Impact of demand flexibility with different RES shares

Sophie Dourlens-Quaranta, Yvann Nzengue, TECHNOFI

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Outline

- Introduction
- The OPTIMATE tool
- Scenarios underlying the studies
- Modelling demand flexibility
- Main findings: impact of demand flexibility deployment on short-term market outcomes
- Conclusions

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Introduction

- Demand flexibility / Demand response / Demand-side management / Active consumers…
  - Papers, pilot projects, recommendations from various stakeholders…
  - … But no large-scale deployment yet
- EC public consultation on market design:
  - *“Successfully integrating renewables' electricity generation into the system requires flexible markets encompassing a broader range of players, both on the supply and **demand** side”*
  - *“To realize the full potential of the European internal energy market, the retail part of the electricity market has to offer **consumers** – households, businesses and industry – the possibility of **active** and **beneficial participation** in the European Union's energy transition. This has to be one of the goals of the **new market design** and requires a **fundamental change in the role of the consumer on the electricity market**”*

Introduction

- Large-scale deployment of demand response is therefore foreseen…
- … What will be the impact of such deployment on short-term market outcomes?
  - Volumes cleared on short-term markets per type of technology (RES/fossil…)
  - Costs and profits per type of stakeholders (producers, consumers…)
  - Market prices (average prices, daily spreads…)
  - Sustainability indicators (CO_2 emissions…)
  - Cross-border market integration (cross-border flows, price differentials, congestion revenues…)

→ Study with the OPTIMATE tool

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The OPTIMATE tool

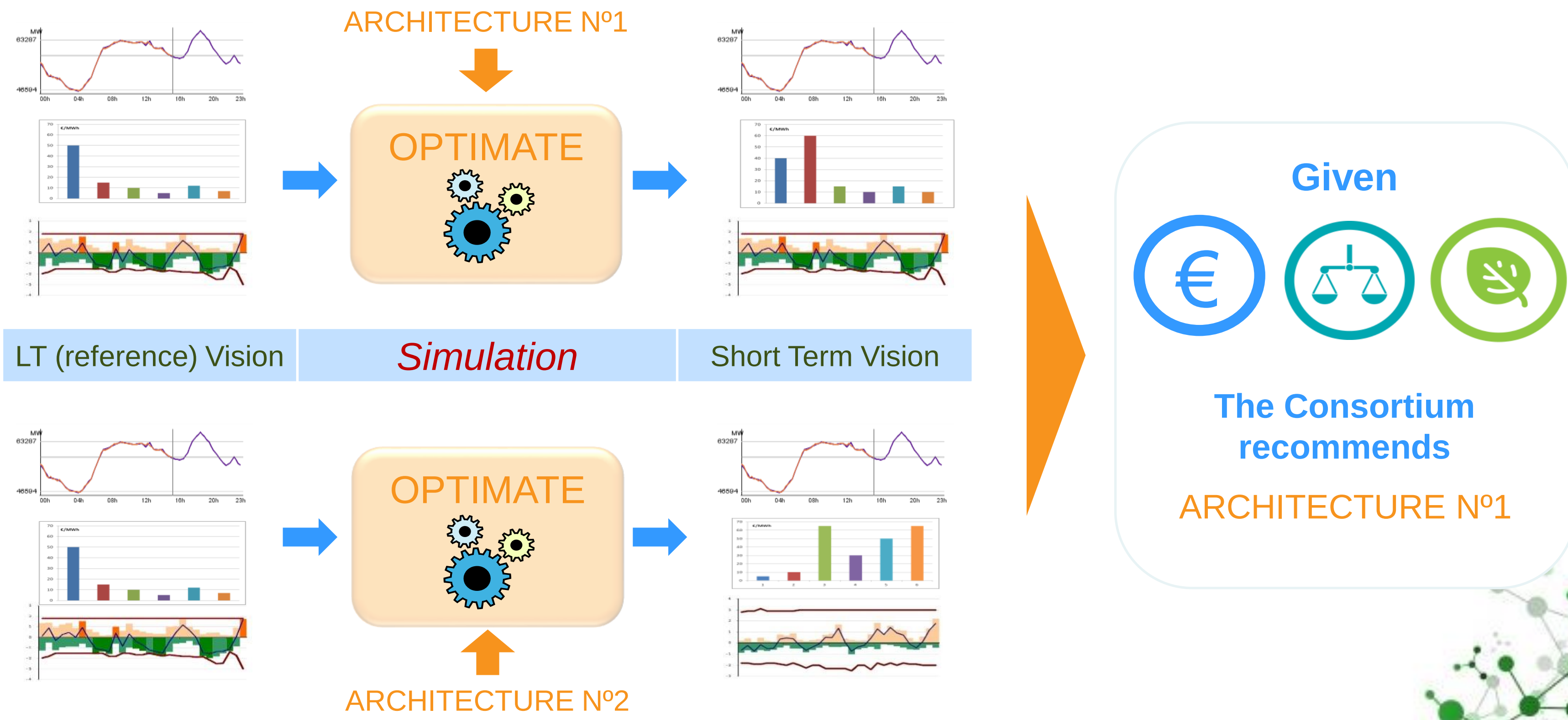
- Prototype simulation platform to compare short-term electricity market designs
- Developed within a co-funded FP7 project 2009-2012

