



Final Public Workshop

**Unlocking Flexibility Potential of
Multi-Energy Systems
Main Results and Lessons**

17 March 2021

Remote connection



This project has received funding from the European Community's H2020 Framework Programme under grant agreement No 774309



Regine Belhomme, EDF

OPENING OF THE WORKSHOP



Rules of participation

- Keep yourself on mute if you are not speaking
- Use of cameras not necessary
- Use the question box or the chat feature for any questions or comments you may have



Regine Belhomme, EDF

INTRODUCTION TO THE MAGNITUDE PROJECT



Why flexibility?

Expected evolutions of the electricity system...

- EU targets: reduction of greenhouse gas emissions, integration of renewables, increased energy efficiency
- Electrification of energy usages (e.g. electric vehicles, heat demand, etc.)

Risks in terms of: quality and security of supply, congestion, system stability, curtailments, system adequacy, etc.

Needs:

- **more flexibility and active involvement** of all the stakeholders at all levels
- service provision capabilities of **both centralized and decentralized resources** in a coordinated way (incl. consumers and producers resources).

Enhanced synergies between different energy carriers:

- **provide flexibility** to the electricity system
- **drive efficiency** and **business innovation** in the energy sector



The MAGNITUDE project

Project target: develop

- **optimization** and **coordination tools**
- **business and market mechanisms**

to provide **flexibility** to the European electricity system, by enhanced **synergies between electricity, gas and heating/cooling systems.**

- Support **cost-effective integration of renewables** and enhance **security of supply**
- Bring under a **common framework**, technical solutions, market design & business models
- Contribute to **ongoing policy discussions** in the energy field

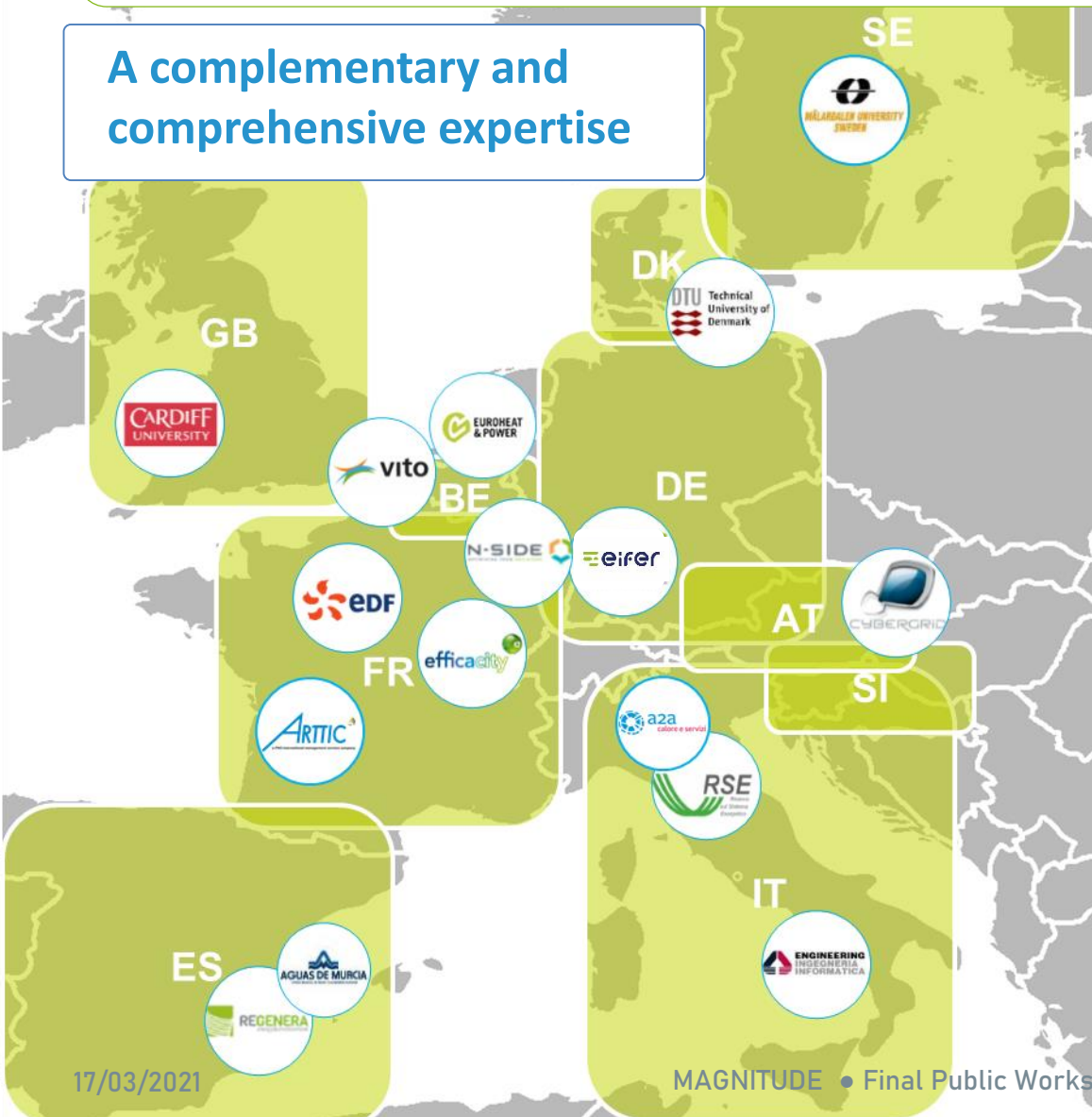
MAGNITUDE is a Horizon 2020 European project

- Research and Innovation Action
- Duration: 10/2017 → 05/2021
- Coordinator: EDF
- EC funding: 4 M€



Consortium: 16 partners from 9 countries

A complementary and comprehensive expertise



Organisation profile	
	International utility
	Retailer
	Industrial association
	Local multi utility
	Local utility
	Aggregation solution provider
	Data solution provider
	Market solution provider
	Consulting/research
	Consulting/research
	Consulting/research
	Consulting/research
	University
	University
	University

17/03/2021

MAGNITUDE • Final Public Worksh



Multi-energy systems: 7 real-life case studies

Main MES categories

- Large industries
- District heating/cooling networks
- Distributed units

3 main flexibility levers

- Fuel shift
- Storage capability
- Demand response

7 countries

- Austria, Denmark, France, Italy, Spain, Sweden, United Kingdom



Different regulatory frameworks, core businesses, sector-coupling technologies, stakeholders and business models

Mälarenergi Sweden	District heating and cooling networks
Paper mill Austria	Integrated pulp and paper mill
HOFOR Denmark	Distributed units at consumers' + district heating network
ACS Italy	Milan district heating network
Neath Port Talbot , UK	Steel industry, CCGT and large RES
EMUASA Spain	Wastewater treatment plant
Paris Saclay France	District heating & cooling networks + distributed units in substations



Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Other market
participants

E - Market
or Service
layers

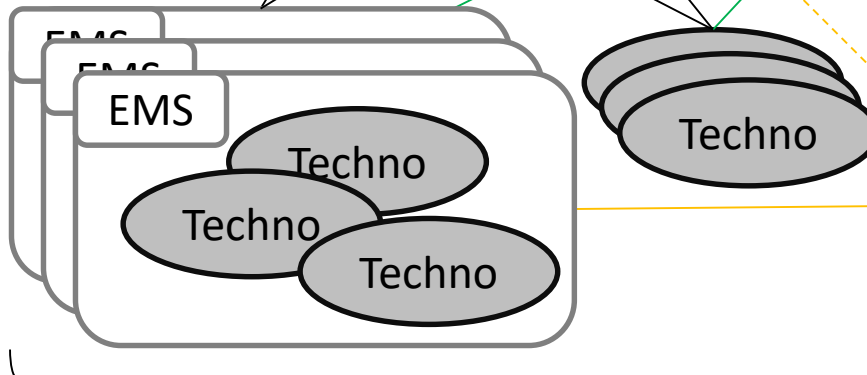
Aggregation

G - Market
or Service
layers

Gas system
stakeholders

H - Market
or Service
layers

Heat system
stakeholders



Multi-energy systems (MES)



Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Other market
participants

E - Market
or Service
layers

Aggregation

G - Market
or Service
layers

Gas system
stakeholders

EMS

EMS

Techno
Techno
Techno

Techno

Multi-energy systems (MES)

Multi-energy systems

- **Actual flexibility providers**
- Optimisation and control
- With or without **EMS** (Energy Management system)
- Mainly connected to **distribution networks**



Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Other market
participants

E - Market
or Service
layers

Aggregation

Aggregation

- **Pooling the flexibility** of MES and DERs (distributed energy resources)
- **Offers** to the electricity markets and service buyers
- **“Deregulated” player:** retailer, Balance Responsible Party,... or a separate player

Heat system
stakeholders

EMS

Techno

Techno

Techno

Techno

H - Market
or Service
layers

Heat system
stakeholders

Multi-energy systems (MES)



Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Electricity markets & service procurement

Different market layers and associated services

- **Day-ahead and intraday** energy markets
- **Balancing and frequency** regulation services for TSO: FCR, aFRR, mFRR
- **Congestion** management
- **Capacity** requirement mechanisms

Other market participants

E - Market
or Service
layers

Aggregation

EMS

Techno

Techno

Techno

Techno

H - Market
or Service
layers

Heat system
stakeholders

Multi-energy systems (MES)



Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Other market
participants

E - Market
or Service
layers

Gas and heat/cooling markets and/or services

- MES stakeholders **procure and/or provide** heat/cooling and/or gas
- MES stakeholders may also **provide services**

G - Market
or Service
layers

Gas system
stakeholders

H - Market
or Service
layers

Heat system
stakeholders

Multi-energy systems (MES)



Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Multi-carrier markets

- **Innovative market designs**
- **Focus on day-ahead energy markets**

Other market participants

E - Market
or Service
layers

Aggregation

G - Market
or Service
layers

Gas system
stakeholders

EMS

EMS

Techno

Techno

Techno

Techno

H - Market
or Service
layers

Heat system
stakeholders

Multi-energy systems (MES)

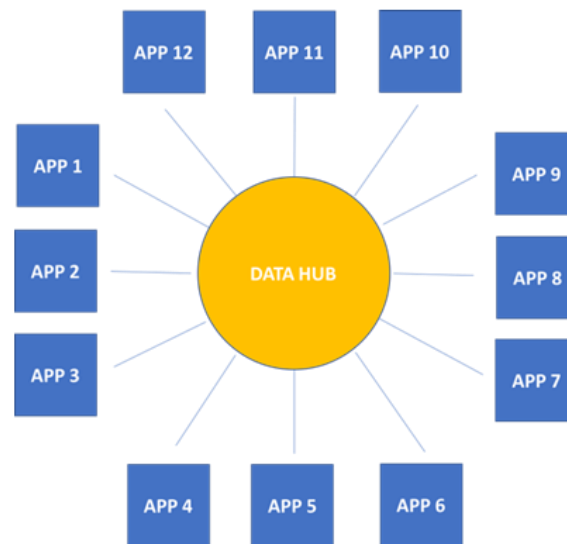
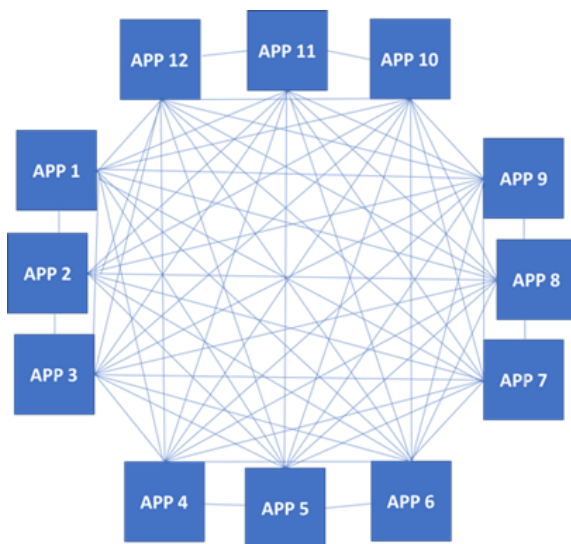


Electricity system stakeholders
Service Buyers

MAGNITUDE approach

Other m
partici

Multi-energy data hub and interoperability layer



system
holders

t system
keholders

Multi-energy systems (MES)



Main results - Deliverables

- MAGNITUDE technical and commercial **functional architectures** **D2.1**
- **Flexibility services** provided by MES to electricity system **D3.1**
- **Flexibility capabilities** of cross-sector technologies and MESs **D1.1, D1.2, D1.3**
- Models and tools for **simulation and optimization** of control strategies of technologies and **MES** to maximize flexibility provision **D4.1, D4.2, D4.3**
- **Aggregation** of flexibilities of decentralized MESs **D5.1, D5.2, D5.3, D5.4**
- **Innovative market designs** for synergies maximization, implemented on a **market simulation platform** **D3.2, D3.3, D3.4**
- **Assessment** of integrated system (MES, aggregation, market) and **replicability** **D6.1, D6.2, D1.4**
- **Business models** for MES and aggregator **D3.5**
- **Multi-energy data hub** and interoperability layer **D2.2, D2.3**
- **Lessons learnt, policy strategy and recommendations** in a pan-European perspective **D7.3, D7.4**



Agenda

9:25 - ACS case study – E. Corsetti, RSE

- **Ability of Multi-Energy Systems to provide flexibility – E. Corsetti, RSE**
- **The role of aggregation and trading in provision of flexibility from MES – C. Gutschi, cyberGRID**
- **Business models – Philippe Maillard, EFFICACITY**

10:10 - Overall assessment of MAGNITUDE case studies – S. Klyapovskiy, DTU

10:30 – 10:40 - Coffee break

10:40 - Innovative market designs for synergy maximization between electricity, gas and heat markets – K. Kessels, A. Virag, VITO

11:05 - Multi energy data hub and interoperability layer – D. Arnone, M. Mammina, ENG

11:35 – 11:45 - Coffee break

11:45 - Main lessons learnt from the MAGNITUDE project – R. Belhomme, EDF

12:00 - Roundtable – Feedback and outlook from real-life case studies – S. Klyapovskiy, DTU, and E. Corsetti, RSE

13:00 - Conclusion



Edoardo Corsetti, RSE

ACS CASE STUDY

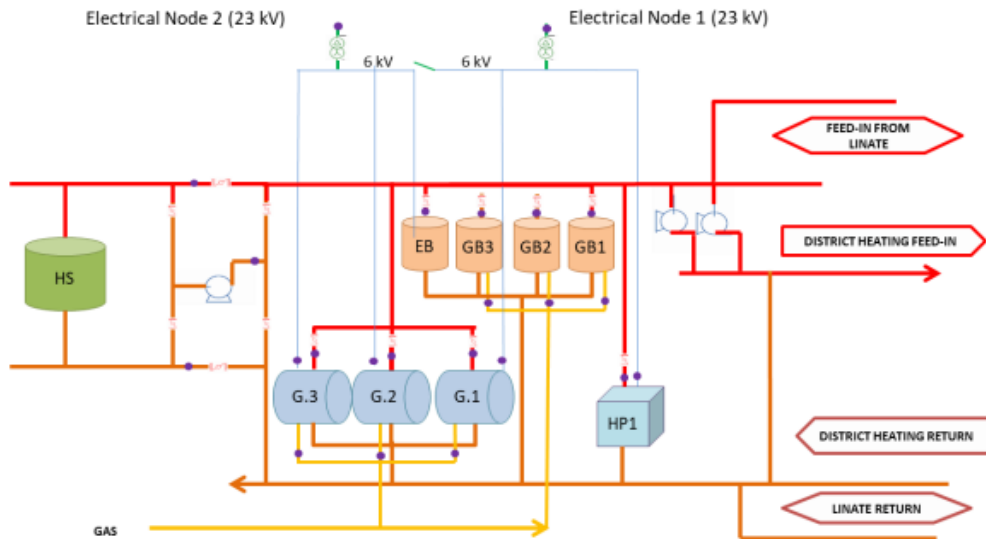


Edoardo Corsetti, RSE

ABILITY OF MULTI-ENERGY SYSTEMS TO PROVIDE FLEXIBILITY



ACS plant at glance



East Milan – DH network

~700 buildings connect

Heated volume more than 9 Mm³

Customers: dwelling, tertiary and municipality buildings (La Scala)

50% yearly heat production from CHP and HP (cogeneration, renewable)

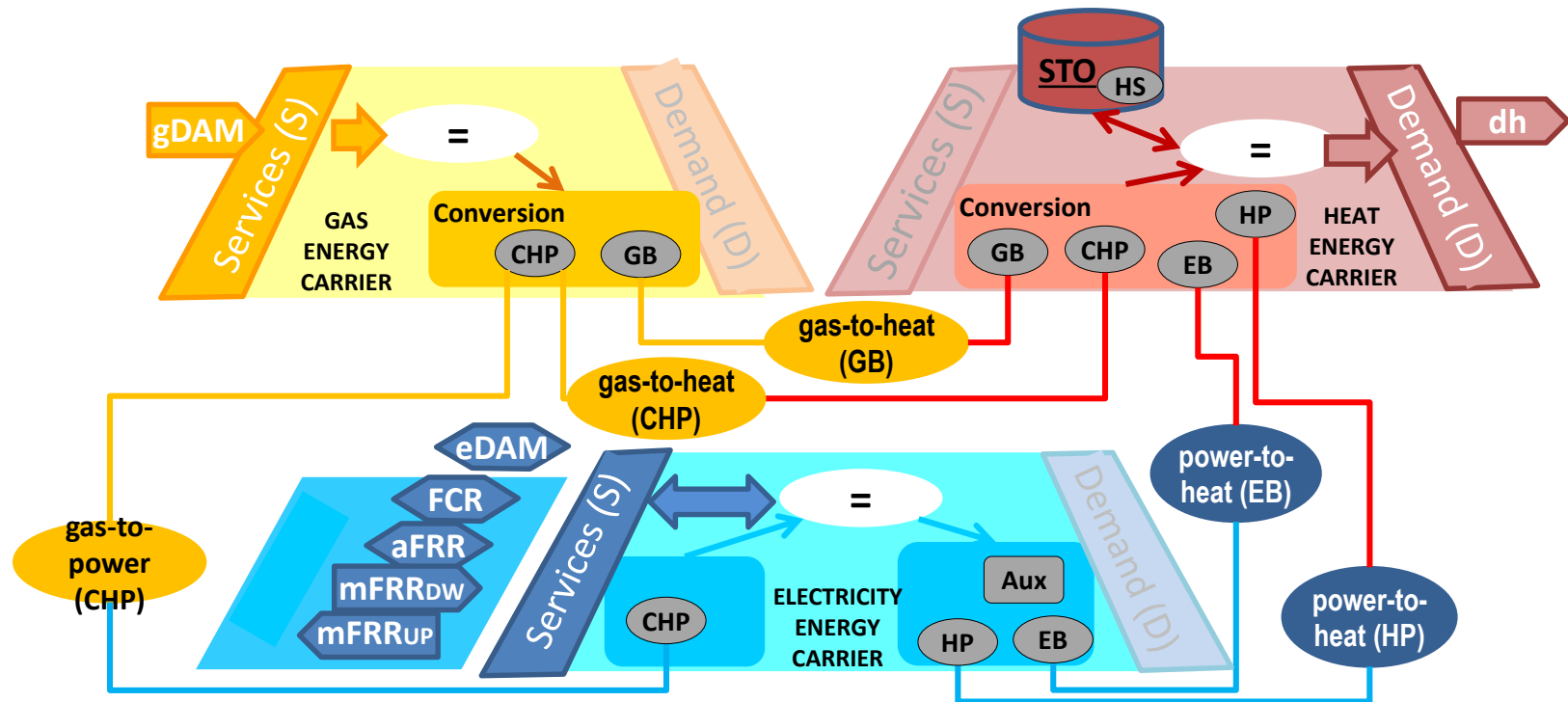
device	Pmin [MW]	Pmax [MW]
CHP (th)	2.5 (2.75)	5 (4,55)
HP	11.2	15
GB	0	15
EB	0.2	10.5
HS	0	11x2

Total electricity generation	Total heat generation (without storage)	Total heat generation (with storage)
15 [MWe] (3 CHP)	86.1 [MWt] (3CHP, 3GB, HP, EB)	108.1 [MWt] (3CHP, 3GB, HP, EB, HS)



ACS: plant, improvements and services

- The plant and the energy carriers involved



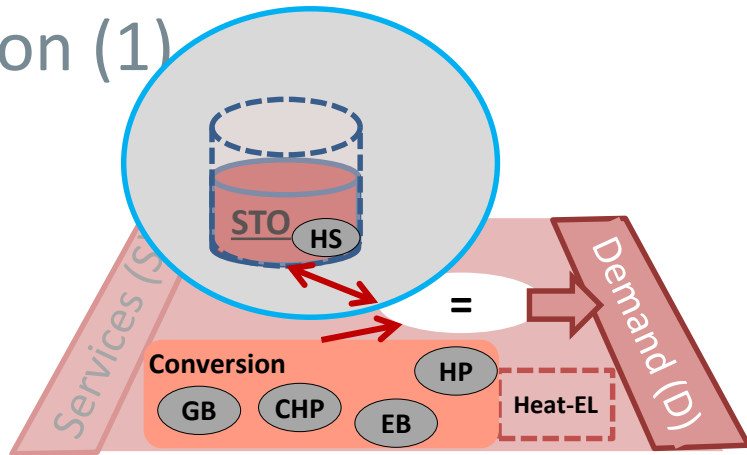


ACS: plant, **improvements** and services

- Improvement configuration (1)

