong generation capacities

Challenge 3 | Representing VRE variability | Practical applications

Three approaches with different levels of detail can represent the cost implications of VRE.

A) Integral approach

Illustration



Haydt et al. (2011)

Level of detail

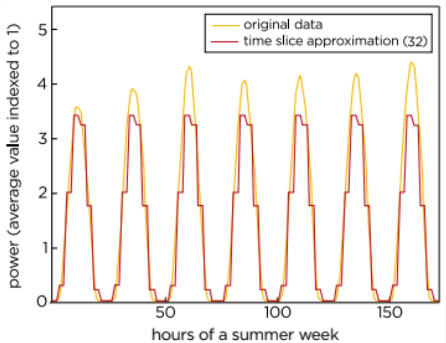
Time steps: 1-10
Time resolution: Monthly-yearly

Model example

LEAP

B) Semi-dynamic approach

Illustration



IRENA (2017)

Level of detail

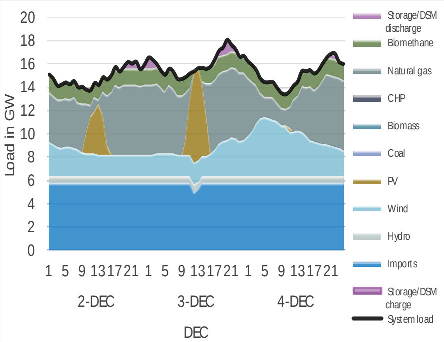
Time steps: 10-100
Time resolution: Daily-hourly

Model example

TIMES

C) Fully dynamic approach

Illustration



Level of detail

Time steps: 10-100
Time resolution: Hourly and better

Model example

ENERTILE

Challenge 3 | Representing VRE variability | Recommendations

Higher spatiotemporal detail better accounts for the system cost implications of supply.

Challenge 1	Capture the broad array of multiple impacts to provide a complete assessment of total system costs	▪ provide comprehensive assessment of positive and negative impacts of demand- and supply-side resources ▪ where possible, monetize impacts for cost-benefit analysis
Challenge 2	Select appropriate discount rates to enable a fair comparison of demand- vs. supply-side resources	▪ apply higher 'Stage 1' discount rate to model actors' decision-making, and lower 'Stage 2' rate (social rate) to evaluate total system costs ▪ carry out sensitivity analyses to ensure transparency
Challenge 3	Represent VRE variability to account for the true costs of supply-side resources	▪ low spatiotemporal detail tends to *under*estimate power system costs + the contribution of demand response ▪ high levels of detail need to be balanced with computational limits in long-term modelling

Conclusion

Modelling E1st has challenges, but does not require completely novel modelling approaches

Challenge 1	Capture the broad array of **multiple impacts** to provide a complete assessment of total system costs
Challenge 2	Select appropriate **discount rates** to enable a fair comparison of demand- vs. supply-side resources
Challenge 3	Represent **VRE variability** to account for the true costs of supply-side resources

...

...	Take explicit account of long-term **technology lock-in effects**
...	Address **uncertainty**, **accessibility** and **reproducibility** of model outputs
...	Integrate **behavioral** and **social factors** into long-term modelling

...

Discussion

Are there other E1st research questions that you can think of?

Do you agree with the modelling challenges presented here?

What other modelling-related challenges appear relevant to you with regard to « Efficiency First »?

Displayed references

- IRENA (2017): Planning for the Renewable Future. Long-term modelling and tools to expand variable renewable power in emerging economies. Abu Dhabi: International Renewable Energy Agency.
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