The OPTIMATE consortium

- 1 Coordinator
- 5 Transmission System Operators
- 6 Research units

4

The OPTIMATE tool – In a nutshell



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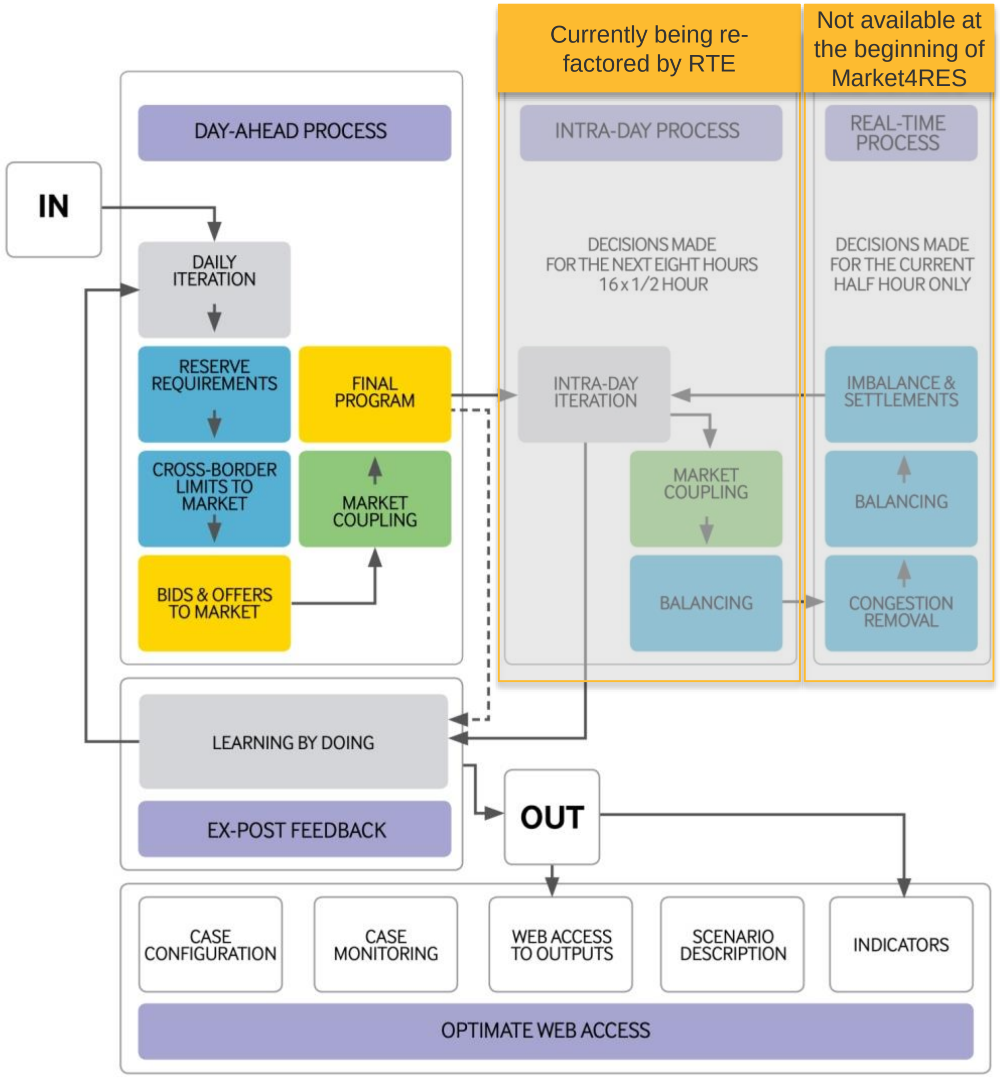
The OPTIMATE tool – Status

- Outputs of the FP7 project
  - A **prototype tool** (under almost perfect competition assumptions) with partial functional scope
  - Validation studies
- RTE is mandated by the FP7 consortium and the EC to exploit the project's results
  - Functional development of the prototype
  - Prototype exploitation (grant access to external users)
  - Industrialization of the tool

OPTIMATE Platform – Architecture

OPERATIONS

- TRANSMISSION SYSTEM OPERATORS
- POWER EXCHANGES
- MARKET PLAYERS



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Scenarios underlying the studies

- To compare the impacts of different market design options in a robust manner, scenarios have to be chosen
  - Support to sensitivity analyses with different features of the electric system
- Three scenarios are proposed
  - A **reference scenario** mimicking the current situation (2013-2014)
  - A **standard 2020 scenario** corresponding to the official publications regarding the expected situation at 2020
  - A **more ambitious scenario at 2020** in terms of RES penetration (RES+ scenario)

Summary of the main features of each scenario (qualitative)

Scenario name	Thermal generation			RES generation	Demand	Transmission network
	Installed capacities	Flexibility	Economic parameters			
Reference scenario						
2020 standard scenario						
2020 RES+ scenario						

Summary of the main features of each scenario

Scenario name	Thermal generation			RES generation	Demand	Transmission network
	Installed capacities	Flexibility	Economic parameters			
Reference scenario	Current installed capacities	Current flexibility level	Current CO_2 price and fuel costs	Current installed capacities	Current level of peak demand	Current cross-border capacities
2020 standard scenario						
2020 RES+ scenario						

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Reference scenario	Current installed capacities	Current flexibility level	Current CO_2 price and fuel costs	Current installed capacities	Current level of peak demand	Current cross-border capacities
2020 standard scenario	**Installed capacities at 2020 as foreseen today**	Current flexibility level	**Foreseen values at 2020**	**2020 RES objectives**	**Level of peak demand at 2020 as foreseen today**	**2020 cross-border capacities as foreseen today**
2020 RES+ scenario						