- Heat storage

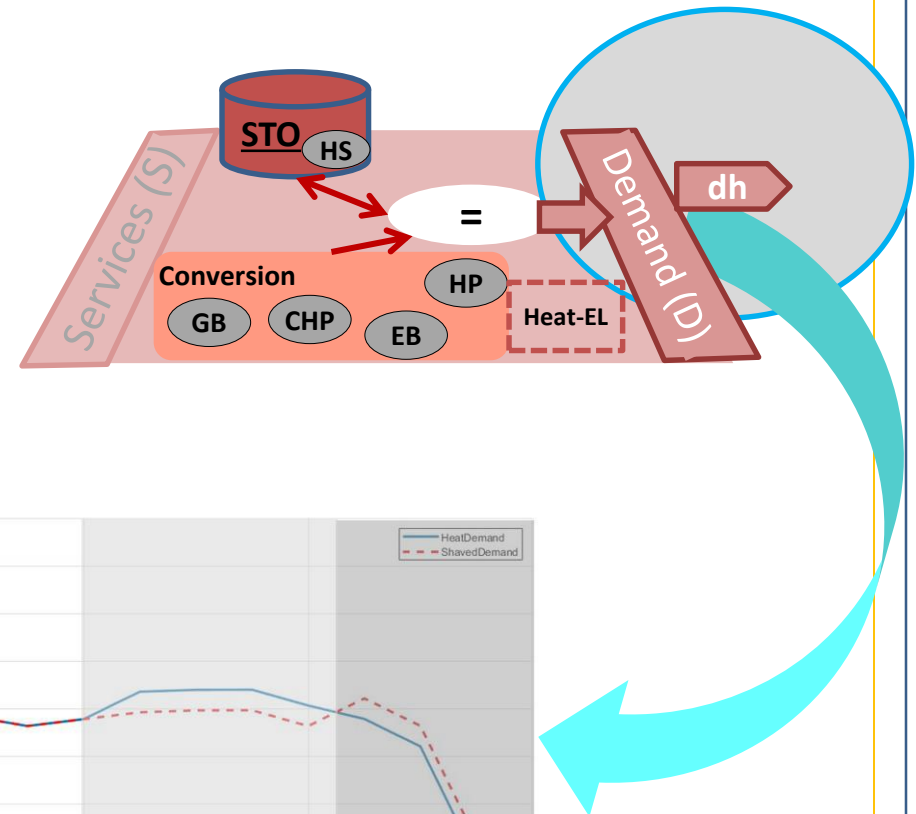
50% capacity increasing
(58 MWh \rightarrow 87 MWh)



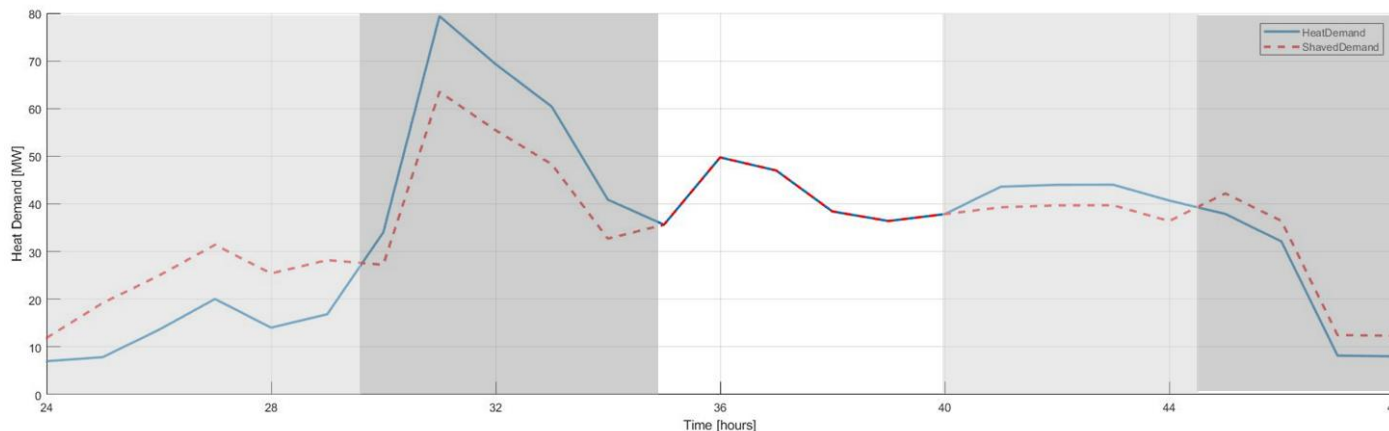


ACS: plant, improvements and services

- Improvement configuration (2)



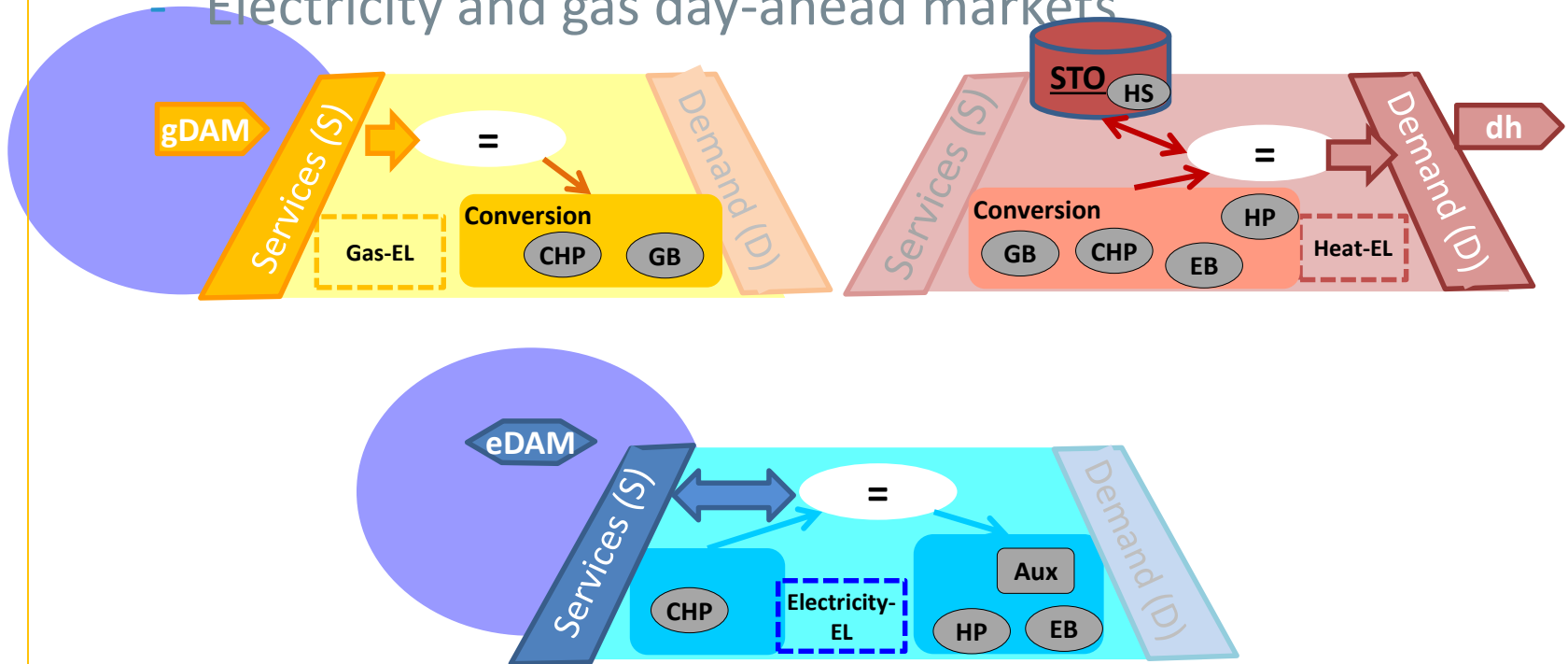
winter heat peak is shaved about 20%





ACS: plant, improvements and services

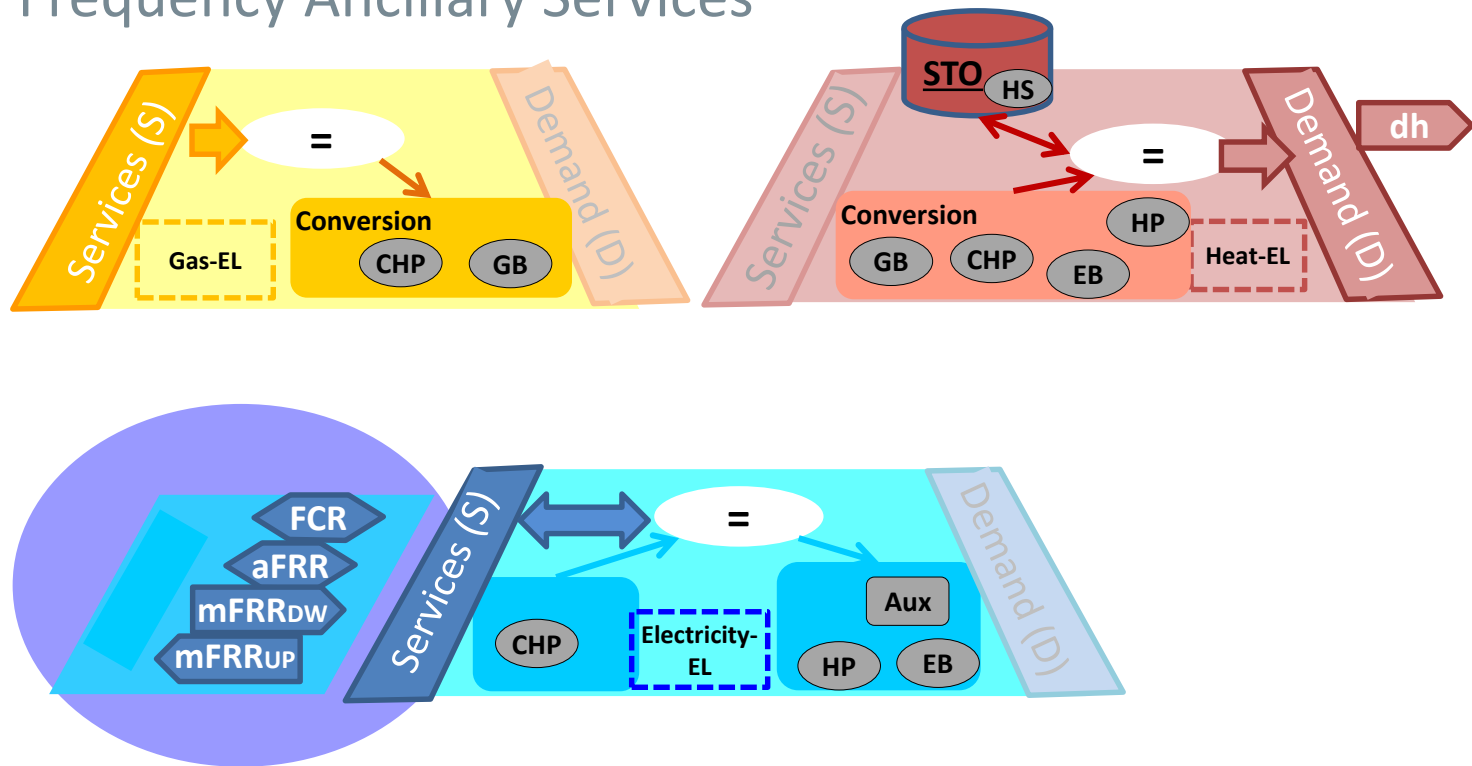
- Services (1):
 - Electricity and gas day-ahead markets





ACS: plant, improvements and services

- Services (2):
 - Frequency Ancillary Services





ACS: plant, improvements and services

- Services (2):
 - Frequency Containment Reserve (**FCR**),
 - automatic Frequency Restoration Reserve (**aFRR**) and
 - upward/downward manual Frequency Restoration Reserve (**mFRR**)
- Services are traded through the Aggregation Platform

Service	FAT (t_k^a) [s]	Call length (ψ_k) [min]	Symmetric (yes/no)	MAX Power	
				CHP [MWe]	EB [MWe]
FCR	30	60	yes	0.125	7
aFRR	200	60	yes	0.83	10
mFRR-Up	900	60	no	2.5	10
mFRR-Dw	900	60	no	2.5	10



ACS: plant, improvements and services

- Services (2):

- Frequency Containment Reserve (FCR),
- automatic Frequency Restoration Reserve (aFRR),
- upward/downward manual Frequency Restoration Reserve (mFRR-Up/mFRR-Dw)

Ramp
constraint

Service
duration
constraint

Service
shape
constraint

These services are traded through the Aggregation Platform

Service	FAT (t_k^a) [s]	Call length (ψ_k) [min]	Symmetric (yes/no)	MAX Power	
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ACS: plant, improvements and services

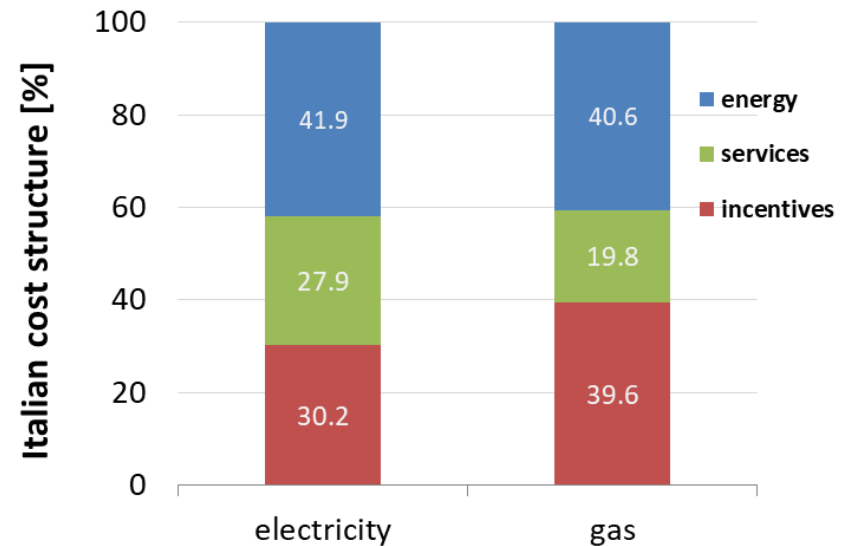
- Services: prices and costs
 - Prices remunerate for selling energy
 - Costs are due for purchasing energy carrier and ancillary services regarding importing energy.

The cost structure:

Price for energy carrier

Services, for transmission, distribution, dispatching, etc.

Incentives, for renewables, etc.





ACS: experimentation

- Scenario definition:

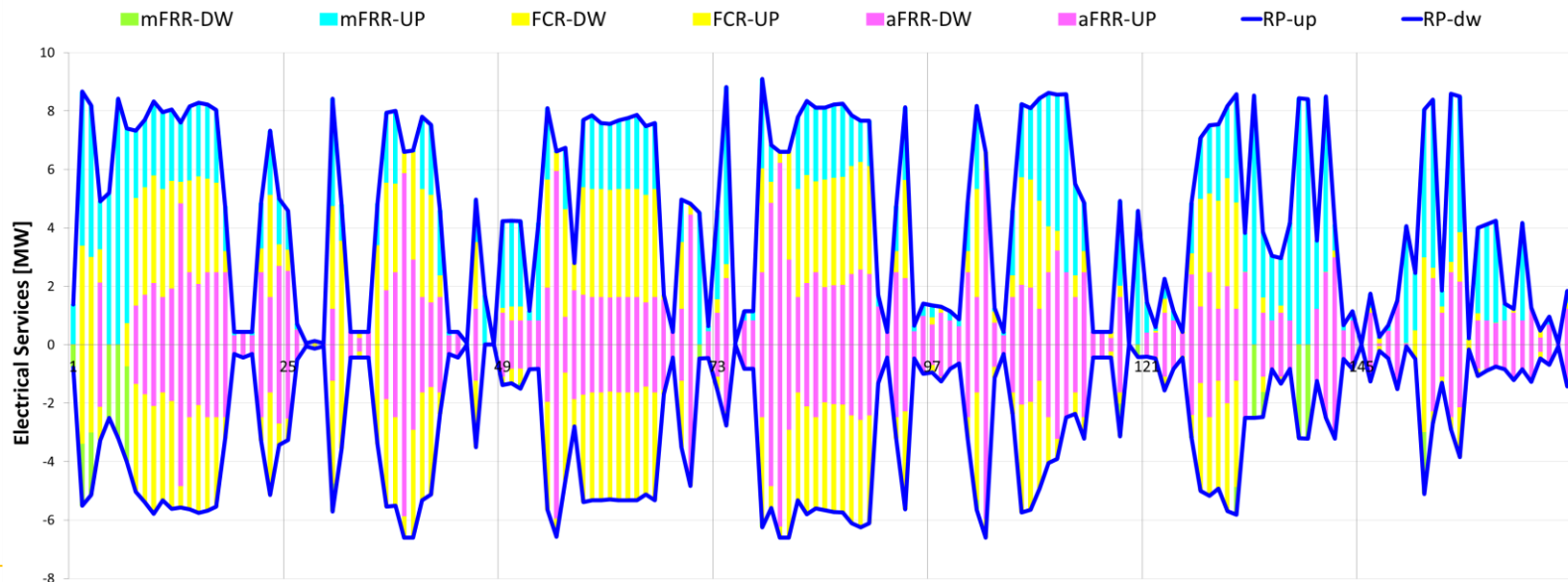
	system configurations	services
SC1	base	-
SC2	Base + 50% heat storage energy capacity increased	-
SC3	Base + winter heat peak demand shaved	-
SC4	Base + 50% heat storage energy capacity increased + winter heat peak demand shaved	-
SC5	Like SC1	ALL
SC6	Like SC2	ALL
SC7	Like SC3	ALL
SC8	Like SC4	ALL

- Data concern 6 weeks along 2019, 4 representing each yearly season and 2 representing two critical weeks (starting and stopping the district heating yearly program). Historical prices for electricity and gas were downloaded from Italian Energy market web site.



Outcome from the Algorithm

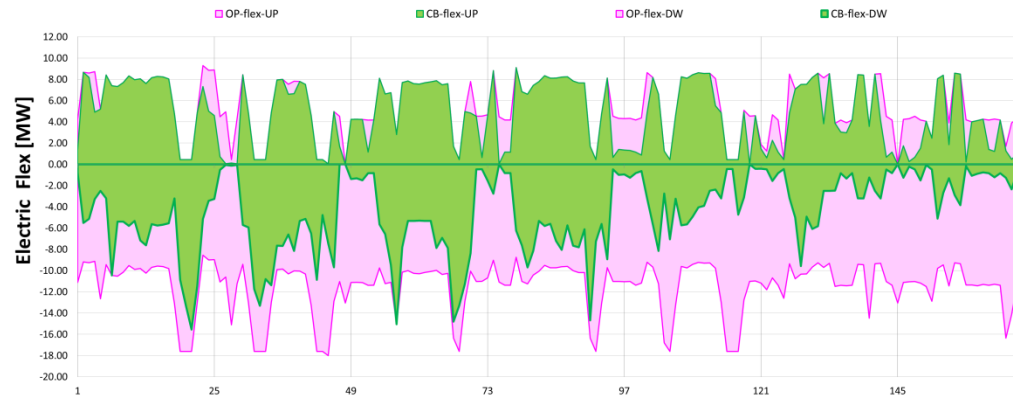
- The optimization algorithm computes in two steps the scheduling of devices and market services
 - The first stage faces the (heat) demand accessing to the day-ahead market to acquire energy deficit and sell energy surplus on the day-ahead markets (electricity and gas);
 - The second stage schedules the devices to face the (heat) demand and maximize the flexibility to exploit market services
- The goal of the algorithm is to maximize the flexibility as market product





Flexibility quantification

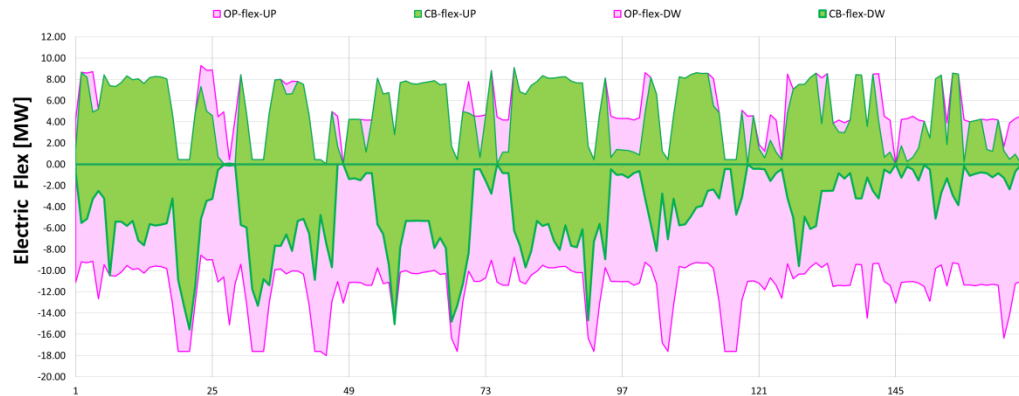
- Flexibility quantification: **operational flexibility** bounded by **balancing energy carriers constraint**



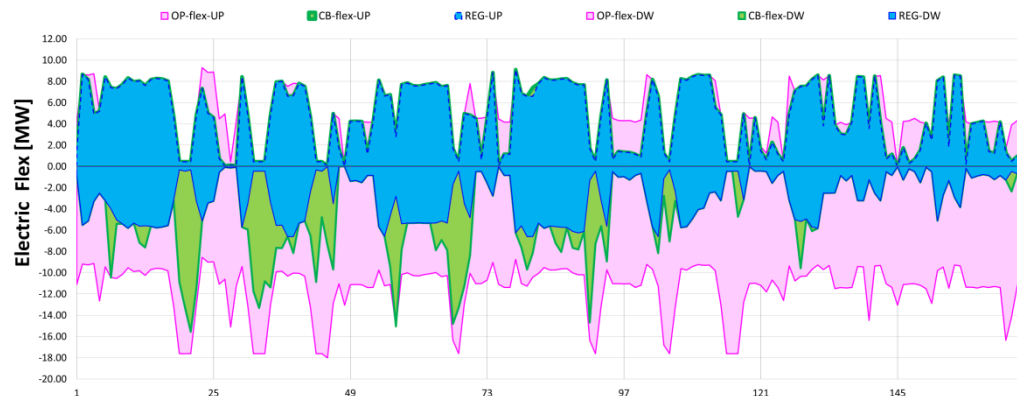


Flexibility quantification

- Flexibility quantification: operational flexibility bounded by balancing energy carriers



