

Session 1:
Methodological challenges
in modelling
« Efficiency First »

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MAKING THE ENERGY EFFICIENCY FIRST PRINCIPLE OPERATIONAL

Introduction

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

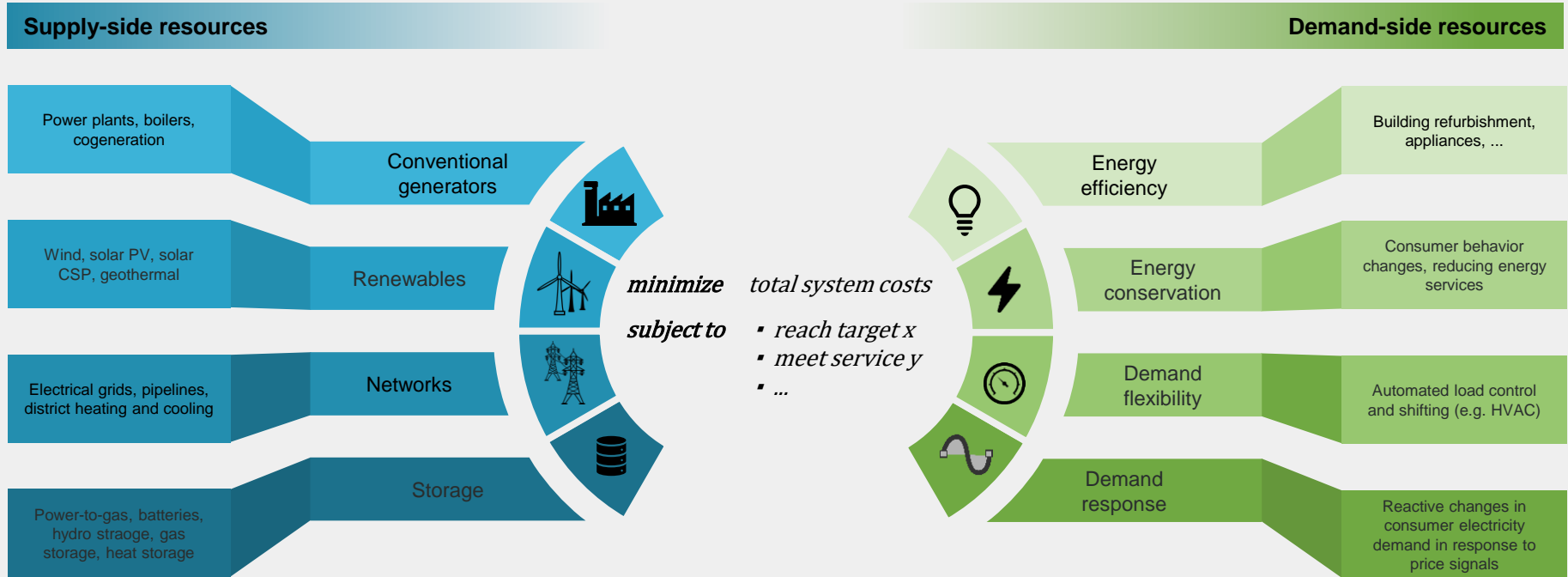


‘Efficiency First’ gives priority to **demand-side resources** whenever they are **more cost effective** from a **societal perspective** than investments in energy infrastructure in meeting **planning and policy objectives**. It is a decision principle that is applied systematically at any level to energy-related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

<i>Model types</i>	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	« <i>What are least-cost technology pathways for the EU buildings sector with a view to the 2050 climate targets?</i> »	« <i>How is the EU energy system likely going to evolve under the given policy framework and what system costs does this entail?</i> »	« <i>What is the economic potential of demand response and to what extent can it contribute to peak shaving and delaying capital investment?</i> »
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)?

- More complete and balanced indication of externalities
- Help achieve policy objectives
- 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					
Impact indicators	Air pollution <ul style="list-style-type: none"> Human health Ecosystem acidification Ecosystem eutrophication Emissions 	Macro-economy <ul style="list-style-type: none"> GDP increase Employment Public budget Fossil fuel prices Abatement costs Trade effects Sectoral shifts 	Energy poverty <ul style="list-style-type: none"> Thermal comfort/winter mortality Asthma burden Active days Workforce performance 	Resource <ul style="list-style-type: none"> Material footprint Fossil fuels Minerals Metal ores Biotic raw materials Unused extraction Direct carbon emissions Carbon footprint 	Energy security <ul style="list-style-type: none"> 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