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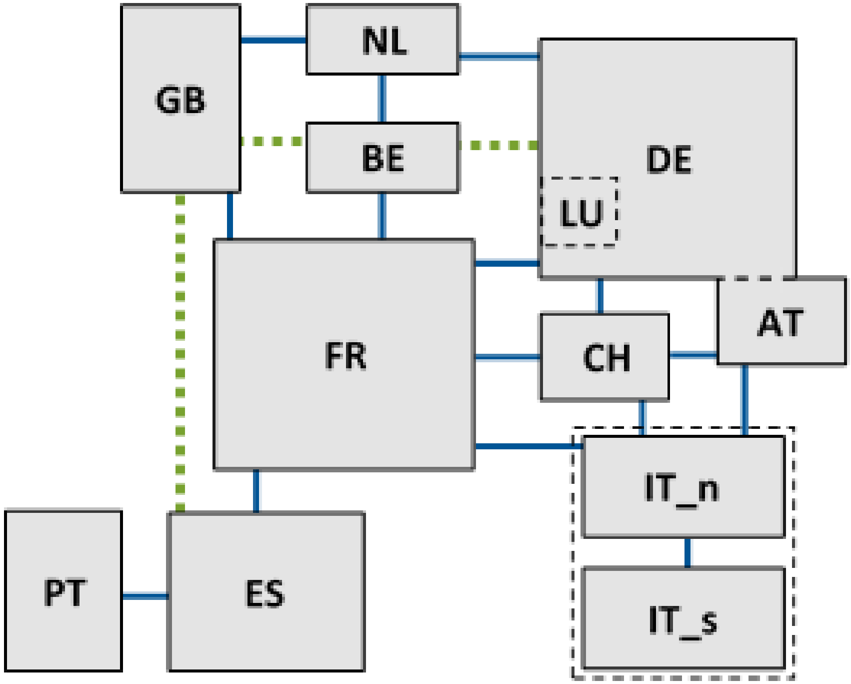
2020 standard scenario	Installed capacities at 2020 as foreseen today	Current flexibility level	Foreseen values at 2020	2020 RES objectives	Level of peak demand at 2020 as foreseen today	2020 cross-border capacities as foreseen today
2020 RES+ scenario	**Significant decrease in thermal installed capacities**	**Higher flexibility of thermal units**	**Higher CO_2 price (impact on merit order curve)**	**Additional RES capacities**	Level of peak demand at 2020 as foreseen today	2020 cross-border capacities as foreseen today

Scope of the studies

- Geographic scope of the studies



Cross-zonal interconnection capacity

New interconnections at 2020

- Period studied = **12 months**

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Modelling demand flexibility

- Here:

Demand flexibility = **Voluntary load shedding** as demand response to **day-ahead market prices**

- Two variants adopted :
  - ***Mid variant:*** **5% of the load** is shed when prices reach the **95th centile** (in other words, during the 5% of the hours with the highest prices)
  - ***High variant:*** **10% of the load** is shed when prices reach the **90th centile** (in other words, during the 10% of the hours with the highest prices)

Modelling demand flexibility

- Modelling of demand shift:
  - In principle, a certain proportion of the load which is shed during high-price hours should be shifted to low-price hours
  - Proportion hardly assessable
- Two extreme cases considered:
  - ***No demand shift (default option in OPTIMATE):*** if peak load is shed, there is **no compensation** by an increase in electricity consumption during off-peak hours
  - ***Full demand shift:*** 100% of the peak load that is shed is compensated by an **increase in consumption** during off-peak hours possibly **before** and **after** the load shedding

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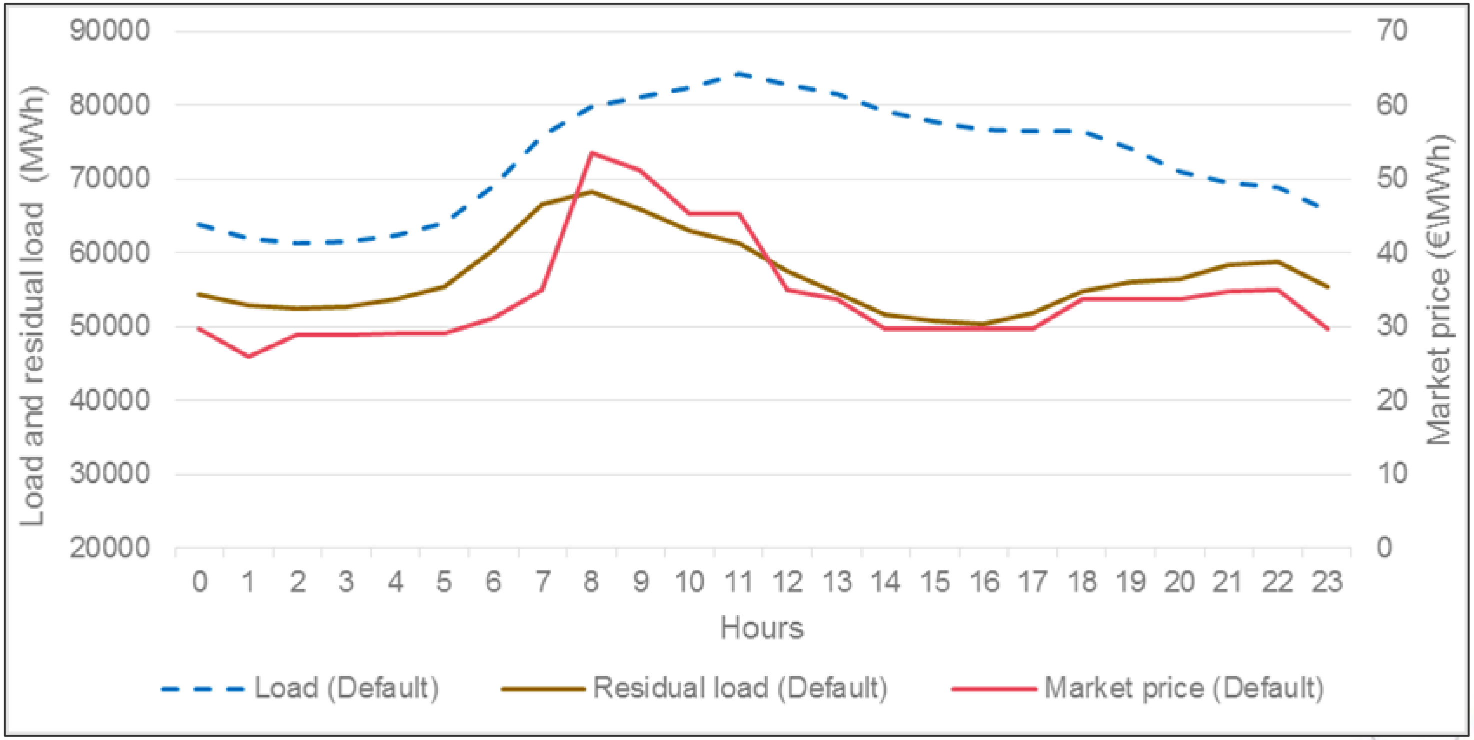
Modelling demand shifts