- Flexibility quantification: introduction of **regulatory constraints** and **market prices and costs** (historical) to set bids

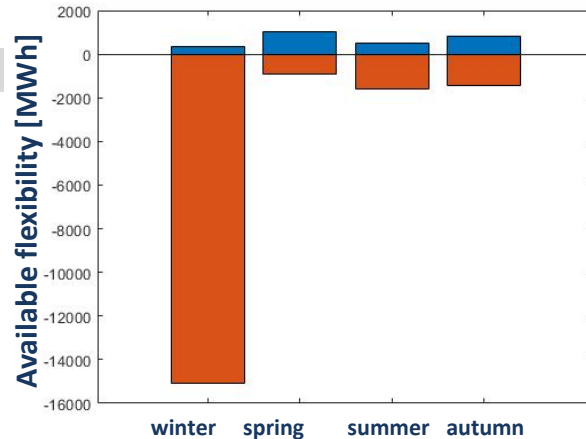




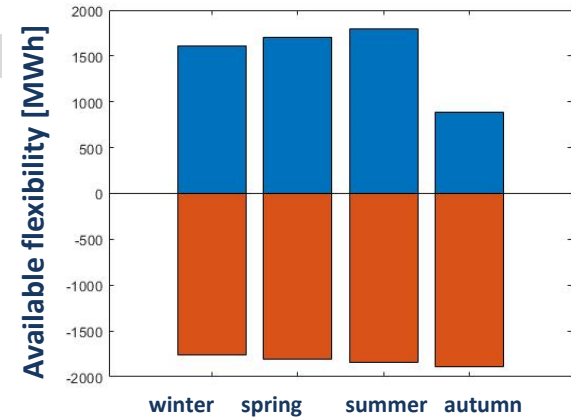
Flexibility exploitation

- (Cumulative) Upward and Downward flexibility available for product bids

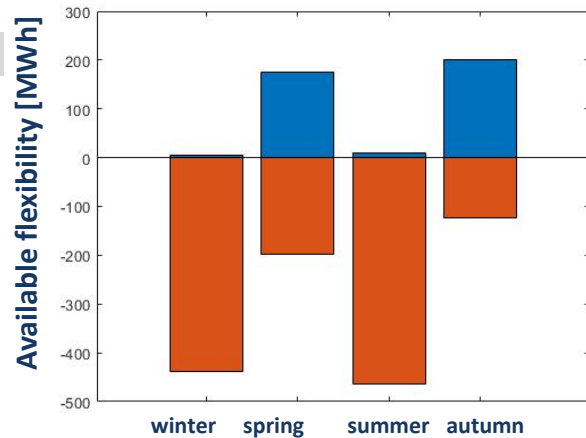
SC1



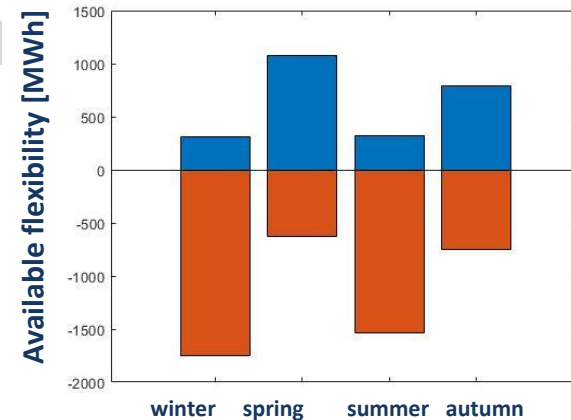
SC5



SC2



SC6

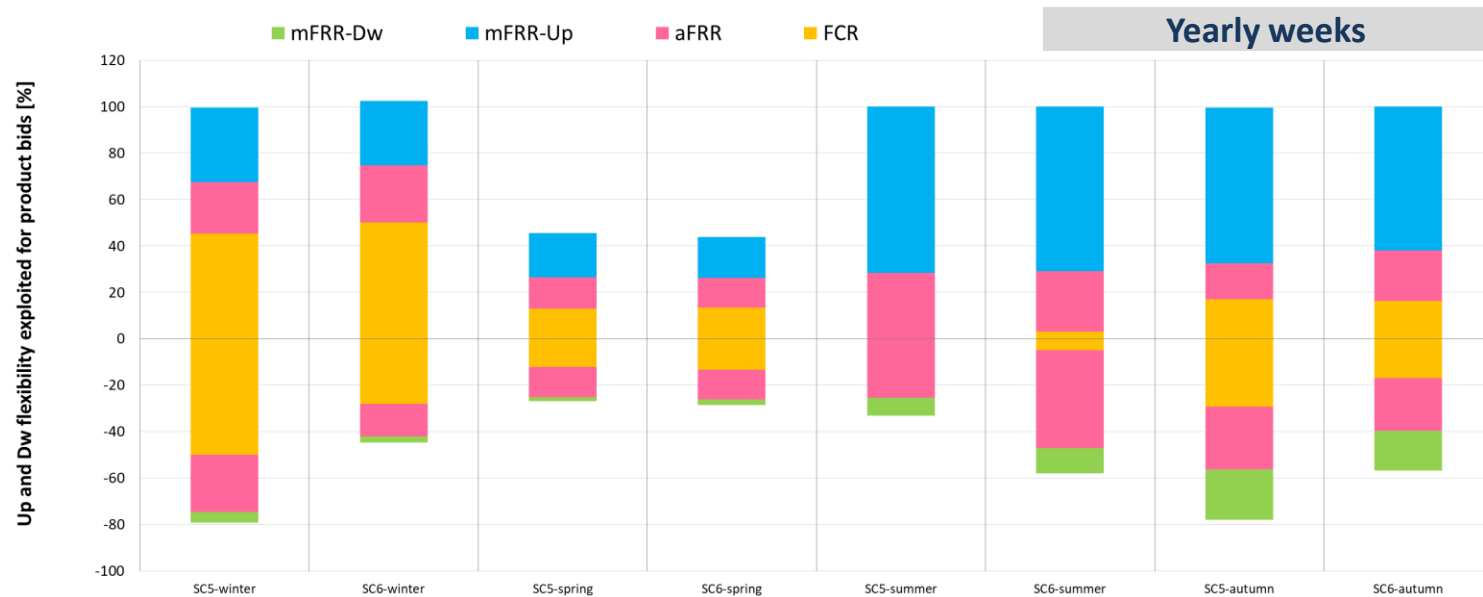




Flexibility exploitation

- Percentage of flexibility exploited for each ancillary product

mFRR-up is averagely the most selected product along the year
FCR product is greatly exploited in winter and spring weeks

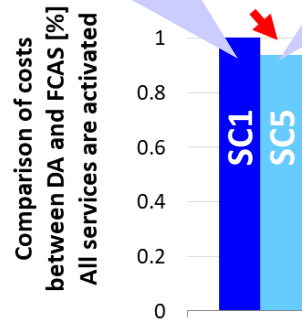




Assessment: regulation drawbacks

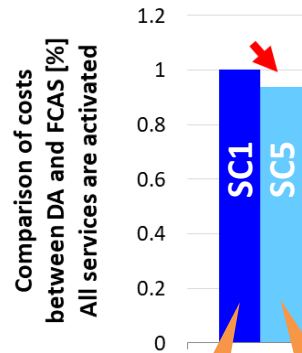
Base case with no
market service
participation
scenario

Base case with
market service
participation
scenario





Assessment: regulation drawbacks-1



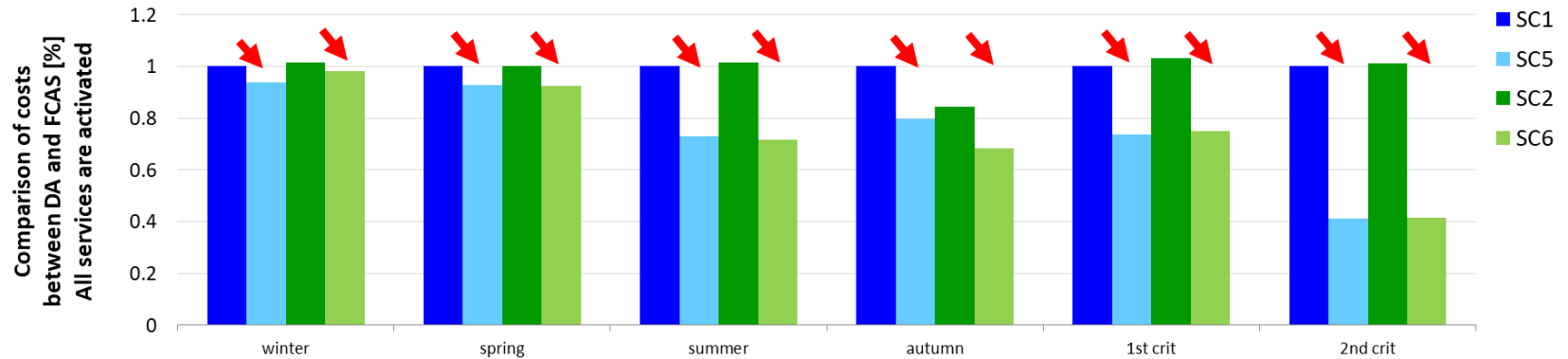
Reference cost
for day-ahead
market bids

Costs for day-ahead
market bids possibly
reduced due to
ancillary service
provision and
reduction in
production costs



Assessment: regulation drawbacks-1

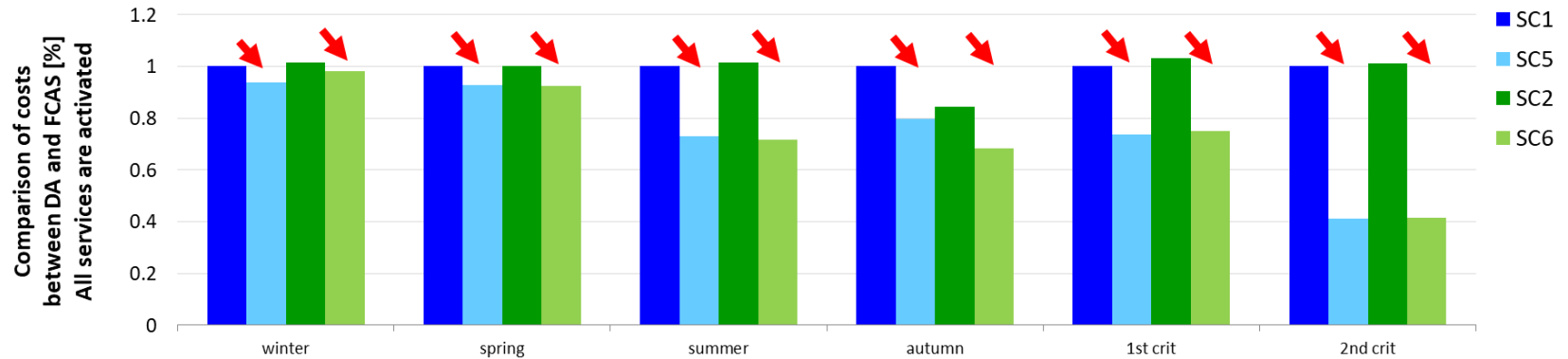
- Cost comparison: all traded services are activated, costs decrease



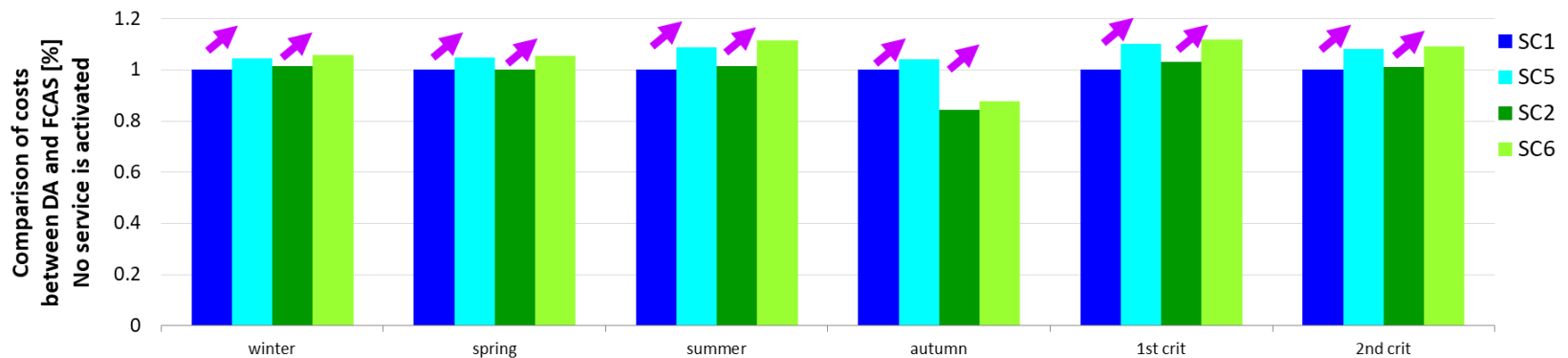


Assessment: regulation drawbacks-1

- Cost comparison: all traded services are activated, costs decrease



- Cost comparison: no traded service is activated, costs increase



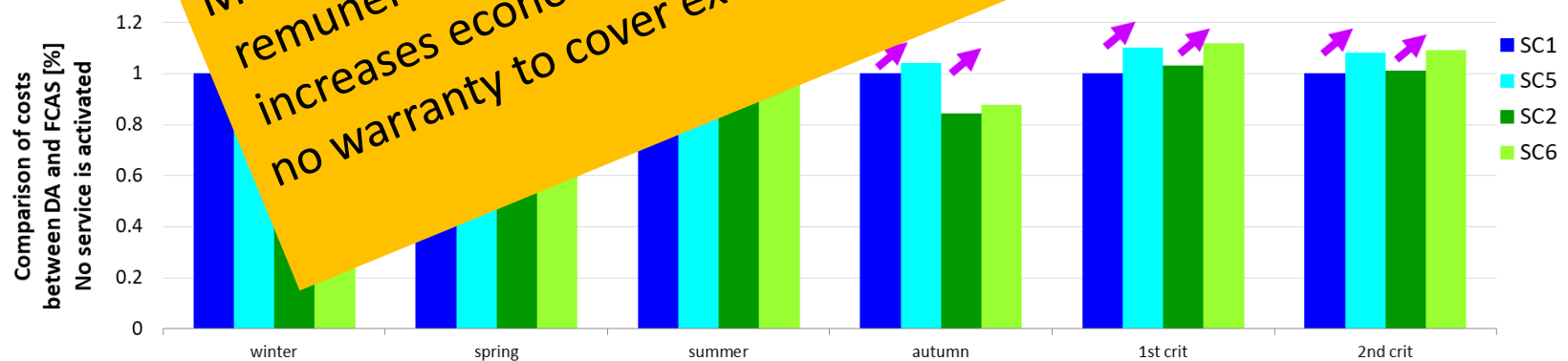


Assessment: regulation drawbacks-1

- Cost comparison: all traded services are activated, costs increase



- Cost comparison: no service is activated, costs increase



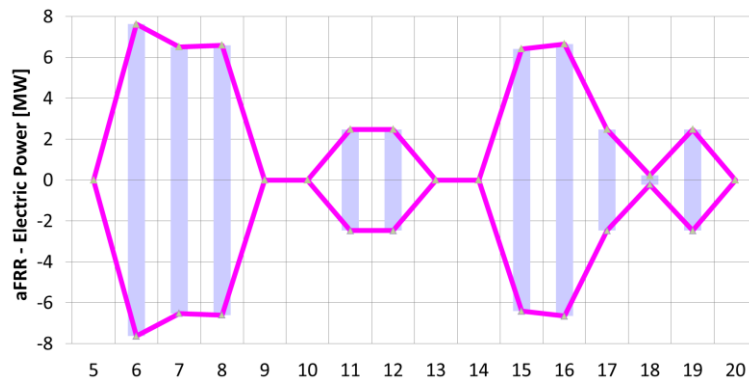
Market service participation with remuneration in energy but not in capacity increases economic-risks, no warranty to cover extra costs



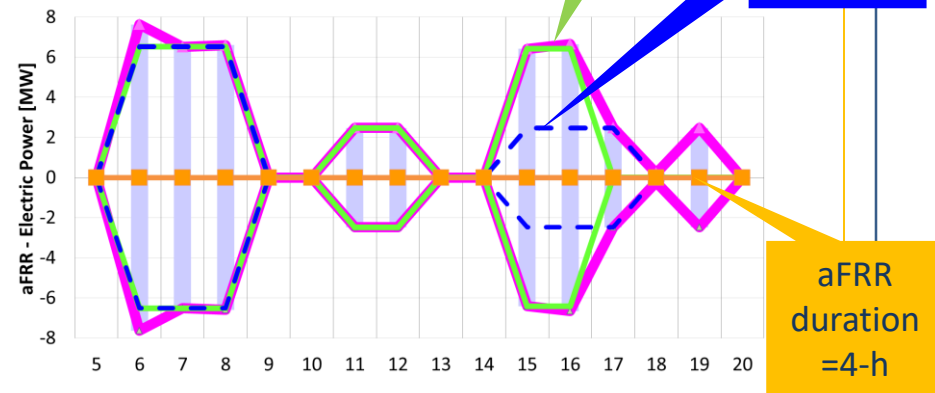
Assessment: regulation drawbacks-2

- Market service duration constraint: aFRR for example

aFRR scheduled with 1-hour service duration, as required by AP (pink line)



aFRR scheduled according several service durations:



The quantitative assessment of flexibility “remaining” in the three hypothesis compared with the aFRR 1-hour duration, gives:

aFRR with 2-hours duration, 85% remains ,

aFRR with 3-hours duration, 61% remains, and finally

aFRR with 4-hours duration no-more flexibility is provided with respect to 1-hour case



Christoph Gutschi, CYBER

THE ROLE OF AGGREGATION AND TRADING IN PROVISION OF FLEXIBILITY FROM MES

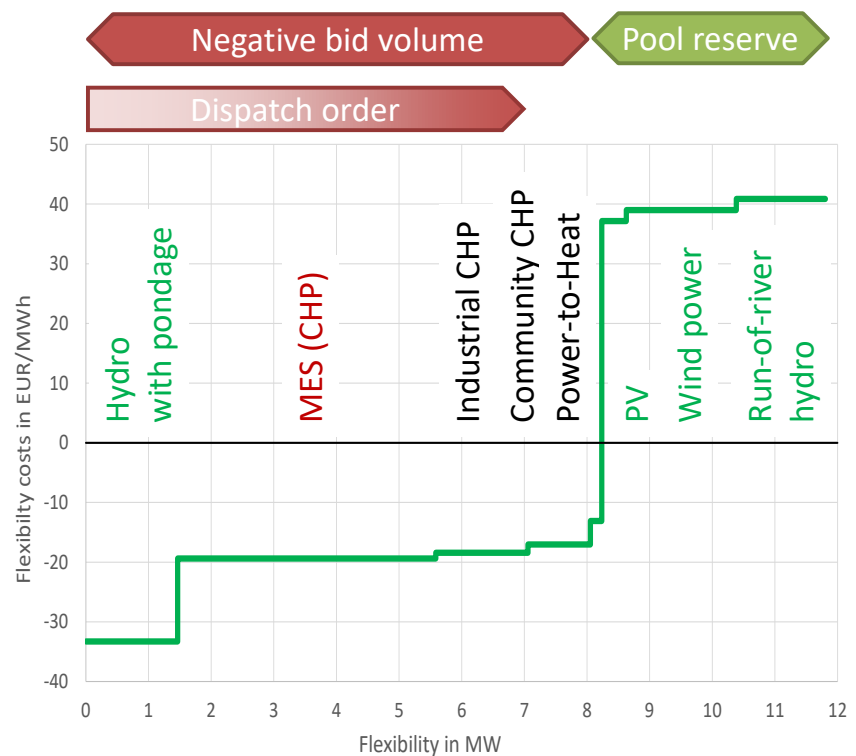
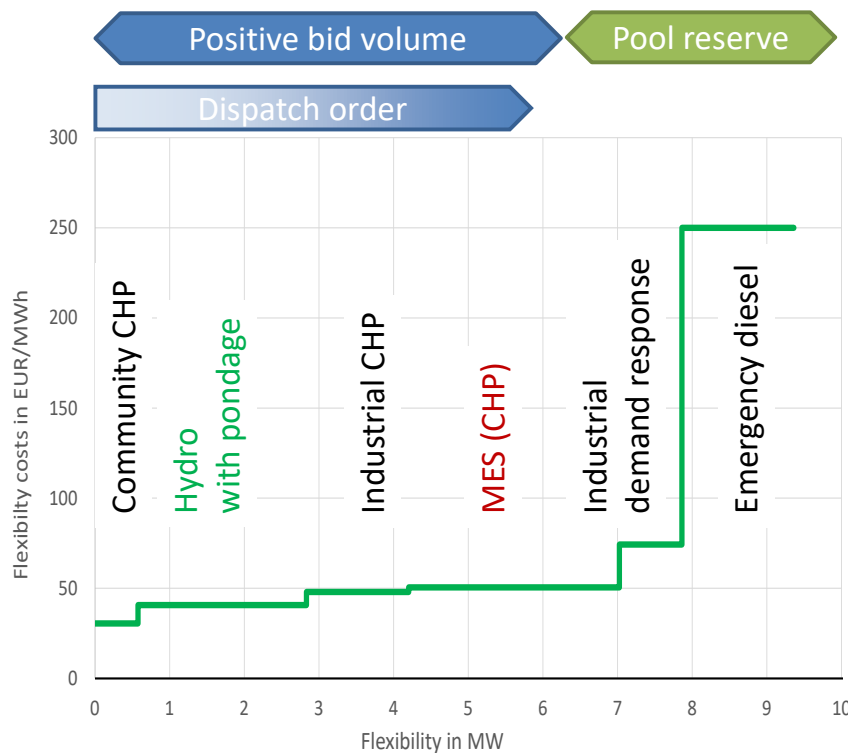


Purpose of aggregation and trading

- To generate revenues from technical flexibilities
- On markets for flexibility:
 - **FCR, aFRR, mFRR**
 - **Intraday**, Redispatch
 - Day ahead market (EMS) and capacity mechanisms (long term agreements)
- By means of aggregation
 - To overcome minimum bid size requirements
 - To share the costs of aggregation, market access and trading
 - To provide internal backup
- Taking into account the national framework.
- The Multi-energy aggregation platform algorithms include
 - Price forecasting
 - **Bid generation**
 - **Optimization of profit expectation**
 - Sizing of backup
 - Real-time dispatch
 - Revenue distribution between units of the pool.