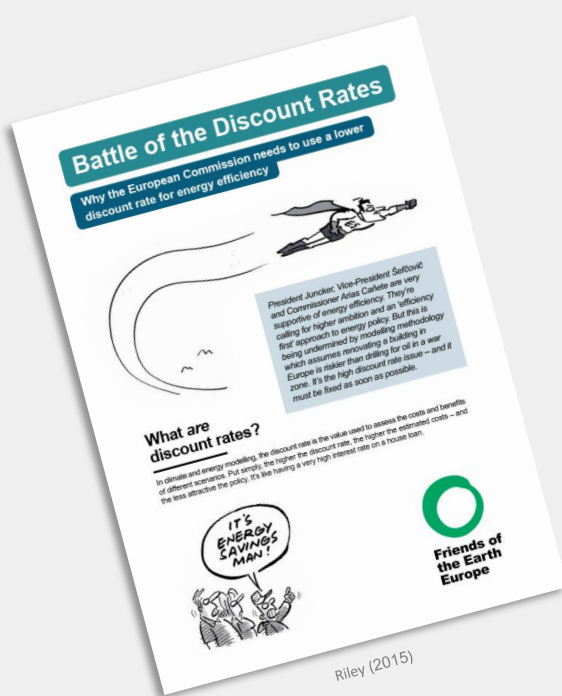
Challenge 1 | Capturing multiple impacts | Recommendations

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

<p>Challenge 1</p>	<p>Capture the broad array of multiple impacts to provide a complete assessment of total system costs</p>	<ul style="list-style-type: none"> ▪ provide comprehensive assessment of positive and negative impacts of demand- and supply-side resources ▪ where possible, monetize impacts for cost-benefit analysis
<p>Challenge 2</p>	<p>Select appropriate discount rates to enable a fair comparison of demand- vs. supply-side resources</p>	
<p>Challenge 3</p>	<p>Represent VRE variability to account for the true costs of supply-side resources</p>	

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

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



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

Rationale

Stage 1: Modeling individual decision-making

- mimic decision making of private/corporate actors about investment choices
- take into account actors' bounded rationality

Typical discount rates

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%

Method. issues

- Adjust discount rates in response to policies
- Use different discount rates for different actors

Stage 2: Accounting total system costs

- allows adding annuities for capital with variable and fixed annual costs to report on total costs
- may create disadvantage for capital-intensive EE

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%

- Enhance theoretical foundation
- ...

Challenge 2 | Selecting discount rates | Recommendations

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

<p>Challenge 1</p>	<p>Capture the broad array of multiple impacts to provide a complete assessment of total system costs</p>	<ul style="list-style-type: none"> provide comprehensive assessment of positive and negative impacts of demand- and supply-side resources where possible, monetize impacts for cost-benefit analysis
<p>Challenge 2</p>	<p>Select appropriate discount rates to enable a fair comparison of demand- vs. supply-side resources</p>	<ul style="list-style-type: none"> 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
<p>Challenge 3</p>	<p>Represent VRE variability to account for the true costs of supply-side resources</p>	

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

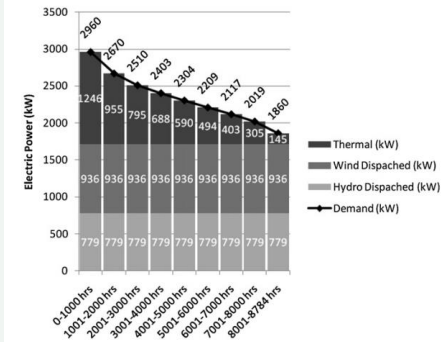
Three approaches with different levels of detail can represent the cost implications of VRE.

Illustration

Level of detail

Model example

A) Integral approach

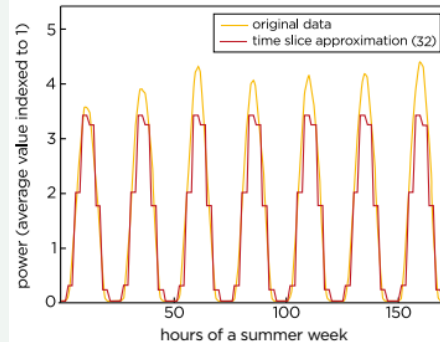


Haydt et al. (2011)

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

LEAP

B) Semi-dynamic approach

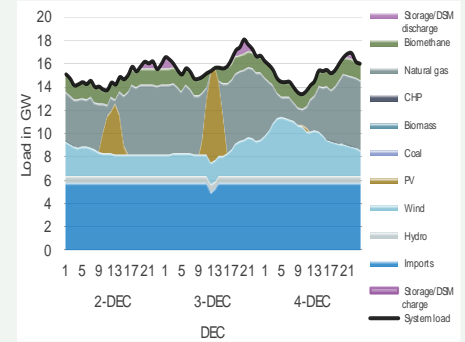


IRENA (2017)

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

TIMES

C) Fully dynamic approach



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

ENERTILE

Challenge 3 | Representing VRE variability | Recommendations

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

<p>Challenge 1</p>	<p>Capture the broad array of multiple impacts to provide a complete assessment of total system costs</p>	<ul style="list-style-type: none"> provide comprehensive assessment of positive and negative impacts of demand- and supply-side resources where possible, monetize impacts for cost-benefit analysis
<p>Challenge 2</p>	<p>Select appropriate discount rates to enable a fair comparison of demand- vs. supply-side resources</p>	<ul style="list-style-type: none"> 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
<p>Challenge 3</p>	<p>Represent VRE variability to account for the true costs of supply-side resources</p>	<ul style="list-style-type: none"> low spatiotemporal detail tends to <i>underestimate</i> 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

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