- Optimization program developed to model demand shift based on residual load curve
  - **Residual load** = load – non dispatchable generation
  - Demand shifts are positioned during low residual load hours (not always matching low load hours!) **before** and **after** load shedding occurs
  - Demand shifts are maximized in case of negative residual load

Modelling demand shifts

Illustration in Germany, day 180

Hourly prices correlate better with residual load than with load



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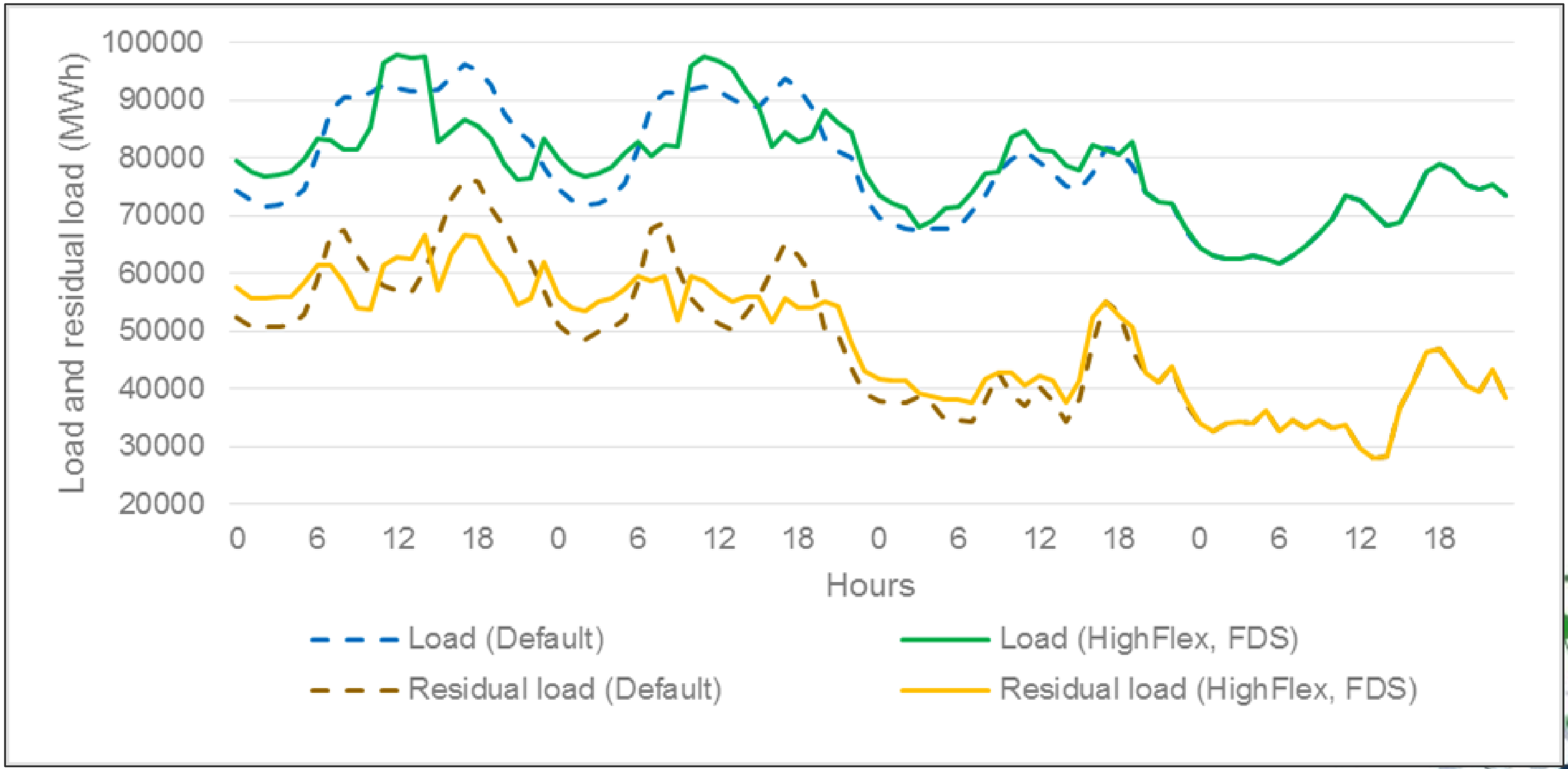
Modelling demand shifts