Flexibility from MES vs. other technologies



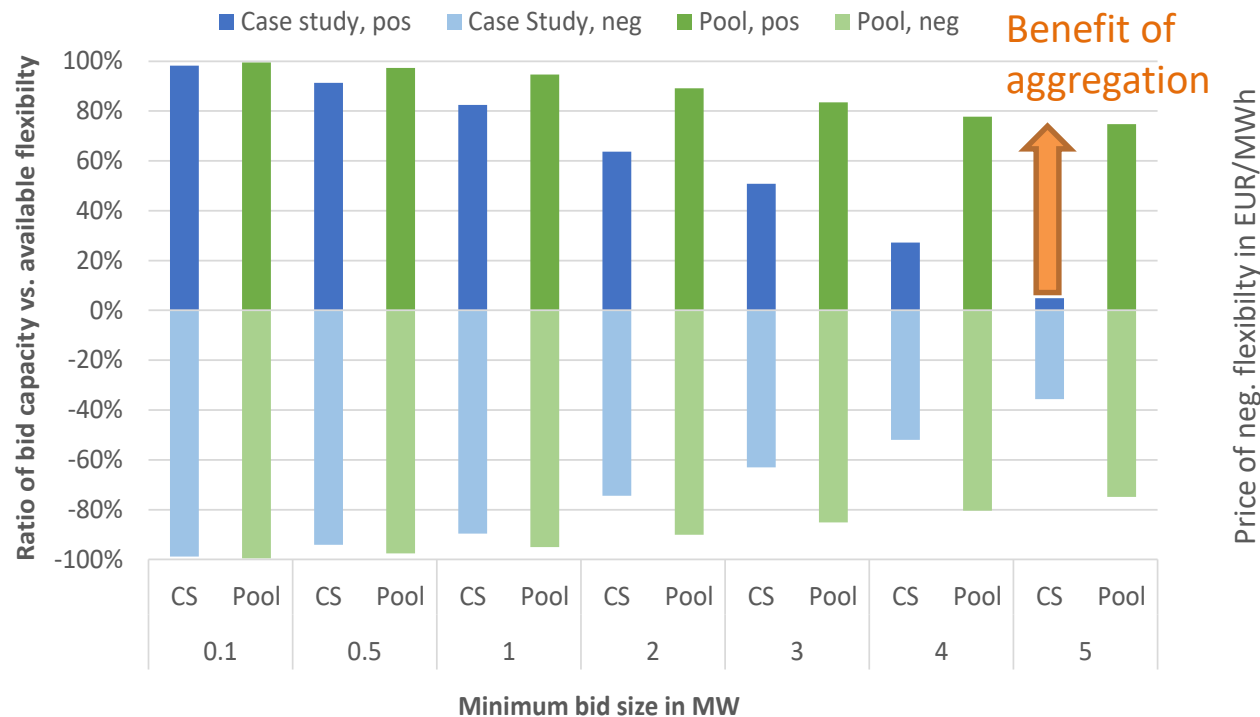
Example: aggregation pool for Austria

Flexibility provided by MES can be competitive compared to other technologies.

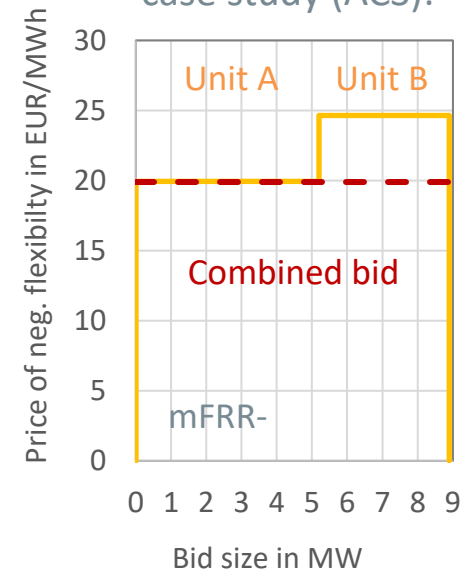


The impact of the minimum bid increment

Example: aggregation pool for Austria



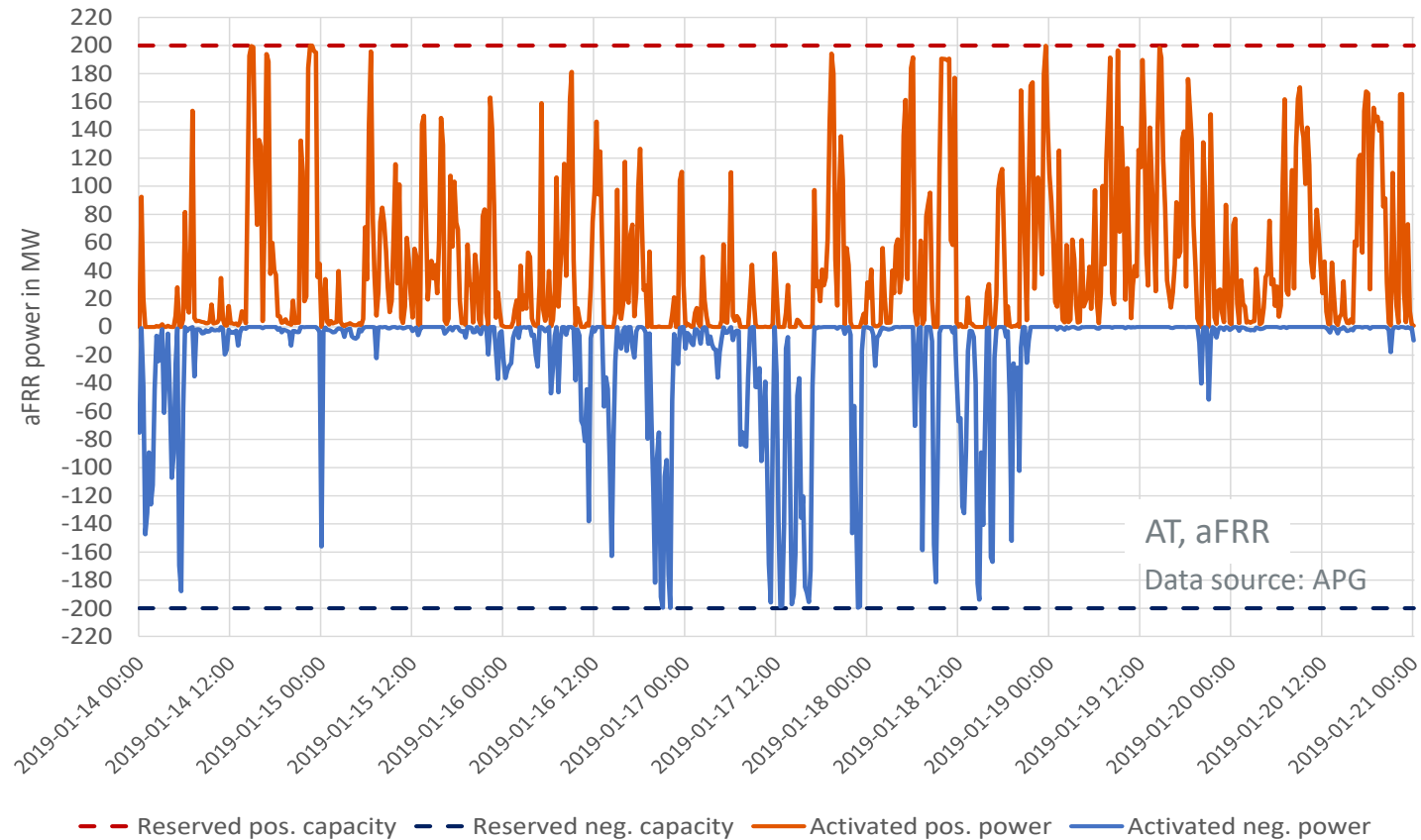
Multiple bids per case study (ACS):



- Pooling can significantly increase the share of exploitable capacity.
- If required bid increment is low, it is beneficial to generate bids per unit.



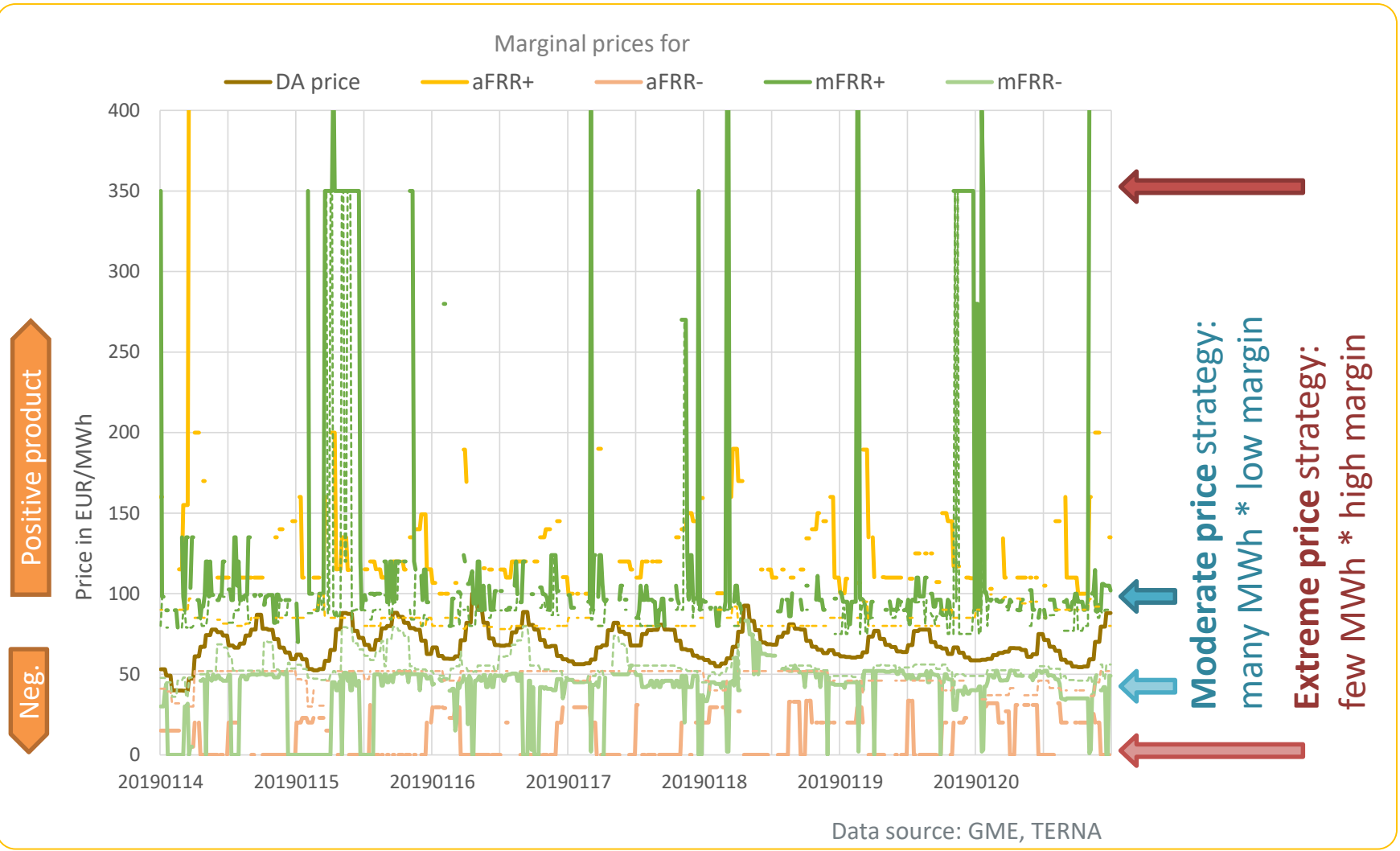
The probability of activation



- The share of activated power was less than 20% of the reserved power in all investigated markets in 2019.
- For Italy, 8% - 15% of the bids were awarded in the investigated weeks.

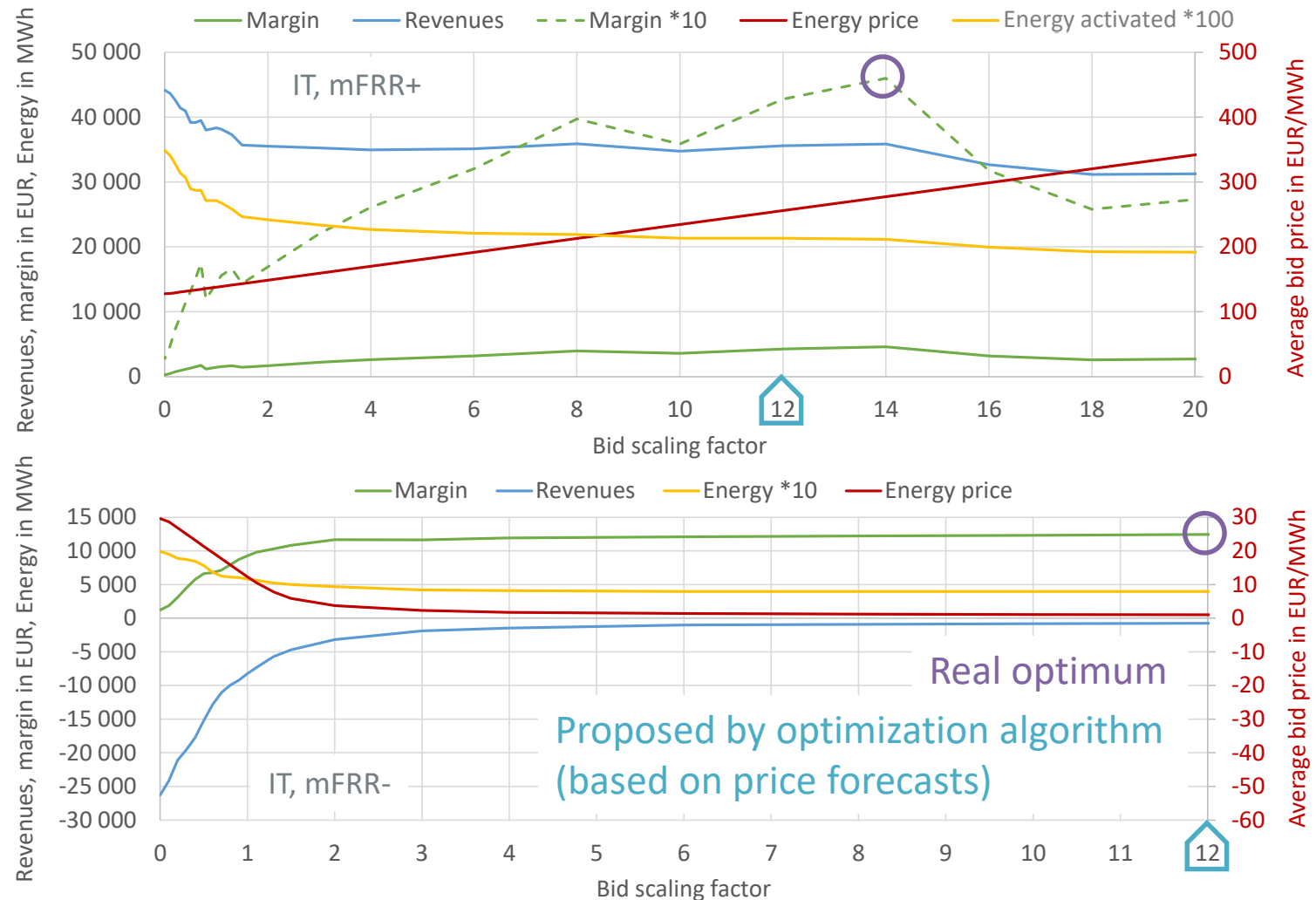


Find the optimal bidding strategy





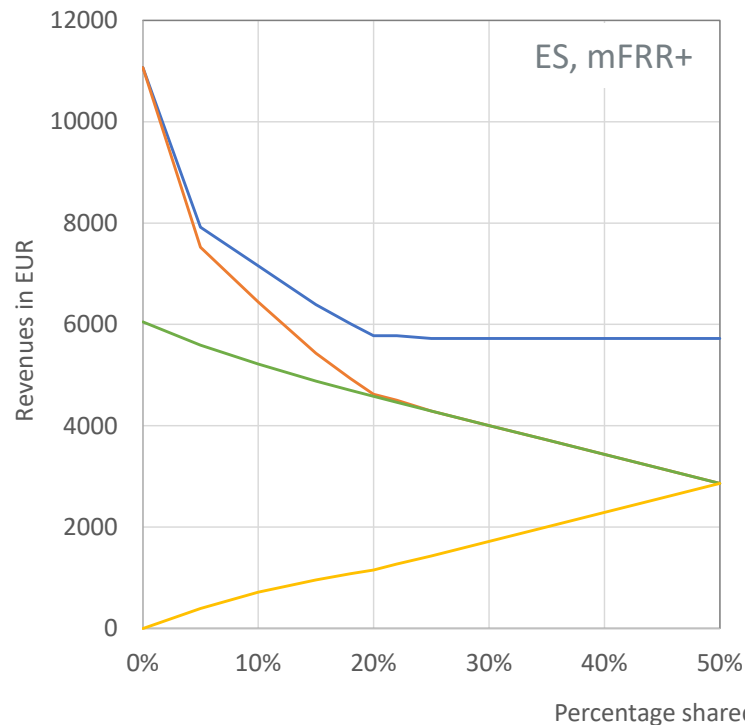
Evaluation of bidding strategy



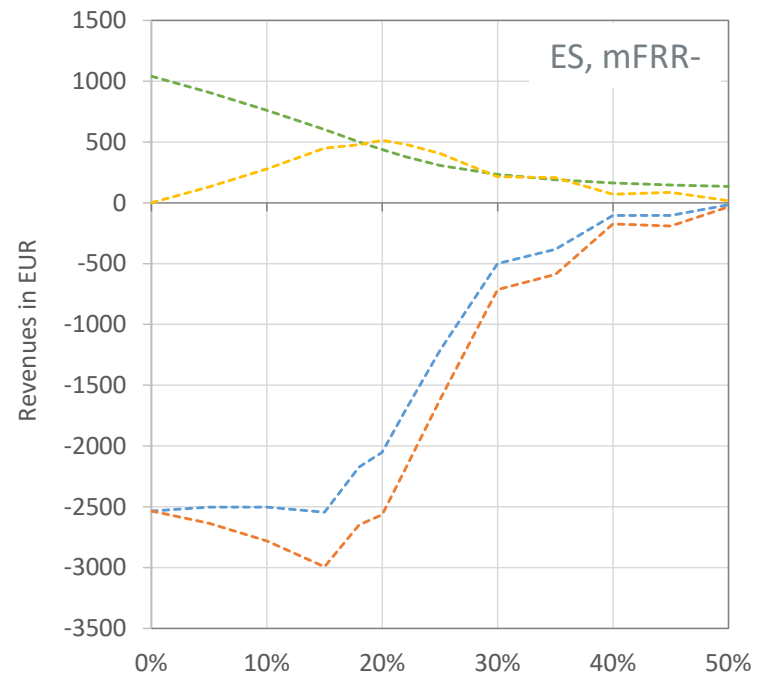


Implications of revenue sharing

- The aggregator receives an agreed share of the revenues, which can show significant impact on the profitability of the case study.
- Revenue sharing increases marginal costs of the bids.