Illustration in Germany, days 332-336, 2020 standard scenario

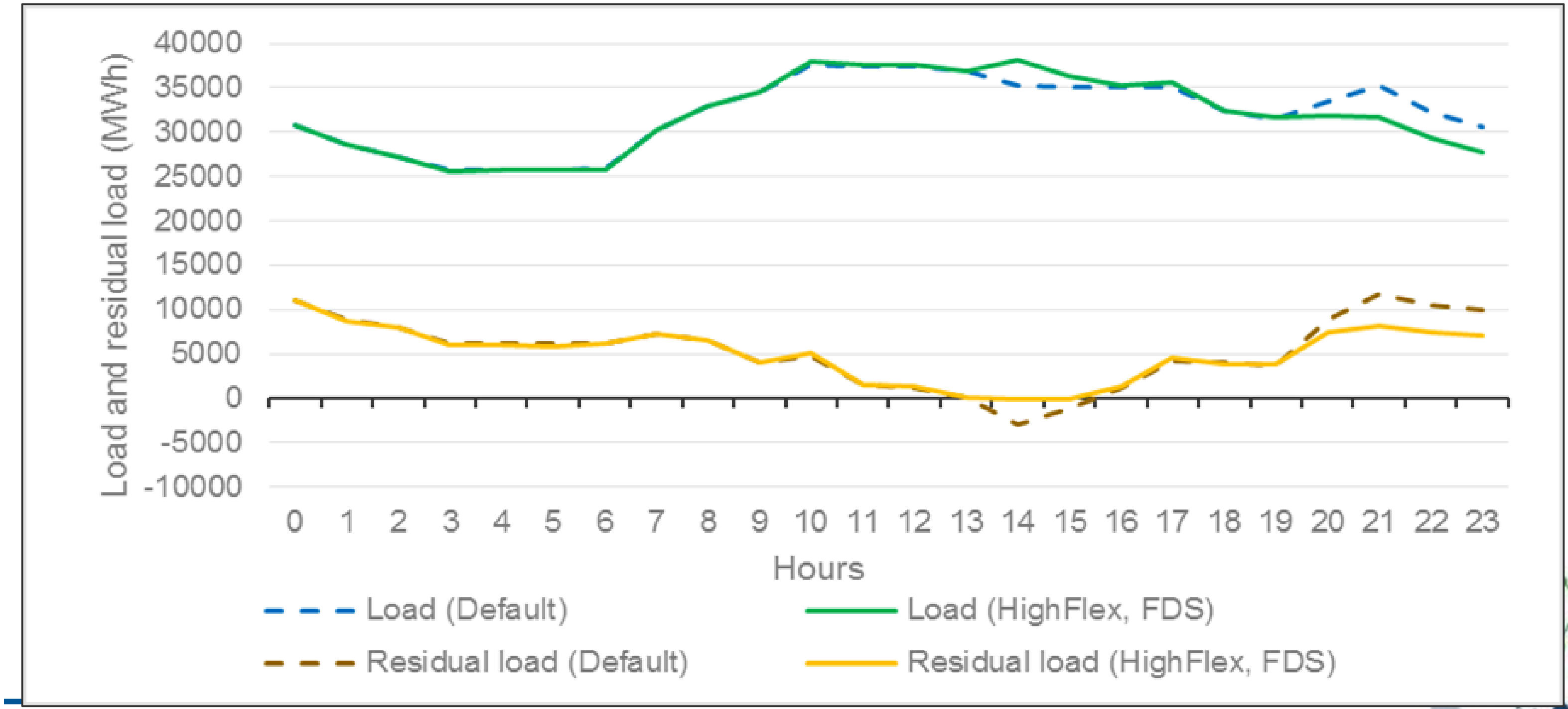
Demand shifts can create load peaks to maximize load when RES production is high



Modelling demand shifts

Illustration in Spain, day 89, 2020 RES+ scenario

The amount of demand shift during hours with negative residual load allows increasing the residual load up to zero, thus avoiding RES curtailment



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Combining demand flexibility variants with scenarios

Studies	Scenarios	Demand flexibility	Demand shift
Default cases	2013	None	-
	2020 standard	None	-
	2020 RES+	None	-
Study on demand flexibility	2013	Mid	None
	2013	Mid	Full
	2013	High	None
	2013	High	Full
	2020 standard	Mid	None
	2020 standard	Mid	Full
	2020 standard	High	None
	2020 standard	High	Full
	2020 RES+	Mid	None
	2020 RES+	Mid	Full
	2020 RES+	High	None
	2020 RES+	High	Full

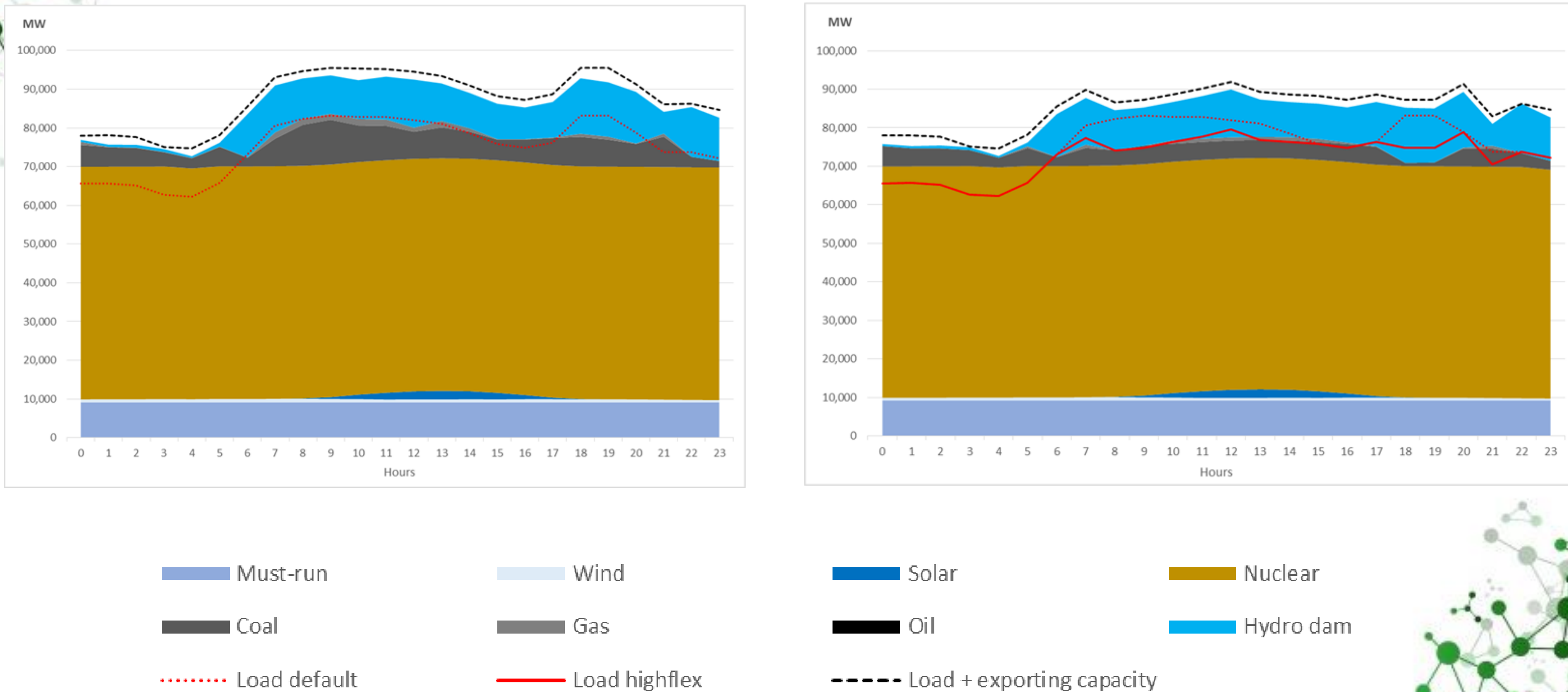
Impact of demand flexibility on the generation mix

Demand flexibility has an impact mainly on the production coming from fossil fuels. Both production from gas and coal units decrease.