— total revenues (p) — revenues MES (p)
— margin MES (p) — revenues aggregator (p)



- - - total revenues (n) - - - revenues MES (n)
- - - margin MES (n) - - - revenues aggregator (n)



Results of market simulation for ACS

- Activated energy (in 6 weeks)

	FCR	aFRR+	aFRR-	mFRR+	mFRR-
Energy in MWh	0	4,8	60,4	213,3	397,7

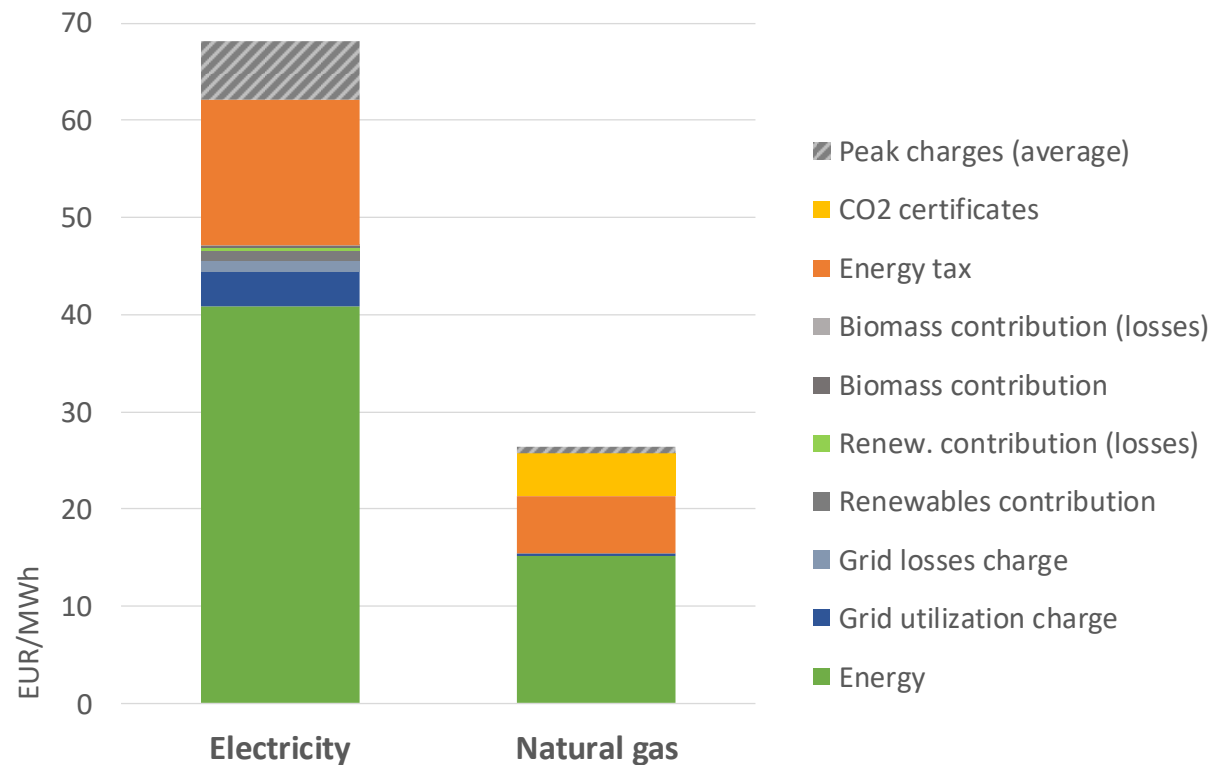
- Revenues:
 - Best possible result (perfect information, unlimited market):
100%
 - Considering activation probability, limited market and liquidity:
8,7% (mFRR: 8,1% aFRR: 0,6%)
 - Considering internal reserve to cover unplanned outages:
8,2% (mFRR: 7,6% aFRR: 0,6%)
 - **Realistic result after 20% revenue sharing:**
5,8% (mFRR: 5,3% aFRR: 0,5%)
 - *Participation in (not yet existing) FCR market could increase total result to up to 14%.*



Impact of non-energetic cost components

- Even if the price for purchased electricity is 0 EUR/MWh, the overall costs may still be higher than for alternative fuels.

Energy price components for an industrial consumer (medium voltage) in AT in 2019:





Aggregation and Trading: Key learnings

- Very diverse rules and conditions for flexibility trading in the investigated countries are a barrier for replicability.
- Too large required bid size and bid increment values may lead to reduced liquidity on ancillary service markets.
- Realistic revenues from flexibility exploitation is often overestimated, in particular for the intraday market.
- The revenue sharing model is not beneficial for the MES, when the market price is close to the marginal costs.
- Most countries have a distinct target market for flexibility, which provides the highest revenue expectation.
- Investigation of the Italian case study:
 - mFRR was the market with highest profit expectation in 2019.
 - aFRR and FCR technically feasible but show far lower profit expectation.



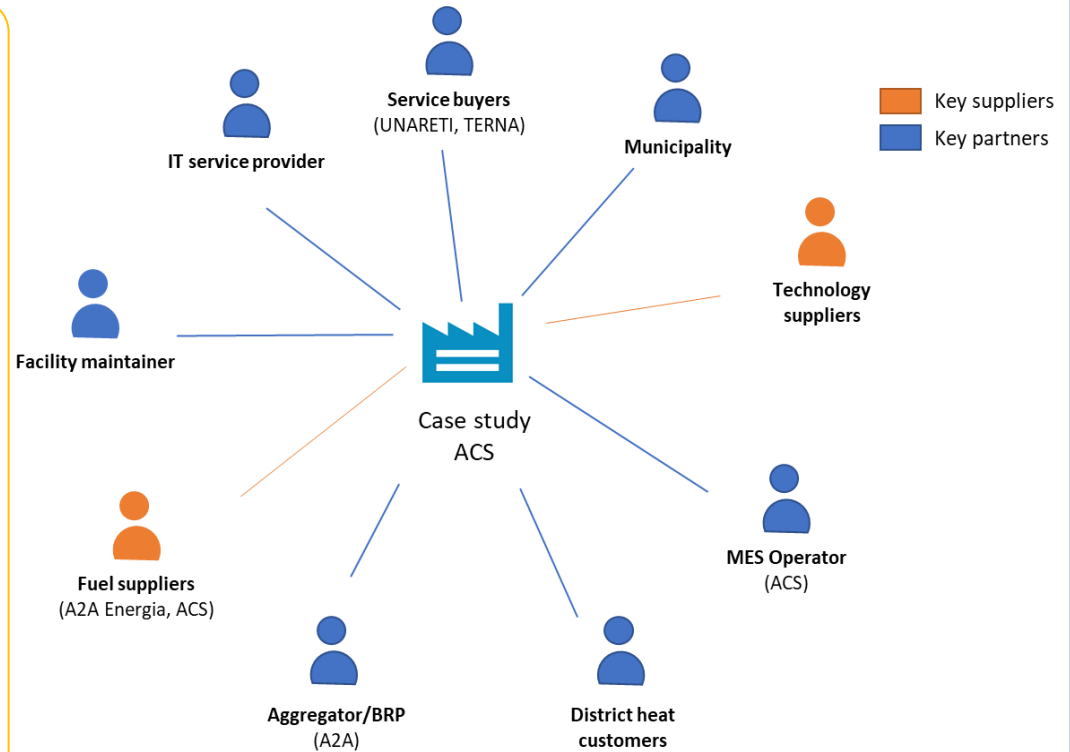
Philippe MAILLARD, Efficacity

BUSINESS MODELS OF FLEXIBILITY SERVICES PROVISION EXAMPLE OF ACS CASE STUDY



Key partners of the ACS CS

- Municipality: owner of the ground, rent to ACS MES
- ACS: DH operator
- A2A: aggregator/BRP/owner of ACS
- A2A Energia: gas and electricity supplier of ACS
- Terna: TSO
- Unareti: DSO
- IT service provider
- Technology provider
- Facility maintainer
- District heating end-users



- Beneficiaries (base case): ACS, A2A
- Additional beneficiary (SC5): TSO
- Additional beneficiary (SC8): Final ACS end-users



Differential assessment of scenarios

Business model scenario	Simulated scenarios
Without flexibility services provision (aFRR, mFRR)	SC1: Base case
	SC4: Base case + improvement strategies 1+2
With flexibility services provision (aFRR, mFRR)	SC5: Base case
	SC8: Base case + improvement strategies 1+2

- Improvement strategy 1 : addition of 50% thermal storage
- Improvement strategy 2 : heat demand peak shaving during winter through incentivization of DH end-consumers



SC5 (vs SC1) analysis (1/2)

Cost and revenue structure	Unit	SC1	SC5	SC5 - SC1
Natural gas consumption	MWhLHV/year	173106	189324	16218
Total Electricity import	MWhelec/year	747	4443	3697
DA electricity import	MWhelec/year	747	507	-239
aFRR downward electricity import	MWhelec/year	0	505	505
mFRR downward electricity import	MWhelec/year	0	3431	3431
Electricity generated by CHP	MWhelec/year	40616	50762	10147
Heat consumption by DHN end consumers	MWhth/year	171123	171123	0
Total Electricity export	MWhelec/year	7502	8118	615
Electricity export to DAM	MWhelec/year	7502	7502	0
Electricity export on aFRR upward	MWhelec/year	0	46	46
Electricity export on mFRR upward	MWhelec/year	0	569	569
Natural gas expenses	k€/year	9252	9880	628
Total electricity expenses	k€/year	78	65	-13
DAM electricity expenses (DAM costs + taxes)	k€/year	78	56	-22
aFRR downward electricity expenses	k€/year	0	4	4
mFRR downward electricity expenses	k€/year	0	6	6
Revenues from the sale of electricity on the DAM	k€/year	497	497	0
Total energy cost	k€/year	8832	9448	616
CO2 allowances related cost	k€/year	1,016	1,111	0,095

- The additional electricity production of the CHP is consumed by the electric boiler during downward flexibility services periods and supply the grid during positive flexibility periods, resulting in an increase of total energy cost of SC5 compared to SC1



SC5 (vs SC1) analysis (2/2)

Cost and revenue structure		Unit	SC1	SC5	SC5 - SC1
Total energy cost		k€/year	8832	9448	616
CO2 allowances related cost		k€/year	1,016	1,111	0,095
Cost for aggregator intermediation		k€/year	0	22	22
CAPEX and OPEX to provide flexibility services	Investment cost	k€/year	-	1,000	
	IT cost	k€/year	-	0,360	
	Manpower	k€/year	-	3,000	
	Operationnal and process cost	k€/year	-	0,300	
	Sub-total	k€/year	-	4,660	4,660
Total cost		k€/year		9476	643
Revenues from flexibility provision (positive mFRR)		k€/year	-	95	95
Revenues from flexibility provision (negative mFRR)		k€/year	-	-2	-2
Net revenue from mFRR		k€/year	-	93	93
Revenues from flexibility provision (positive aFRR)		k€/year	-	13	13
Revenues from flexibility provision (negative aFRR)		k€/year	-	-1	-1
Net revenue from aFRR		k€/year	-	12	12
Total revenue for flexibility provision		k€/year	-	105	105
EBIT		k€/year			-538
CAPEX		k€	-	10	10
Number of years for Amortization		years			10
Annual Cash Flow		k€/year			-537
Internal Rate of Return					no IRR

- Revenues from mFRR and aFRR cannot balance the overall cost of flexibility provision, generating thus a negative cash-flow



SC8 (vs SC4) analysis (1/2)

Cost and revenue structure	Unit	SC2	SC8	SC8 - SC4
Natural gas consumption	MWhLHV/year	175 314	192 665	18249
Total Electricity import	MWhelec/year	293	4 319	3903
DA electricity import	MWhelec/year	293	416	0
aFRR downward electricity import	MWhelec/year	-	649	649
mFRR downward electricity import	MWhelec/year	-	3 253	3253
Electricity generated by CHP	MWhelec/year	43 576	55 770	11799
Heat consumption by DHN end consumers	MWth/year	171 124	171 129	0
Total Electricity export	MWhelec/year	9 551	9 858	1186
Electricity export to DAM	MWhelec/year	9 551	8 672	0
Electricity export on aFRR upward	MWhelec/year	-	224	224
Electricity export on mFRR upward	MWhelec/year	-	962	962
Natural gas expenses	k€/year	9 399	10 031	691
Total electricity expenses	k€/year	26	42	1
DAM electricity expenses (DAM costs + taxes)	k€/year	26	41	0
aFRR downward electricity expenses	k€/year	-	0	0
mFRR downward electricity expenses	k€/year	-	1	1
Revenues from the sale of electricity on the DAM	k€/year	634	585	0
Total energy cost	k€/year	8 791	9 488	692
CO2 allowances related cost	k€/year	1,029	1,131	0,107

- The additional electricity production of the CHP is consumed by the electric boiler during downward flexibility services periods and supply the grid during positive flexibility periods, resulting in an increase of total energy cost of SC8 compared to SC4



SC8 (vs SC4) analysis (2/2)

Cost and revenue structure		Unit	SC2	SC8	SC8 - SC4
Total energy cost		k€/year	8 791	9 488	692
CO2 allowances related cost		k€/year	1,029	1,131	0,107
Cost for aggregator intermediation		k€/year	-	42	42
CAPEX and OPEX to provide flexibility services	Investment cost	k€/year	38,50	39,500	
	IT cost	k€/year	-	1,360	
	Manpower	k€/year	-	3,000	
	Operationnal and process cost	k€/year	1,75	2,050	
	Sub-total	k€/year	40,25	45,910	4,660
Total cost		k€/year		9577	739
Revenues from flexibility provision (positive mFRR)		k€/year	-	167	167
Revenues from flexibility provision (negative mFRR)		k€/year	-	0	0
Net revenue from mFRR		k€/year	-	167	167
Revenues from flexibility provision (positive aFRR)		k€/year	-	41	41
Revenues from flexibility provision (negative aFRR)		k€/year	-	0	0
Net revenue from aFRR		k€/year	-	41	208
Total revenue for flexibility provision		k€/year	-	208	208
EBIT		k€/year			-531
CAPEX		k€	385,00	395	10
Number of years for Amortization		years			10
Annual Cash Flow		k€/year			-530
Internal Rate of Return					no IRR

➤ In spite of the implementation of improvements strategies, revenues from mFRR and aFRR cannot balance the overall energy costs, generating thus a negative cash-flow



Note – inclusion of FCR services

- In the meanwhile, the results of the ACS business model have been updated to include delivery of FCR services
 - No additional costs need to be considered as the ACS system is ready to provide FCR services due to baseload adjustments needed to deliver aFRR and mFRR. These costs can therefore be seen as sunk costs.
 - The FCR service is theoretically integrated in the simulation, as in practice FCR cannot yet be offered on the Italian market.
 - Revenues from FCR (only remunerated for availability) are comparatively significantly higher than the revenues for aFRR and mFRR.
 - Overall these additional revenues still do not outweigh the costs related to flexibility delivery (mainly due to adaptation of baseload)
 - ACS could further look internally to optimize its operations to be able to provide flexibility in a “softer way”, which could potentially lead to a positive business case.



Conclusions

- Revenues from ancillary service markets are not sufficient for the MES to recover the additional costs to provide the flexibility for the chosen simulation set-up.
- Several reasons could explain why no business model could be reached in the simulated scenarios
 - In case ACS provides downward flexibility, it imports more electricity from the grid. Yet, on these imports, ACS needs to pay taxes and tariffs.
 - The relationship between electricity and gas prices is unfavorable for the electric boiler usage as electricity is comparatively more expensive.
 - In Italy, there is no capacity remuneration for mFRR and aFRR. For these services, ACS is not remunerated for flexibility availability, even though it significantly increases its baseline costs to be able to provide flexibility.
 - Furthermore, even though ACS has a significant amount of flexibility available, its activated capacity is less than 10% of the available capacity.
 - Finally, costs are further increased due to the aggregator costs.
- If future electricity systems need more flexibility, a change in regulatory / economic framework (e.g. compensation for flexibility availability, reform of grid costs and taxes) could have a positive impact on the business case.



Edoardo Corsetti, RSE

CONCLUSIONS



ACS: Concluding remarks

- The simulation of the MES showed a relevant amount of flexibility available
- ACS plant is able to provide highly performing products like FCR and aFRR (usually provided by EB), and also relevant amount of mFRR
- Flexibility traded generally requires extra-costs that can affect the economic sustainability
- Aggregation Platform reduces the impact of Regulatory framework barriers, e.g.: it did not require minimum bid size, product duration. At the same time, the costs of aggregation reduce the competitiveness of the MES's bids
- The amount of activated services is a small percentage of the potentiality of ACS, and it is impossible to foresee when they are activated
- The simulated scenario of maximized flexibility provision did not result in a positive business case under the conditions of 2019. The current remuneration schemes would only allow more conservative strategies for provision of a lower amount of flexibility
- The ACS business model results from the carried out simulations, based on the current regulatory and market framework, will be impacted by the transformation of the energy system
- Current energy decarbonization targets (e.g. 2030) will require a huge amount of flexibility. It can be expected that the future framework for flexibility provision will provide technical requirements more suited for MES and economic rules enabling to increase the MES contribution



Sergey Klyapovskiy, DTU; Nicolas Hastir, EFFICACITY

OVERALL ASSESSMENT OF MAGNITUDE CASE STUDIES



Outline

- Introduction
- Overview of case studies
- Assessment
- Conclusions



Introduction

- Case studies from 7 EU countries that represent:
 - Centralized district heating & cooling
 - Distributed district heating & cooling
 - Industrial facilities
 - Multi-energy systems for redispatch
- Each case study is a multi-energy system with several energy carriers (electricity, heat, gas, etc.)
- Both electricity consumers and suppliers are analysed
- Base case with present configuration and improvement strategies were considered with and without flexibility provision



Overview of case studies

- Swedish case study of **Mälarenergi** and Italian **ACS** are examples of centralized district heating & cooling

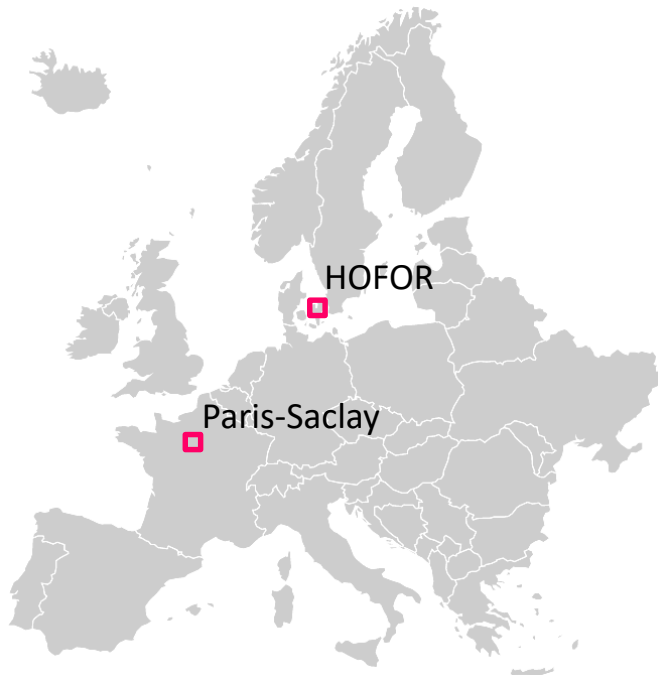


- Flexibility units:
 - **Mälarenergi** – steam turbines at CHP and electric boiler
 - **ACS** – gas turbines at CHP, electric boiler and heat pump
- Improvement strategies:
 - **Mälarenergi** – larger thermal storage
 - **ACS** – larger thermal storage and heat demand peak shaving



Overview of case studies

- Danish case study of **HOFOR** and **Paris-Saclay** in France represent distributed district heating & cooling



- Flexibility units:
 - **HOFOR** – heat pumps and electric heat boosters
 - **Paris-Saclay** – heat pumps
- Improvement strategies:
 - **HOFOR** – improved control following market prices
 - **Paris-Saclay** – heat and cold storage; PV generation



Overview of case studies

- Industrial facilities: Austrian **paper mill** and Spanish waste water treatment plant **Emuasa**



- Flexibility units:
 - **Paper mill** – steam turbines at CHP
 - **Emuasa** – gas turbines at CHP
- Improvement strategies:
 - **Paper mill** – steam accumulator
 - **Emuasa** – larger gas storage; new thermal storage



Overview of case studies

- British case study of Neath Port Talbot (**NPT**) is a multi-energy system for redispatch



- Flexibility units:
 - **NPT** – combined cycle gas turbines and electricity generators at steel factory
- Improvement strategies:
 - **NPT** – changed gas market gate closure time



Assessment of case studies

- The aim of assessment is to determine the effect of flexibility provision and improvement strategies on a case study
- Assessment is performed by analysing KPIs in the 4 categories:
 - Flexibility
 - Energy efficiency
 - Sustainability
 - Economy
- Results are based on the case studies simulations performed throughout 6 distinctive weeks (for the year 2018 or 2019)



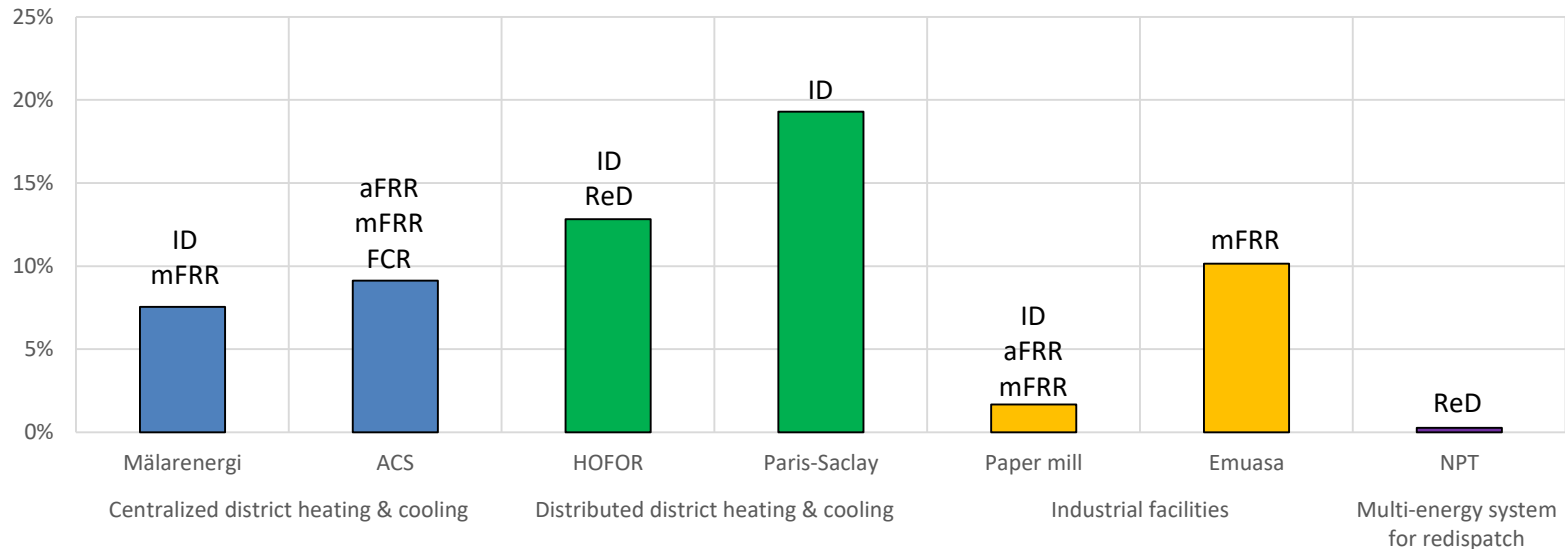
Assessment – Flexibility

- Case studies can provide upward and downward flexibility
- Available flexibility could be constrained by the need to provide services or reach production goals
- Improvement strategies increase available flexibility by decoupling production and demand of energy carriers
- Available flexibility is offered to different markets and trading process is simulated using aggregation platform