- Production from gas significantly impacted in all countries; but impact limited in countries with the highest amounts of generation from gas (Italy, Great Britain, Netherlands and Germany) → *this is because in those countries gas actually is a semi-base means*
- Little impact on coal production in countries with the highest coal generation (Germany, Great Britain, Italy and Spain); higher relative impact in France and in Portugal
- Production from gas and coal units less impacted if demand shift occurs
- Impacts of load flexibility and demand shift on the generation mix closely linked with cross-border flows

Impact of demand flexibility on the generation mix

Illustration in France, day 35



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Impact of demand flexibility on costs and profits

Demand flexibility greatly impacts the thermal generation costs

- This impact increases with the development of demand response (from mid to high development) and with more RES penetration (from scenarios 2013 to 2020 standard and RES+)
- Revenues of thermal producers particularly impacted:
  - by the decrease in market prices due to load shedding (as all other producers)
  - but also by the decrease in volumes sold (while RES production remains stable)

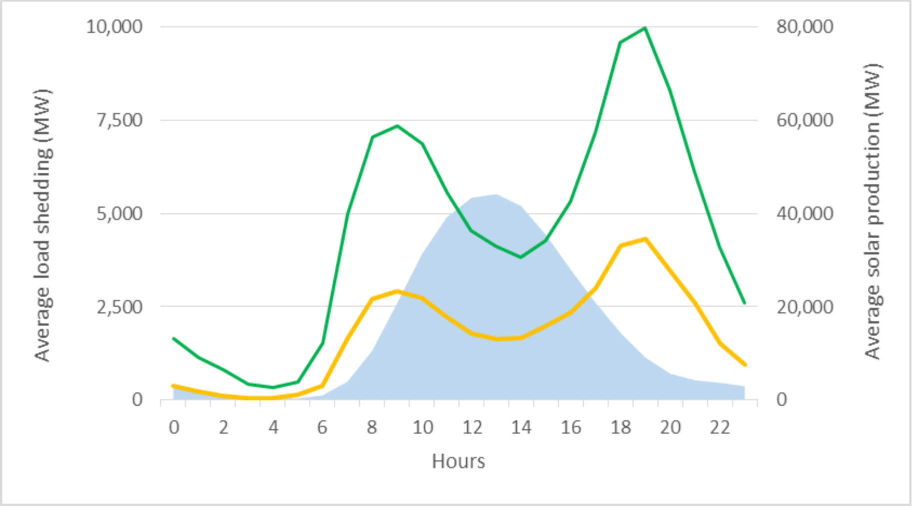
Impact of demand flexibility on costs and profits

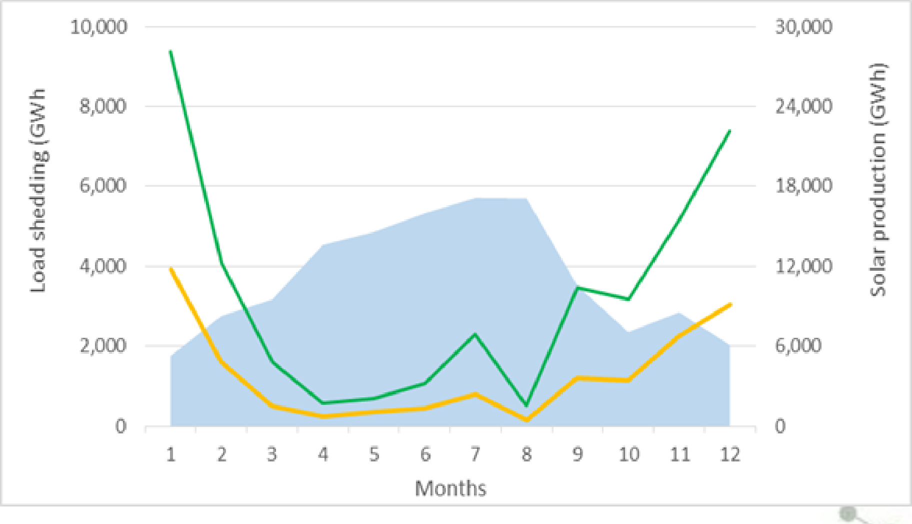
With high RES penetration (2020 scenarios), average wind producers revenues are more impacted by demand flexibility than those of solar producers

- Load shedding occurs mainly at hours with high residual load (combining consumption peaks and low RES generation) → Those hours barely correspond to solar production hours

Impact of demand flexibility on costs and profits

Average solar production (2020 standard scenario)