Assessment – Flexibility

Average activated flexibility compared to available flexibility

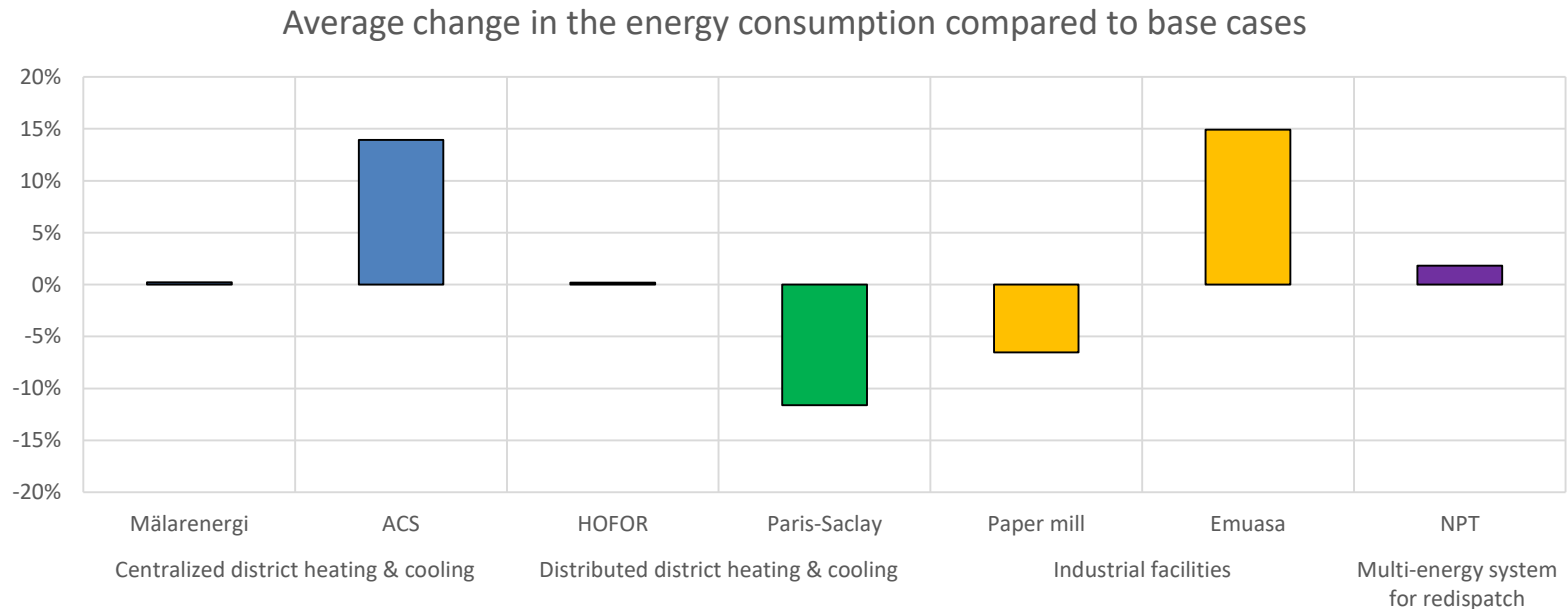


- Only a small portion of available flexibility is activated (energy delivered)
- Cost of providing flexibility from multi-energy systems is relatively high



Assessment – Energy efficiency

- Energy consumption is a sum of all energy carriers used during case study's operation and it is determined by specific process



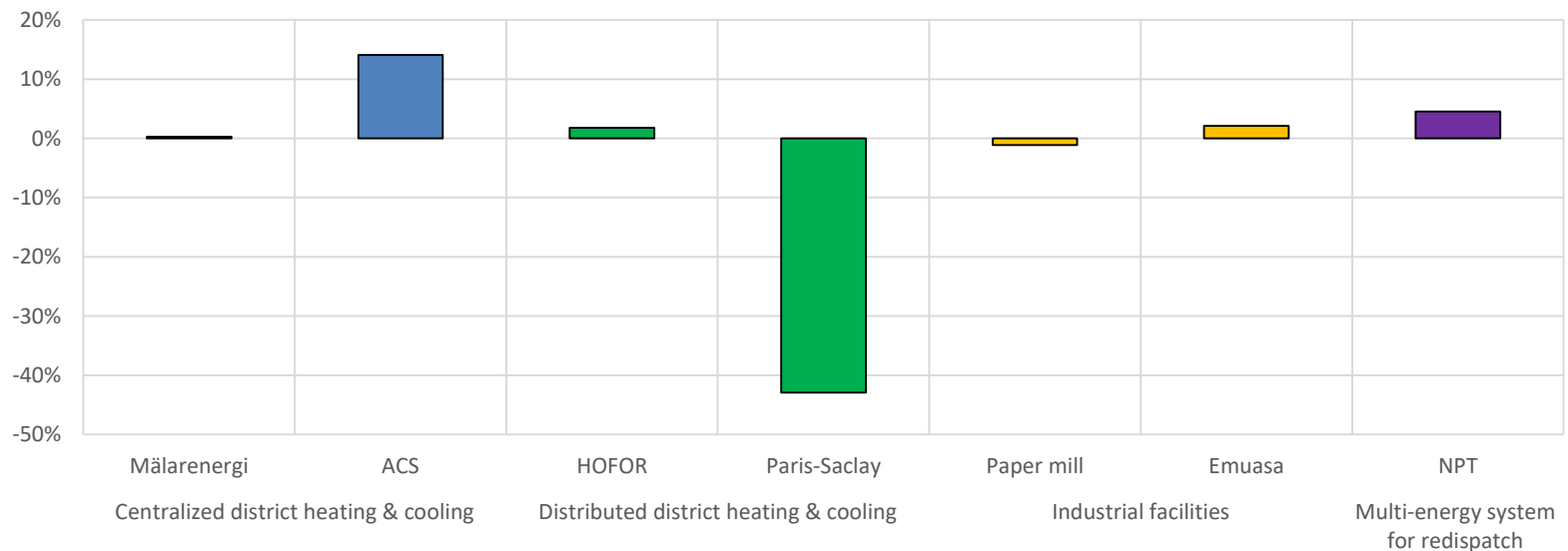
- Generally **flexibility provision increases energy consumption**
- Introduction of storage can lead to reduction of wasted energy and therefore reduce overall consumption



Assessment – Sustainability

- Each case study generates some direct and indirect GHG emissions
- Indirect GHG emissions coming from imported grid electricity or district heating vary each hour

Average change in the GHG emissions compared to base cases



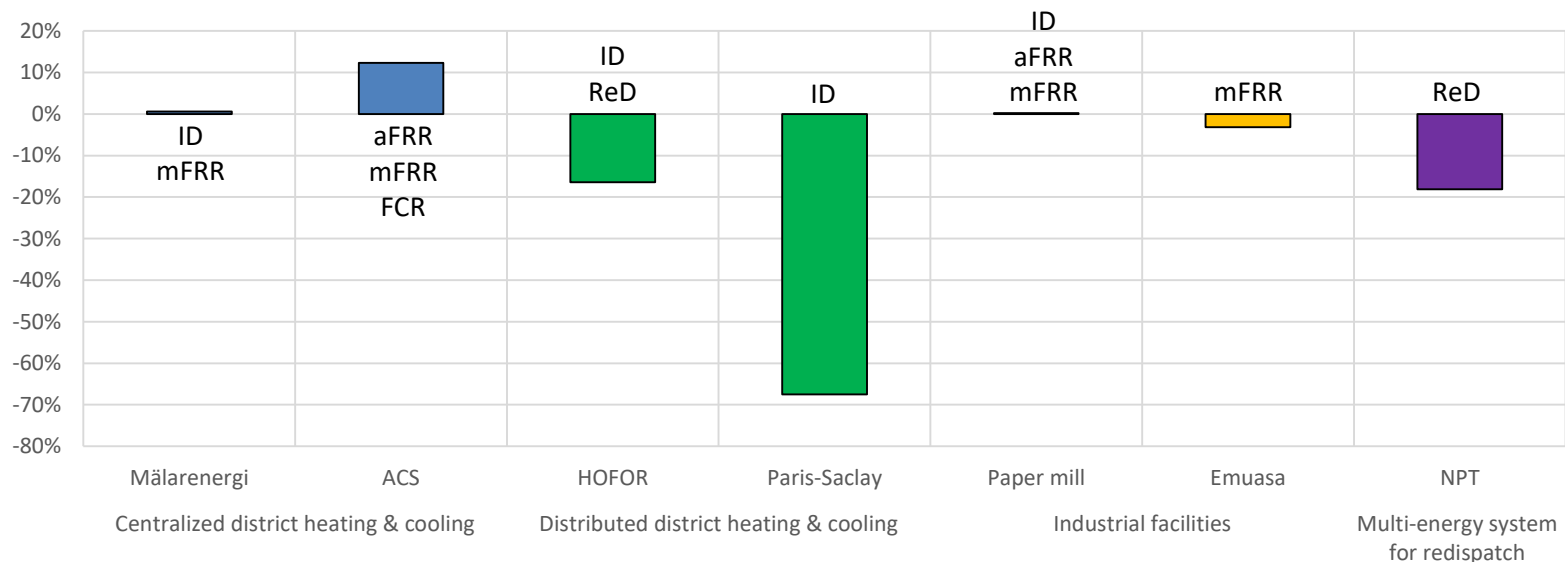
- **GHG emissions generally are higher because of the flexibility provision**
- Installation of local PV generation reduces GHG emissions



Assessment – Economy

- Operational costs = costs for purchasing energy minus revenues from flexibility provision
- Maximizing available flexibility increases operational costs
- Activated flexibility brings revenues and reduces the cost of purchased energy

Average change in the operational costs compared to base cases

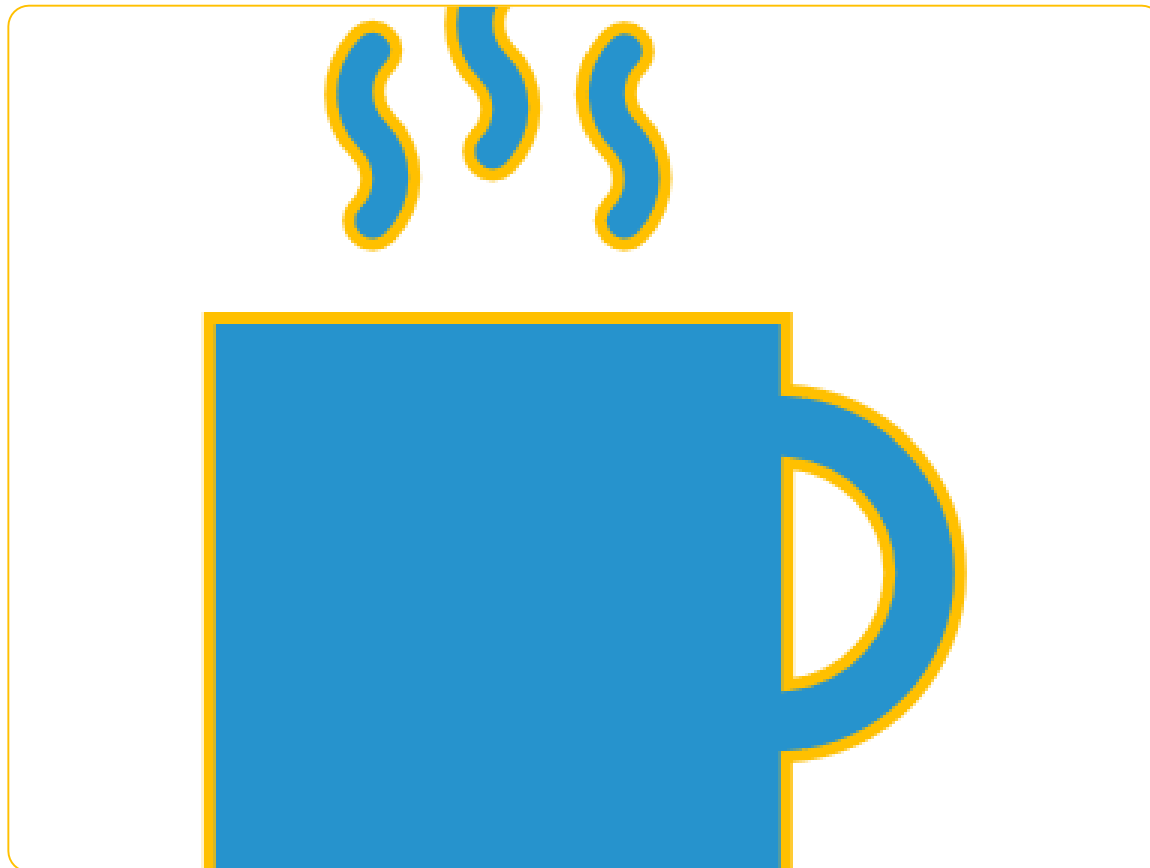


- **Small number of flexibility activations results in economic losses**



Conclusions

- Case studies have potential to provide electrical flexibility that is presently not fully utilized
- Maximizing available flexibility impairs economic performance
- Improvement strategies increase the available and activated flexibility, but have limited effect on other KPIs (except for the PV generation at Paris-Saclay)
- Participation in the multiple markets not necessarily better than participation in a single market



Coffee break



Kris Kessels, Ana Virag, VITO

INNOVATIVE MARKET DESIGNS FOR SYNERGY MAXIMIZATION BETWEEN ELECTRICITY, GAS AND HEAT MARKETS



Content

- Introduction - Market design for energy system integration
- Multi-carrier market schemes
- Multi-carrier market designs
- Products for multi-carrier markets
- Multi-carrier market simulator
- Case study: Italy North Results
- Results, conclusions and outlook



Need for a market-based system integration



Brussels, 8.7.2020
COM(2020) 299 final

**COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN
PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL
COMMITTEE AND THE COMMITTEE OF THE REGIONS**

Powering a climate-neutral economy: An EU Strategy for Energy System Integration

- A **key obstacle**?
 - The **fragmented way** in which the energy system integration and **different energy vectors are governed**



Market design for energy system integration

Goals of a day-ahead multi-carrier market:

- Enable **market-based** coordination of energy systems
- Increase **the system reliability**
- Boost the **renewable energy integration** by increased flexibility integration

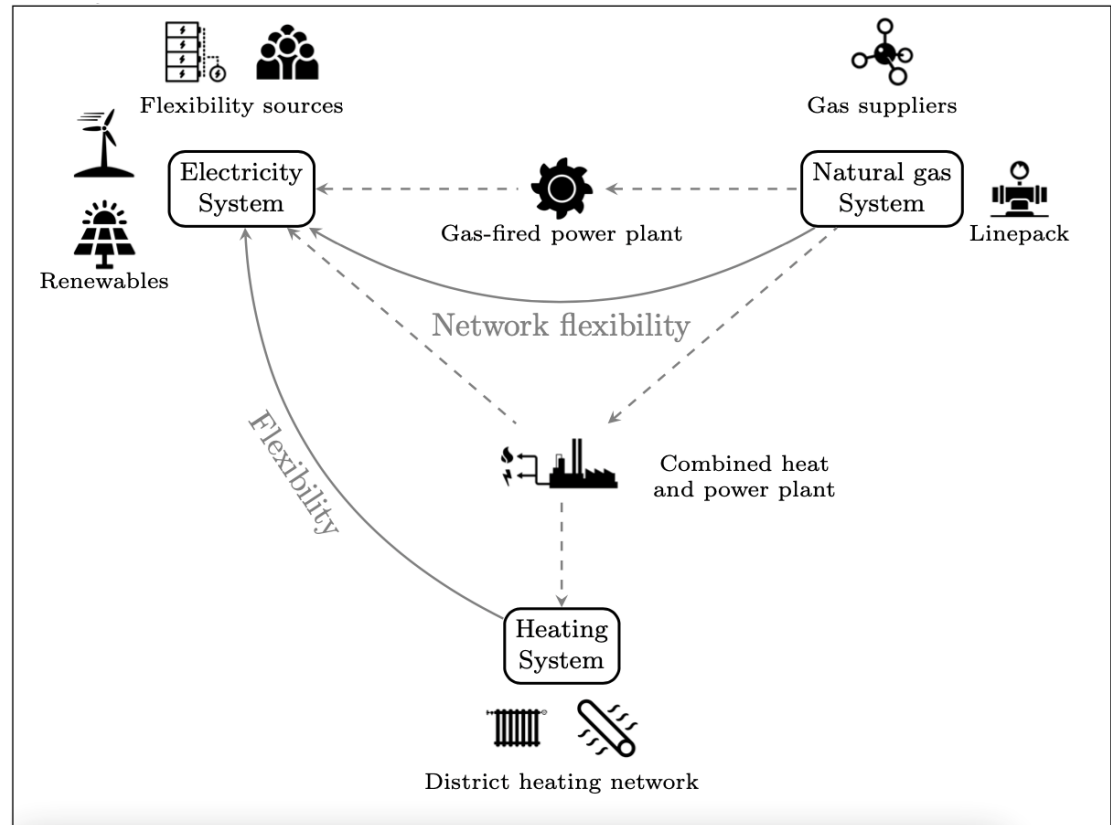
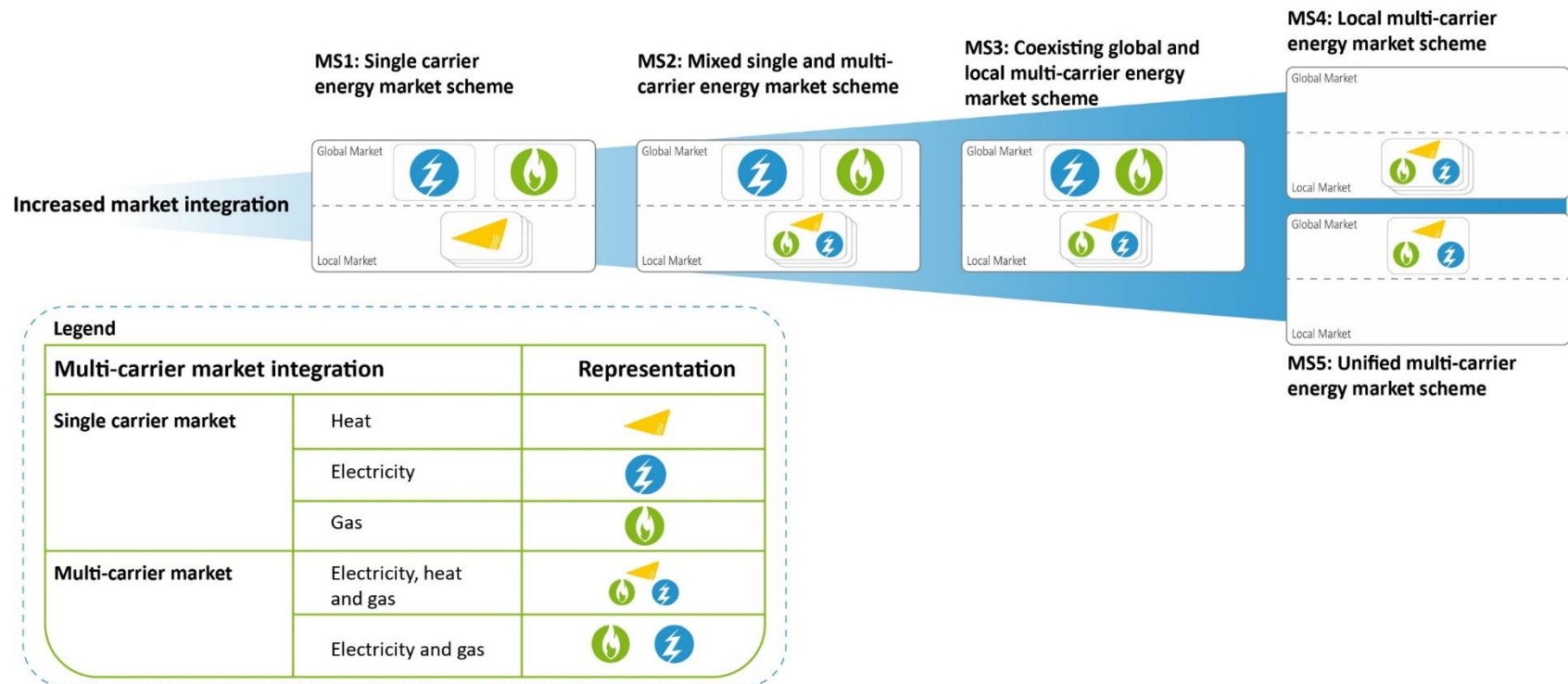


Figure courtesy of A. Ratha, DTU and VITO/EnergyVille



Multi-carrier market schemes





Multi-carrier market design



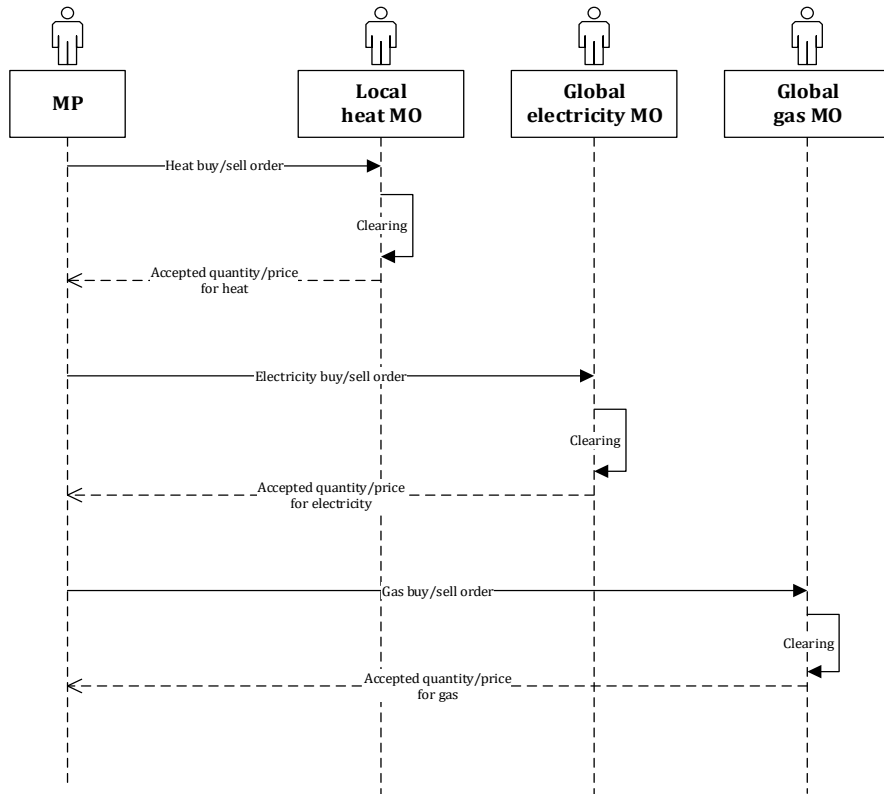
decoupled multi-carrier market design



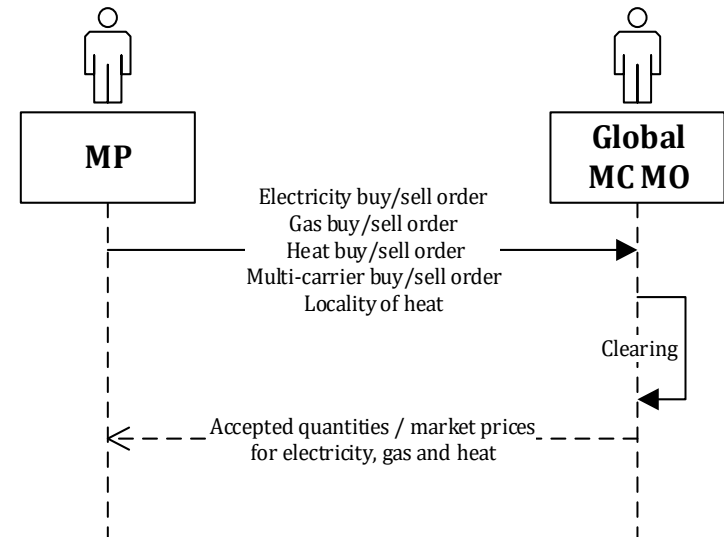
integrated multi-carrier market with centralised clearing



Multi-carrier market design



decoupled multi-carrier market design



integrated multi-carrier market with centralised clearing



Products for multi-carrier markets

ORDERS




Elementary
Conversion
Time shifting

CONSTRAINTS

Pro-rata
Cumulative
Implication
Exclusive

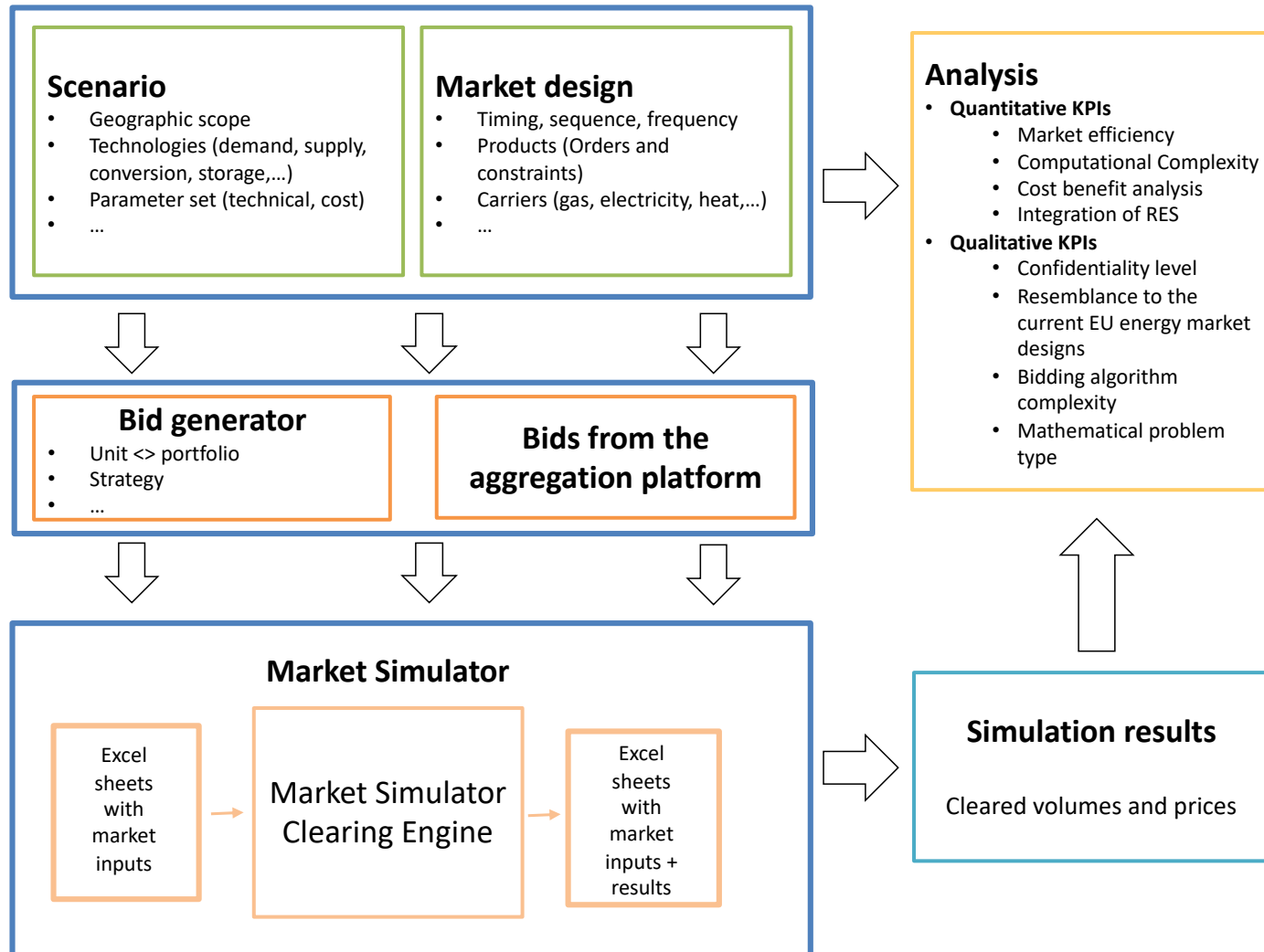


Examples orders

- A building with a connection to the district and a heat pump:
 - Heat demand order and electricity demand order coupled by an exclusive constraint
- A building with thermal mass energy storage:
 - Time shifting order, or
 - A group of elementary demand electricity orders coupled by cumulative constraint
- Micro-CHP:
 - Conversion order, or
 - Heat supply order and gas supply order coupled with pro-rata constraint, gas supply order and electricity supply order coupled with pro-rata constraint



Multi-carrier day-ahead market simulator





Simulation for ACS/Milan/Italy North

- Assumptions:

- Heat, gas, and electricity systems
- Power exchange model
- Marginal pricing
- 6 weeks (2019): 4 seasons and 2 extreme weeks
- 2 different market designs:
 - Sequential (only elementary orders)
 - Coupled (also conversion, time-shifting and pro-rata)
- Bidding based on historical data and marginal pricing
- Grids not included

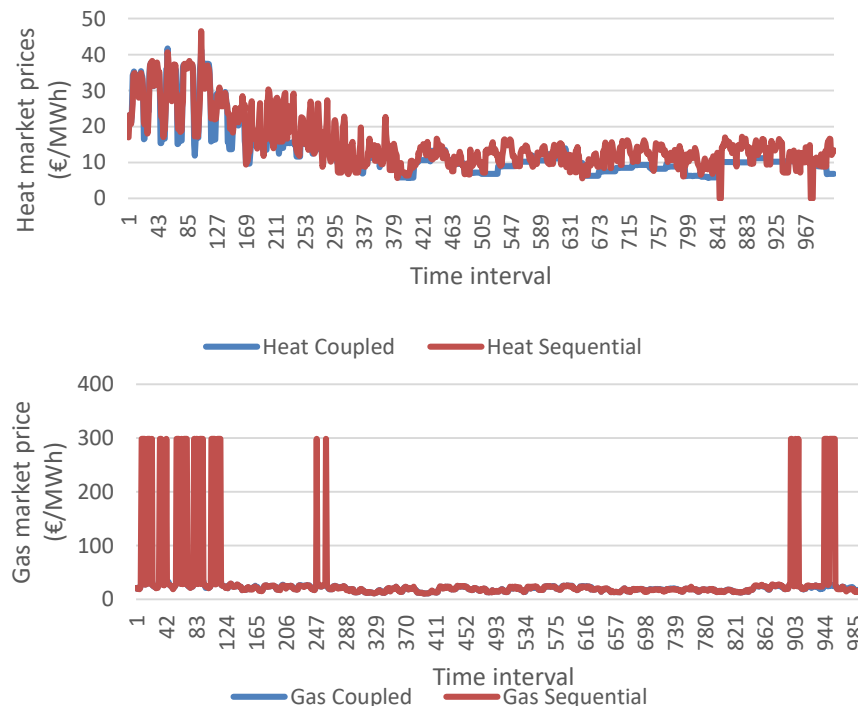


Figure source: <https://www.groundai.com/project/a-machine-learning-model-for-long-term-power-generation-forecasting-at-bidding-zone-level/1>



Results

- Coupled multi-carrier markets:
 - can better deal with situations when supply limits in any of the energy carriers are being reached
 - externalise market risks related to the price forecasts





Results

- Coupled multi-carrier markets:
 - result in a higher social welfare

Social Welfare	Coupled Markets	Sequential Markets	Difference (coupled- sequential)
All weeks	7.553.887.968 €	7.522.192.894 €	31.695.074 €

- have a higher computational time, but still acceptable for practical implementation

Solver time	Coupled markets [s]	Sequential Markets [s]	Difference (coupled- sequential) [s]
All weeks	32.65	22.54	10.11



Conclusions and outlook

- The integrated multi-carrier markets
 - can better deal with forecast errors
 - can better deal with shortages
 - can more easily integrate RES
 - have higher computational times for calculating market-clearing outcomes
- The proposed design is in line with the EC ambition
- Additional organisational changes are needed for the implementation



Credits

- Kris Kessels, Ana Virag, Yuting Mou (VITO/EnergyVille)
- Mehdi Madani (N-Side)
- Peter Sels (former N-Side, now Logically Yours)
- Shahab Torbaghan (former VITO, now Wageningen University)



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Diego Arnone, Marzia Mammina, ENG

MULTI ENERGY DATA HUB AND INTEROPERABILITY LAYER



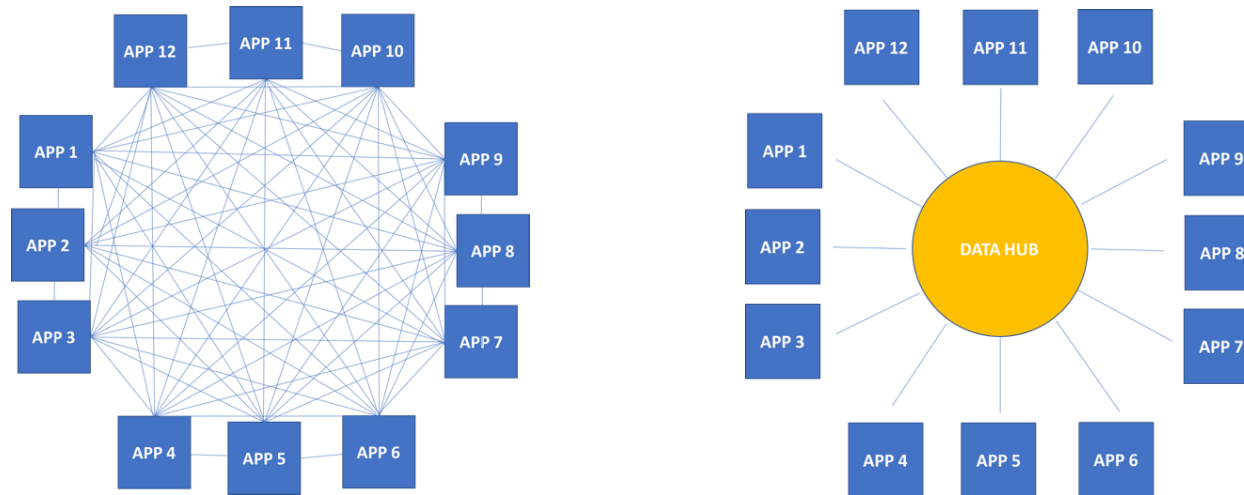
Background

- In the evolving energy systems:
 - the **exchange of information** is becoming an increasingly complex and resource intense process with many stages;
 - a **significant amount of data** will be exchanged;
 - a **growing number of stakeholders** will be involved, and this requires the management of an increasing number of connections between pairs of stakeholders.
- From the IT point of view, exchanges between pairs of actors often take place on point-to-point connections, creating a so called “**spaghetti architecture**”, which is not scalable and is expensive to maintain in the long run.
- The **absence of standardized procedures** for the information exchanges and the spread of spaghetti architectures is reflected in a **slowdown in the information exchange and in the fragmentation of information into systems belonging to various companies**.



The need of a Hub and Spoke solution

- A **Data Hub**, centralised computing architecture, can **provide powerful data integration strategies and improve data management and exchange processes** between the different parties connected to the energy systems and markets, **enabling greater and more consistent data quality and transparency**.



- It enables to **decrease costs**, to **simplify operation** like adding or removing applications, **high scalability** of the entire system.
- Moreover, this architecture uses **a central message broker** which enables to apply rules to the message content and determine the receiver spokes.



What MAGNITUDE proposes

Several studies and reports have dealt with the development of **Data Hubs in the electricity and gas sectors**, mainly from a retail market perspective and a centralised approach based on data hubs has already been **adopted in some European countries** for those energy sectors.

The MAGNITUDE project extends what already done for the electricity and gas sectors to the heat and cooling sectors by proposing a centralised data hub as multi-carrier market facilitator:

- **centralises** the information;
- **persists** the data in a queryable data store;
- enables the communication for the data sender with a **unique system that will take care of delivering the data to the recipient in the most appropriate way.**



A data hub enables new opportunities

The **amount and granularity of data stored** in the data hub pave also the way to **new sector and cross sectors business services**:

- **MESs** could access data to use their own conversion technologies to **produce energy in the form most requested and best paid by consumers** by transforming energy from the form less requested and therefore less paid, maximizing their profits.
- **Consumers/Prosumers** could:
 - **manage the contracts** with their suppliers in a simpler way,
 - **switch more easily between suppliers**, thus achieving significant savings in utility bills.
 - access, in a single point, the history of their consumption of different forms of energy, gaining **greater awareness of their energy usage**.
- **Retailers** could have access to consumption and production on the various markets in one place, managing to size up affiliate campaigns based on the customer's energy mix.



A data hub enables new opportunities

- **DSOs and TSOs** could have **information** from producers, resellers, aggregators, consumers **available in one place** useful for balancing the energy distribution and transmission networks and for facilitating the activities of multiple networks distribution and transmission operators.
- **New players** could be authorised by the customers to access metering data and smart devices to **develop new services to increase energy awareness and to improve energy efficiency through smart advices.**
- A **new generation of aggregators** could emerge operating not only in the electricity sector but also in other energy sectors.



Approach adopted by the project

Starting point: **analysis of the MAGNITUDE Case Studies** (D2.1).

- For each of the seven real-life case studies, a detailed analysis has been carried out on the current situation for the energy sectors considered in MAGNITUDE (electricity, gas, heat and cooling) and the results have been presented in the form of:
 - a table mapping the actual stakeholders involved with the roles they carry out,
 - sequence diagrams presenting the sequences of the interactions between the roles involved, which are relevant for the MAGNITUDE project goals.
- The functional similarities in all energy sectors have led to the **identification of very similar roles in the four sectors**. It has been observed that some actors can take different roles.
- A comparative analysis of the current role models (roles and main interactions) of the Case Studies has allowed to highlight **functional similarities between the case studies** and to propose **generic role models**, in the form of sequence diagrams, able to represent their main characteristics in the four energy sectors.

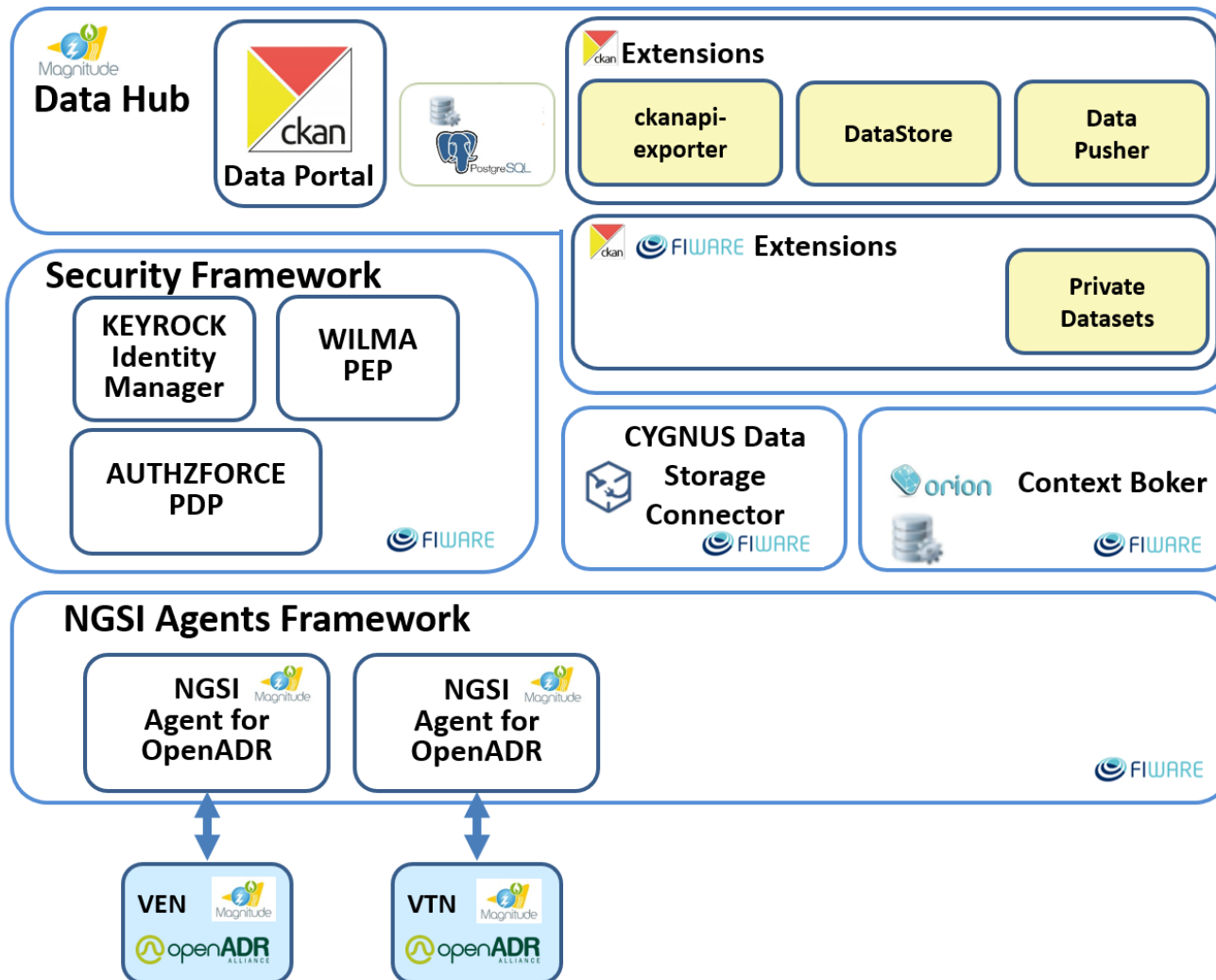


Approach adopted by the project

- **Survey and audio conferences** to collect specific information on Case Studies (communication mechanisms, protocols, data formats used for the data exchanges, frequency of the exchanges, etc.)
- **Requirements elicitation** and analysis.
- **High-level architecture specification.**
- **Analysis of open source solutions** reusable in MAGNITUDE:
 - FIWARE modular framework for interoperability;
 - Comprehensive Knowledge Archive Network (CKAN) data portal platform.
- **Final architecture specification.**
- **Implementation** and **test.**



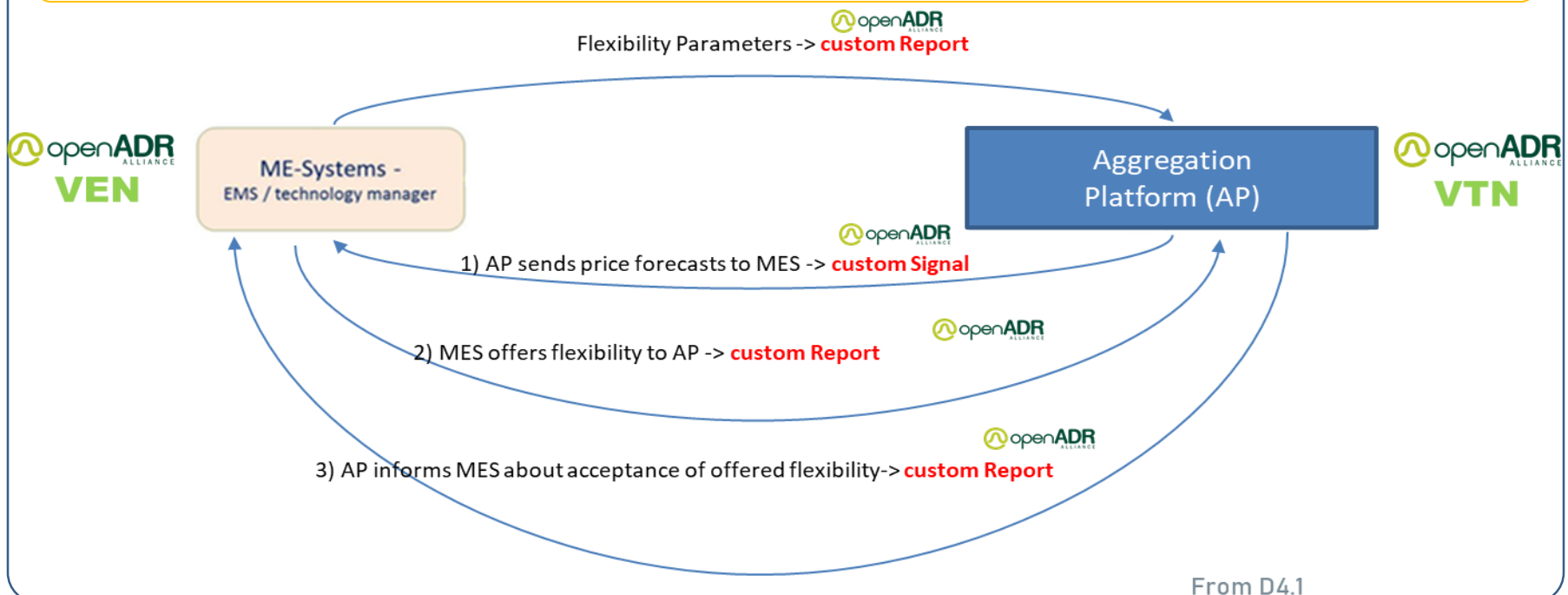
Final Architecture of the technical solution





A novel NGSI agent for OpenADR

- **OpenADR** is an open and interoperable information exchange model (**IEC 62746-10-1 ED**) that standardises the message format used for automated Demand Response (DR) and Distributed Energy Resource (DER)
- MAGNITUDE intends to exploit the opportunity to extend the semantic of OpenADR, provided by for the standard itself, to propose OpenADR as a protocol **to convey the information exchanges between the MES and the Aggregation Platform (AP)**. This approach might be easily extended to the information exchange between the MES and their stakeholder.