solar production MidFlex load shedding HighFlex load shedding

Impact of demand flexibility on market prices

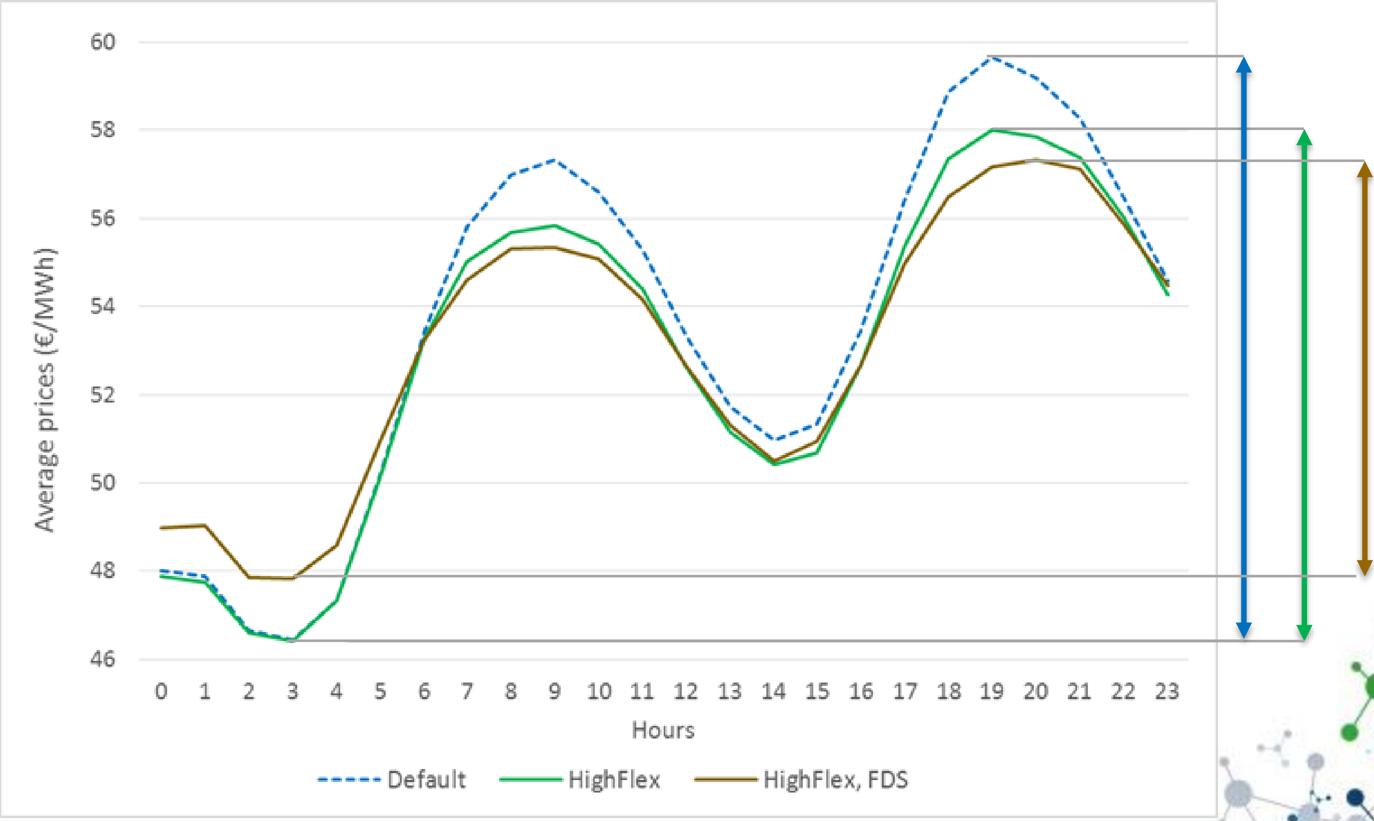
Significant impact on average market prices and major impact on the average daily spread

	2013 scenario			2020 standard scenario			2020 RES+ scenario		
	Default case	**MidFlex** *(Variation / default)*	**HighFlex** *(Variation / default)*	**Default case**	**MidFlex** *(Variation / default)*	**HighFlex** *(Variation / default)*	**Default case**	**MidFlex** *(Variation / default)*	**HighFlex** *(Variation / default)*
Average market price (€/MWh)	34.63	33.71 *-3%*	33.15 *-4%*	47.64	47.21 *-1%*	46.37 *-3%*	45.46	45.06 *-1%*	44.70 *-2%*
Average daily spread (€/MWh)	34.03	23.41 *-31%*	21.02 *-38%*	26.71	25.17 *-6%*	23.23 *-13%*	43.47	38.29 *-12%*	36.57 *-16%*

- But significant differences between countries!
- Average daily spread would be even more reduced if demand shift applies

Impact of demand flexibility on market prices

Illustration: average hourly prices in Belgium (2020 standard scenario)



Impact of demand flexibility on CO_2 emissions

Demand flexibility has an important impact on CO_2 emissions compared to the proportion of load shed

- Within our hypotheses, between **10 and 39 million of tons (Mt) of CO_2 would be saved each year**, representing 0.7% to 3.7% of the total CO_2 emissions from power generation
- The distribution per country of these savings depends on the impacts on fossil fuel generation
- The existence of demand shift would allow lower savings, from 5 to 29 Mt depending on the different scenarios cases studied

Impact of demand flexibility on cross-border market integration

Demand flexibility causes a general increase of cross-border flows. Cross-border interconnections are used closer to their full capacity.

- The average price differential magnitude drops: price peaks being shaved, price differentials between countries are also reduced, on average
- The occurrence of price convergence significantly decreases. This means that even if on average, prices are closer to each other, they are less often equal!
- The congestion revenue decreases

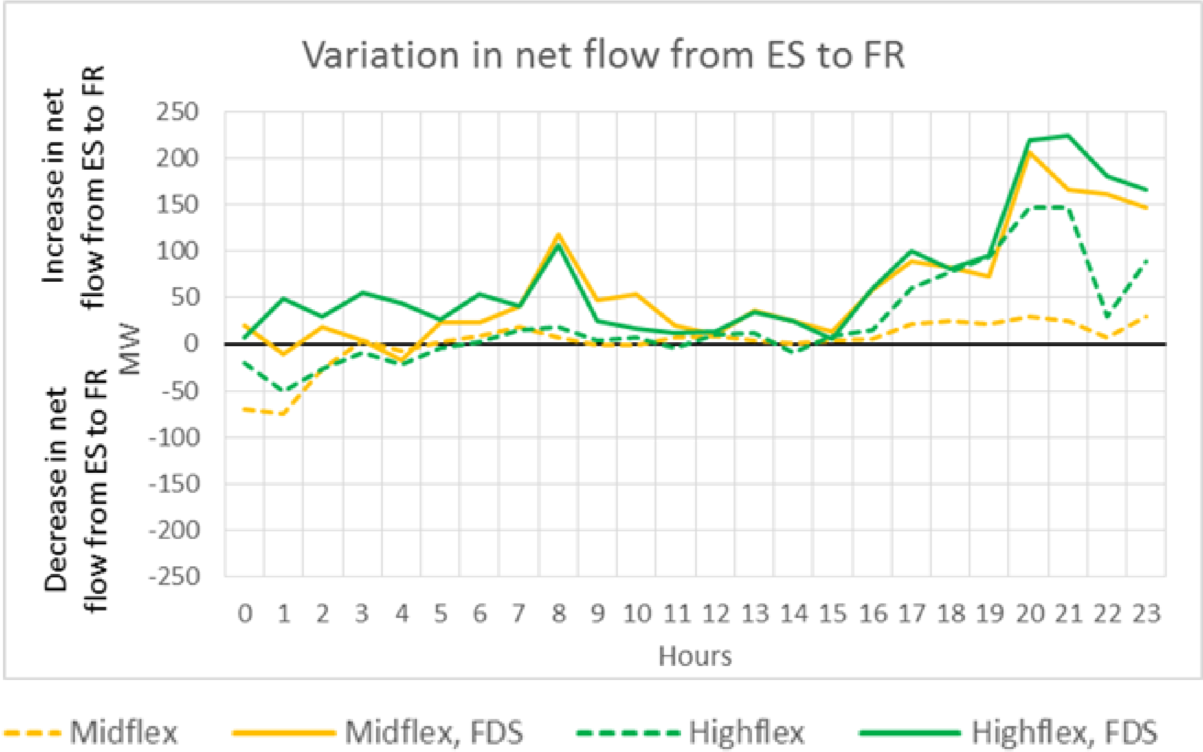
Impact of demand flexibility on cross-border market integration

On individual borders, the impacts of load shedding possibly combined with demand shift vary a lot

- **Countries with high interconnection capacities**: load shedding and demand shifts partially compensated by domestic production, the rest being addressed by an adaption of cross-border flows
- **Electric peninsulas**: load shedding and demand shifts compensated mainly with an adaptation of the domestic production

Impact of demand flexibility on cross-border market integration

Illustration: Average hourly variation in cross-border flow between Spain and France, when load flexibility and demand shift apply (2013 scenario)



Market RES

Detailed results available on Market4RES website!

- **See detailed and quantified results of the study on demand flexibility in the report D4.3** "Quantification of the expected impacts coming from evolutions of RES support schemes and demand flexibility (Final report)"
- See results of the OPTIMATE study about the **impact of RES support schemes on short-term market outcomes** in **D4.2** "Intermediate report"
- **Detailed methodology and specifications** for both studies presented in the report **D4.1** "Specifications of the most adequate options for flexibility markets and RES support schemes to be studied in a cross-border context"

→ All reports available at http://market4res.eu/!

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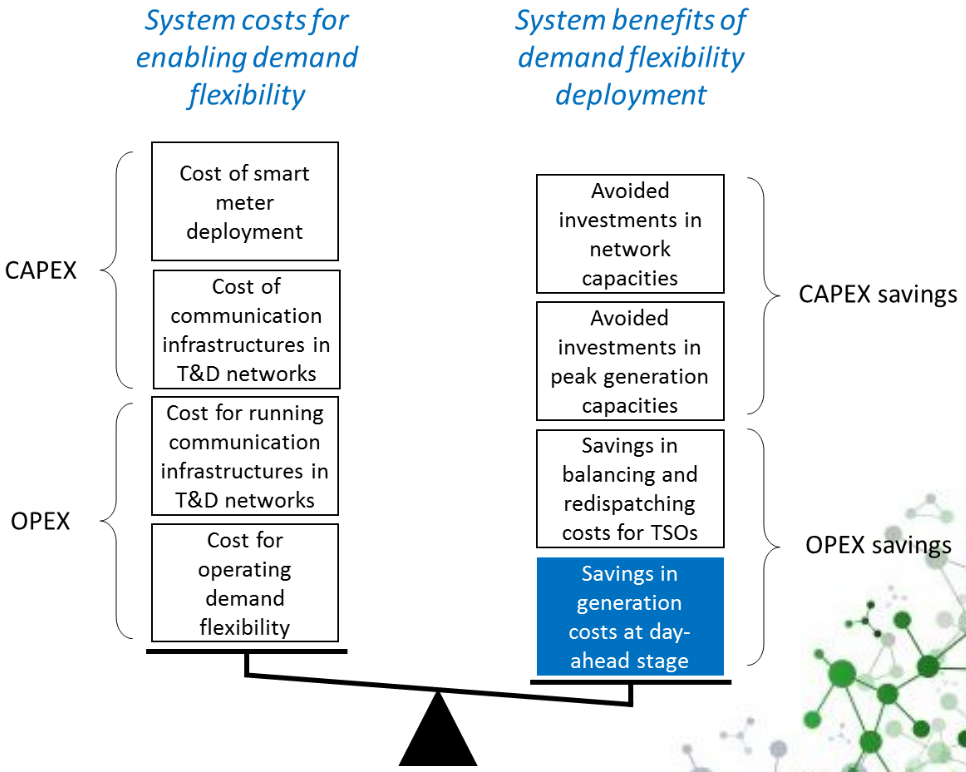
Conclusions

- Quantifying demand response impacts on short-term market outcomes is challenging
  - Results highly depend on initial assumptions, scenarios…
  - Participation in day-ahead markets have been assessed, while demand response could also participate in
    - shorter-term markets
    - ancillary services
    - capacity markets



Conclusions

- The Market4RES project has also studied:
  - The status of demand response in Europe
  - The different market design options related to demand response
  - The barriers to its deployment

- Synthesis of those analyses and recommendations will be provided in D6.1.1 report to be published soon

  "Report on the Roadmap for RES penetration under the current Target Model high-level principles (2014-2020). Part 1: recommendations about RES support schemes and demand flexibility"

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Thank you very much for your attention

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Coordinated by SINTEF

Info: Market4RES@sintef.no
Results and news: www.market4RES.eu

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