Coffee break



Regine Belhomme, EDF

MAIN LESSONS LEARNT

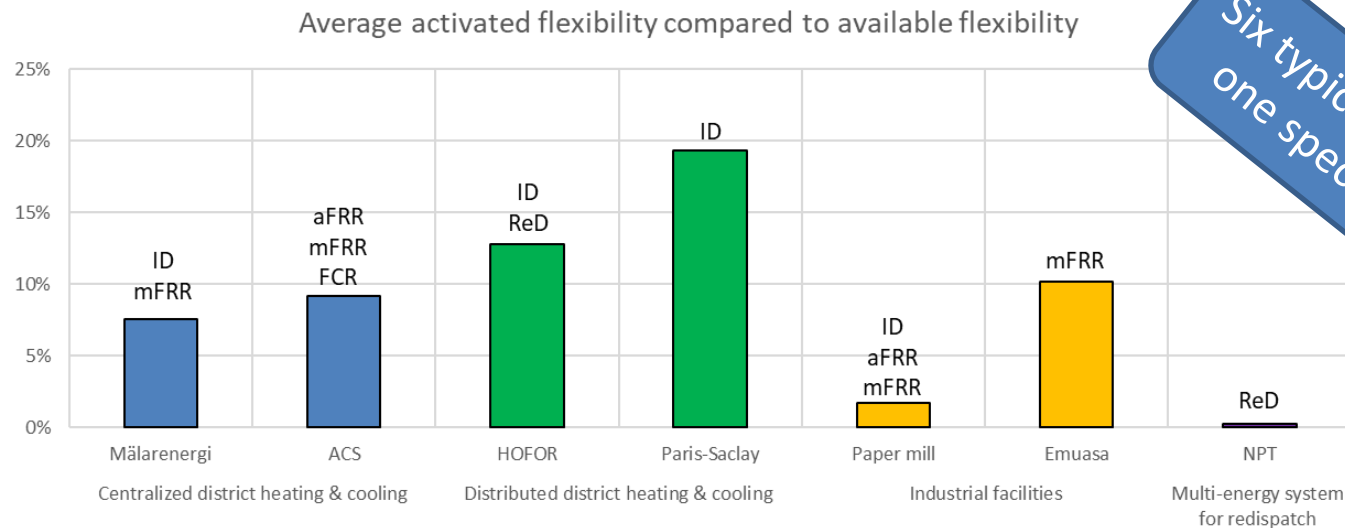


Multi-energy systems can provide flexibility

- and already do so for some of the considered case studies (e.g. ACS, Austrian paper mill) most often through an “internal” or “external” aggregator

Potential for MES to participate in energy markets, frequency ancillary service procurement and congestion management in local markets

Results show that flexibility provision strongly depends on technologies in MES site, the process and operation strategies



Six typical weeks for one specific year



Technological perspectives

Technical limitations due to intrinsic flexibility capabilities of technologies with respect to market products requirements (e.g., full activation time, minimum duration of service provision, symmetric product)

- Key characteristics need to be **known and monitored**
- **Integrated management** of different technologies at site level (EMS)
- **Aggregation** of MES and other resources

Increased operating costs due to flexibility provision:

- **Deviation/change in operation** plan can lead to increased operating costs
- Participation if **sufficient remuneration** to cover extra costs

Priority to satisfy the needs of the main/core process, e.g. supply heat or cooling to consumers, produce paper or steel, treat wastewater, etc.



Technological perspectives

Introduction or increase of storage (heat, cooling, steam, gas)

- **Increases flexibility capability:** [add a few %] to [multiply by > 5]
- Oversizing may reduce profitability → **compromise** to be found

District heating and cooling:

- **Highly seasonal nature** with strong constraints for some seasons

Long-term operation efficiency

- Limitation of the **lifetime of the equipment** (e.g. frequent starts and stops and load ramps)

Interconnections with external networks

- Capacity of the networks may impose limitations on **the maximum amount of power** that the MES can exchange



Markets & service procurement mechanisms

Similarities between countries for day-ahead & intraday energy markets in electricity system but still **country specificities**

Large diversity for balancing and frequency regulation services

- market clearing, product definitions (FAT, bid duration, minimum bid size, ...)
- **harmonization initiatives of TSOs** (FCR cooperation, PICASSO, MARI, TERRE)

Even larger diversity for capacity requirement mechanisms and congestion management

Rather heterogeneous situations for gas markets and heat networks

- For heat networks from **one area to the other** and **from one MES to the other**.
 - **No unbundling, no “organized market”** as such, **inherently local systems**

Very fast evolving field!

➔ Account for **specificities both at national and local scales** and closely monitor **evolutions**



Markets & service procurement mechanisms

Rules or requirements limiting service provision by MES in some countries

- Restrictions on **some technologies** or **aggregation**, high **thresholds** to access some markets

Intraday market issues in some countries

- Lack of liquidity
- Insufficient difference with respect to day-ahead market prices

Remuneration of frequency regulation services

- **Remuneration only for energy** activated by TSO → risk for providers
- **Remuneration of capacity and energy** (hybrid markets)

Increased costs due to network tariffs, retail prices, taxes,...

- Price of energy plus other costs: network charges, taxes, charges/contribution for RES

Need for improved:

- **Compatible incentive schemes**, (e.g. DSOs; RES support schemes vs flexibility provision)
- **Coordination between network operators**: (e.g. DSOs and TSOs; between energy carriers)
- Attractiveness of **flexibility remuneration**



Stakeholders

Similar roles in electricity, gas, heating & cooling systems:

→ synergies between the three sectors

But different characteristics for system operation and market aspects

- time constants, inherent resilience, dynamic behaviours
- operation needs and requirements
- gate closures, etc.

Large diversity of stakeholders with deeply different professional culture

- **Complexity and multiplicity** of interactions/transactions
- Increased complexity of business processes
- Needs for awareness raising, learning and training

Roles
Producer
Consumer
Transmission network operator
Distribution network operator
Balance responsible
Supplier
Storage provider
Metering-related roles
Regulator
...



Innovative market designs

With decoupled energy carrier markets

- Physical and economic **dependencies** not explicitly taken into account
- Imperfect forecasts can lead to **loss of profit** for conversion technologies, and **lost opportunity** for market participants.

With integrated multi-carrier day ahead market

- **Dependencies** between various carriers explicitly considered
- New order types and constraints allow market participants **to describe their technical limitations and cost structures**
- **Economic efficiency** can be increased

However

- **Higher computational time**
- **More information** to be shared with the market operator
- **Organizational changes** are required
- **Cost-benefit analysis** of possible implementations is required



Sergey Klyapovskiy, DTU and Edoardo Corsetti, RSE

ROUNDTABLE - FEEDBACK AND OUTLOOK FROM REAL-LIFE CASE STUDIES



Participants and moderators

- **Panelists:**
 - Marco Riello – ACS
 - Tore Gad Kjeld – HOFOR
 - Nicolas Eyraud – Paris-Saclay
 - Erwin Zlabinger – Austrian paper mill
 - Mar Castro Garcia – Emuasa
- **Moderators:** Sergey Klyapovskiy (DTU) and Edoardo Corsetti (RSE)




Roundtable organization

- Introduction to the roundtable
- Case study discussion
 - Overview of case study
 - Presentation of the case study owner or operator
- Common discussion
- Last remarks

- ACS
- HOFOR
- Paris-Saclay
- Austrian paper mill
- Emuasa



ACS

- Italian case study of **ACS** is a large supplier of district heating and cooling to the Milano area
- 
- Flexibility comes from turbines at the CHP, electric boiler and heat pump
 - Participation to the aFRR, mFRR and FCR markets has been analysed
 - In the absence of capacity payments providing ancillary services is not beneficial
 - High grid fees negatively affect plant ability to provide flexibility



Feedback and Barriers

- General Feedback



The algorithm can be used as a **Decision Support System** for plant manager



Acquired power plant **Flexibility awareness**



Model results can be **guideline for future investments**

- Barriers:



Downward services have to be paid



Services are remunerated just **for energy not capacity**





Plans for the future



Milano area has **huge potential** for DH expansion.

In order to connect new customers the plant has to be extended (new investments)



New connection requests are managed in the short term by a new **Heat Storage**

- Increase thermal power
- Heat Demand Peak shaving
- HP optimization





HOFOR

- Danish case study of **HOFOR** is providing domestic hot water for the area with ultra-low temperature district heating
 - Flexibility comes from heat pumps and electric heat boosters
 - Participation to the ID and ReD markets has been analysed
 - Providing ReD services to a local DSO significantly limits flexibility traded in the ID market
 - Potential challenges with aggregation of a large number of small-scale units



Feedback - MAGNITUDE

- Indicates our assumption that EHB's main flexibility is “negative flexibility” and HP's are mixed.
- 20 % to the AP and 80 % to the utility seem generous. In cases, we've seen 50/50 splits.
- A challenge right now is to integrate ULTDH in Copenhagen. First step is zones with LTDH, and next steps could be ULTDH.
- Integration with the heat market could harness more price signals to utilize.



Feedback - MAGNITUDE

- We have plans to utilize AP to mobilize heating flexibility.
- In a future, mobilizing flexibility for ULTDH units are interesting, but not investigated yet – an AP would most likely be needed.
- We are curious to see the possibilities of delivering flexibility to the DSO. Our current plans for this are to follow the DSO initiatives to see if the value proposition is strong enough to prioritize these services – for now, we also see the highest potential in DA prices and ID.
- Our results indicate 6 % reduced costs in DA and 7 % additional reduced costs in ID





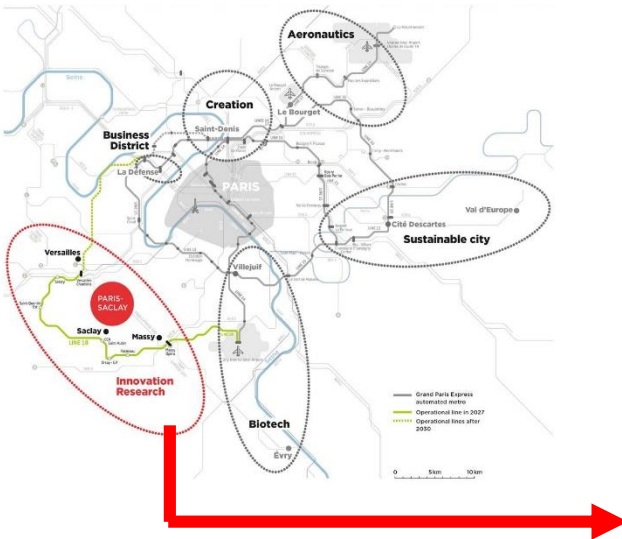
Paris-Saclay

- French case study of **Paris-Saclay** is providing district heating and cooling through distributed heat and cold substations
 - Flexibility comes from heat pumps
 - Participation to the ID market has been analysed
 - Small difference between ID and DA market prices
 - High potential for reducing operational costs and emissions from installation of PV generation



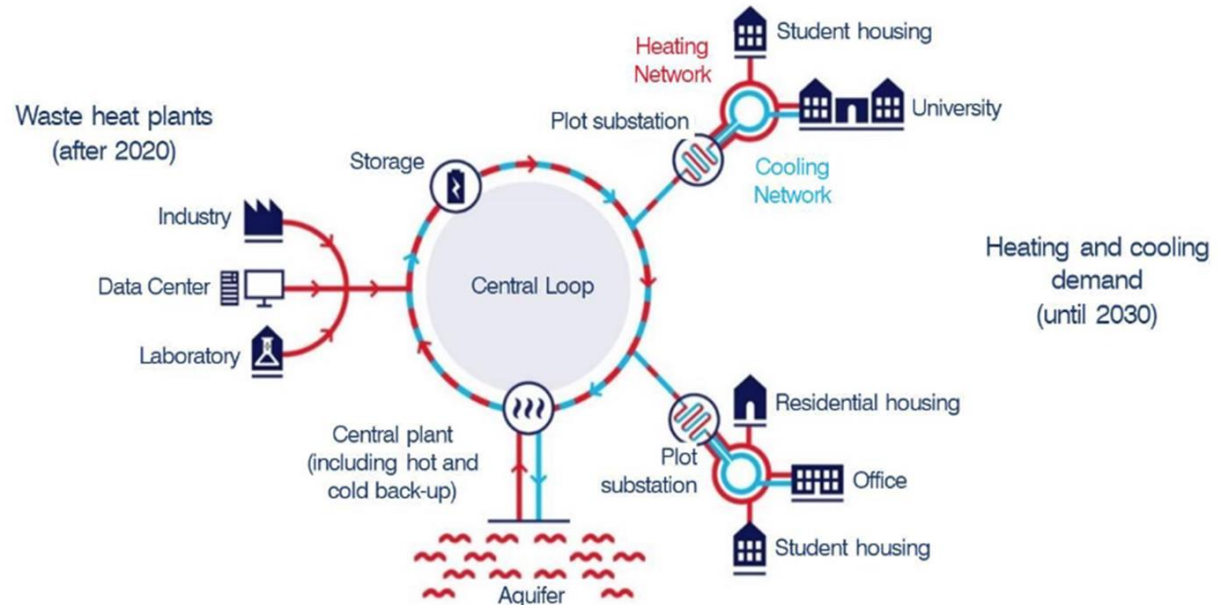


Paris-Saclay: an innovative DHC network for one of the top world innovation clusters



PARIS-SACLAY

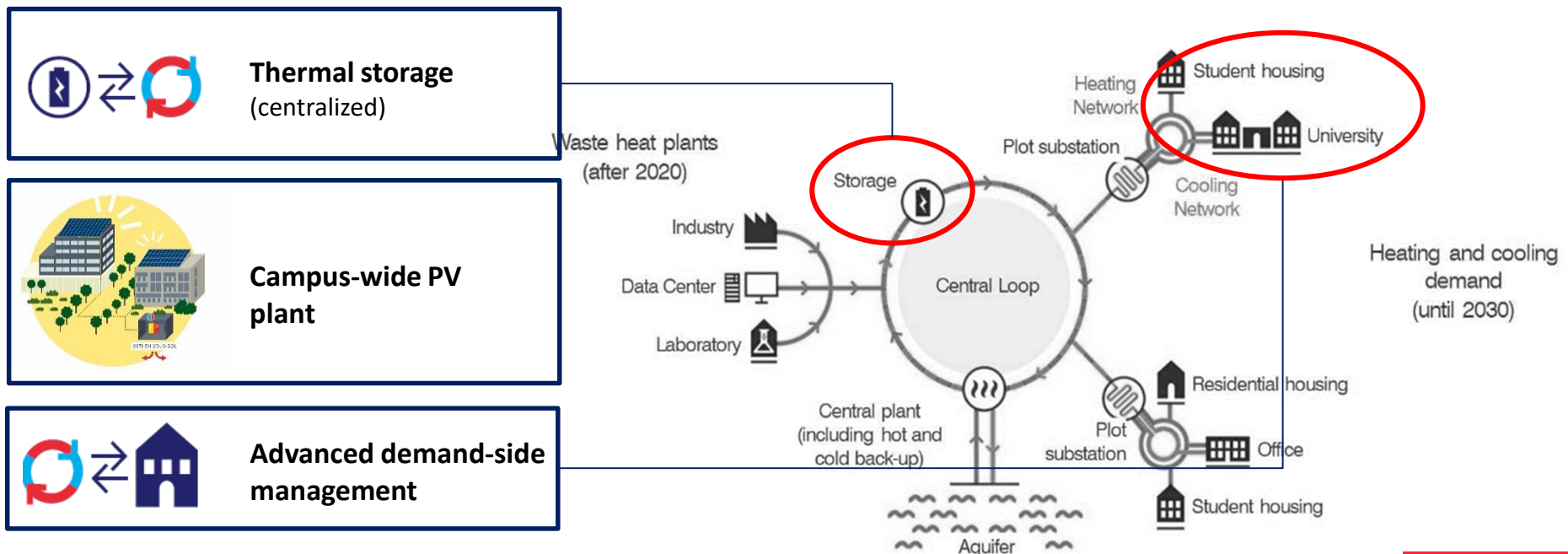
INNOVATION
PLAYGROUND





Current plans to implement the project proposals

> The Magnitude project showcases new opportunities for enhancing environmental benefits of a multi-energy system and diversifying revenues with electrical flexibility services.





Austrian paper mill

- In the case study of Austrian **paper mill** steam and electricity is used for the paper production process



- Flexibility comes from steam turbines at CHP
- Participation to the ID, mFRR and aFRR markets has been analysed
- Presence of capacity payments improve the business case for providing flexibility
- Steam accumulator improves economy, energy efficiency and sustainability



Emuasa

- Spanish case study of **Emuasa** is a waste water treatment plant with self generation of renewable biogas



- Flexibility comes from gas turbines at CHP
- Participation to the mFRR market has been analysed
- Upward flexibility is more likely to be activated than downward flexibility
- Thermal storage significantly increases the amounts of available flexibility

EMUASA FEEDBACK

The results, specially those related to the combination of the gas and heat storage, are in line with the results of previous studies developed by us to store heat or even to take advantage of the excess of heat by producing cold.

BARRIERS

- 1.Legislatives. The plant cannot participate in the reserve market by itself – it must be aggregated to another plant until reaching minimum 10 MW and, to participate in the reserve market, the plant should be discharged as producer.
- 2.Energy Market. Currently economically self-consumption is more profitable than selling (e.g on Day-Ahead market).



BARRIERS

3. Administrative. Any investment should be approved by the appropriate authorities.
4. Our own process: (i) We have very short capacity for controlling the amount of biogas produced because it is a biological process mainly dependent of the load of pollution in WWTP influent, (ii) Our base consumptions, related to pumping and the aeration of the biological reactor can't be stopped and represent the 58% of the total plant demand.
5. Due to the plant situation, we cannot export the surplus heat because there are not heat networks or demand close.

SUPPORT TO ENERGY SYSTEMS

Emuasa 2021-2030 Strategic Plan includes increasing energy production from renewable sources (PV panels).

In case of production in a self-consumption regime with excess of generation, we could raise Demand Response (also with aggregation) if in a future it is implemented in Spain – participation in the electricity market.



Common discussion

How could the available flexibility in the multi-energy systems be increased?

- Emuasa
- Austrian paper mill
- Paris-Saclay
- HOFOR
- ACS



Last remarks

- ACS
- HOFOR
- Paris-Saclay
- Austrian paper mill
- Emuasa



CONCLUSION



Many thanks...

- To all the speakers and panellists
- Valérie Mellier (ARTTIC) and Jack Corscadden (EHP) for the logistics



.... And for your participation and feedback

Please visit our website for more information on the project and the deliverables

<https://www.magnitude-project.eu/>



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