Consequential LCA to assess environmental benefits of Smart Grids

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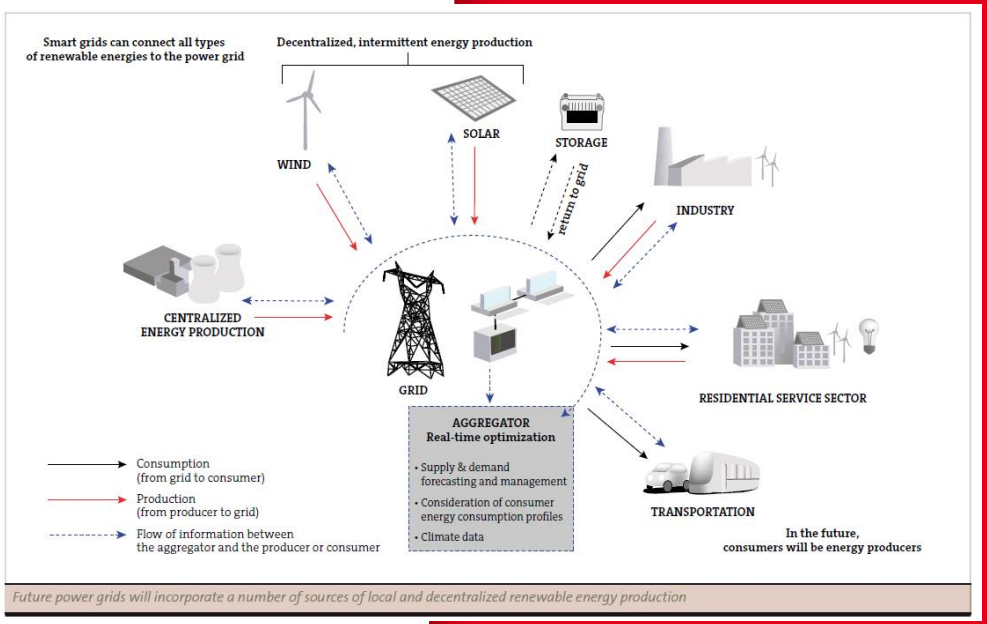
What is a Smart Grids?



Future power grids will incorporate a number of sources of local and decentralized renewable energy production

Why a Smart Grid?

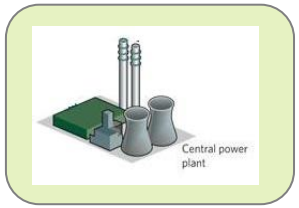
- A Smart Grid in order to face electricity distribution problems
  - Increase in demand and peak consumption
  - Desiquilibrium between production and demand (volume and time schedule)
  - Tension on the network
  - Blackout

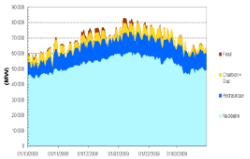
- Emergence of new technologies offers new possibilities
  - Increase of decentralized production of energy especially renewables energy ➔ Smart Grids helps integrate renewables energies
  - Development of Information and Communication Technologies (TIC) ➔ Forecasting tool helps optimizing the grid and limiting the environmental impacts

Simplified current network

Consumption

Centralised production



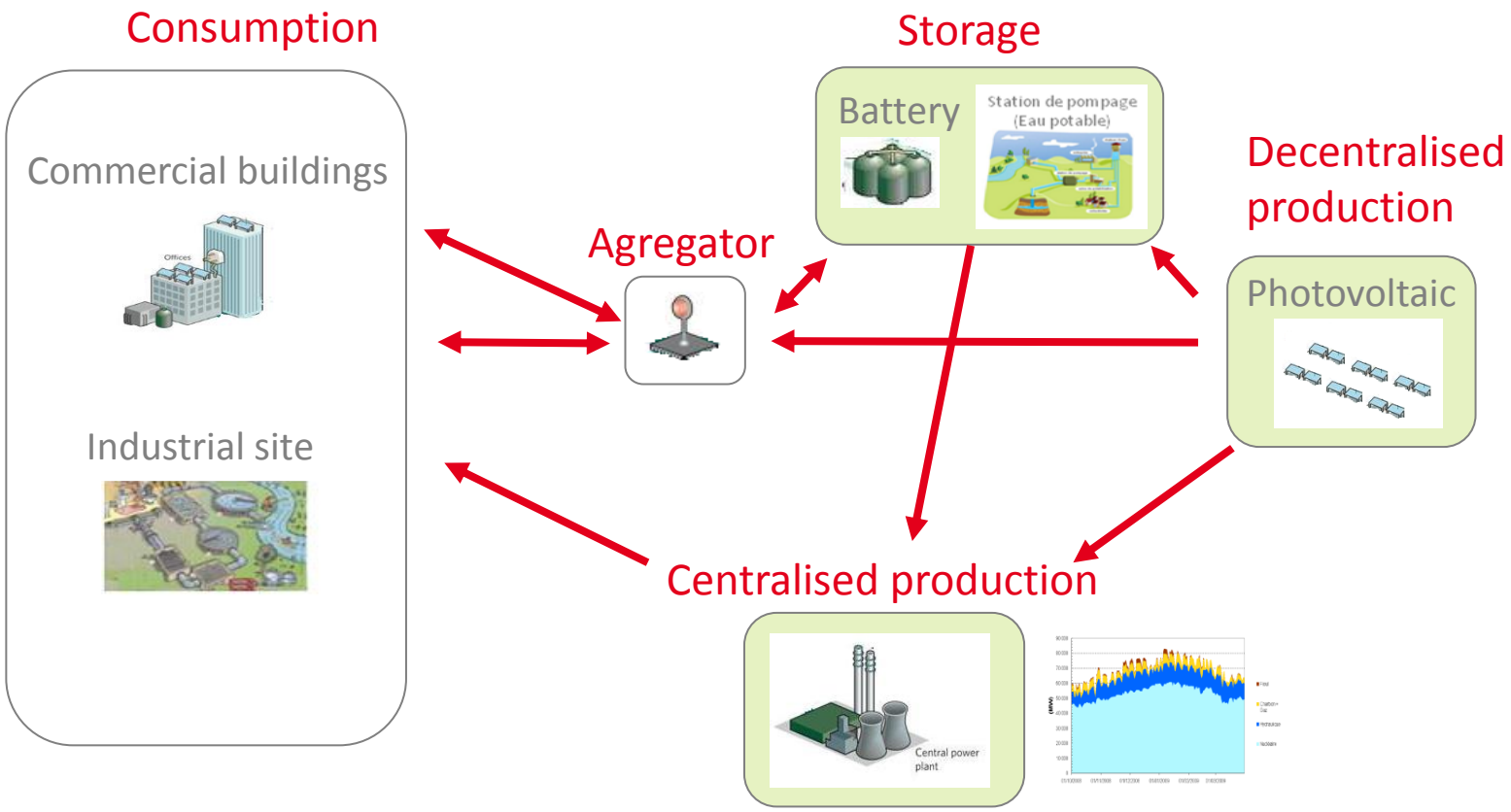


Commercial buildings

Industrial site

- Production plant produce electricity for all type of consumers
  - Few integration of renewables energy production

What is a Smart Grid?



- Forecasting tools generate local flexibility
- Aggregator allows choosing the most sustainable load management / flexibility strategy among a set of scenarios

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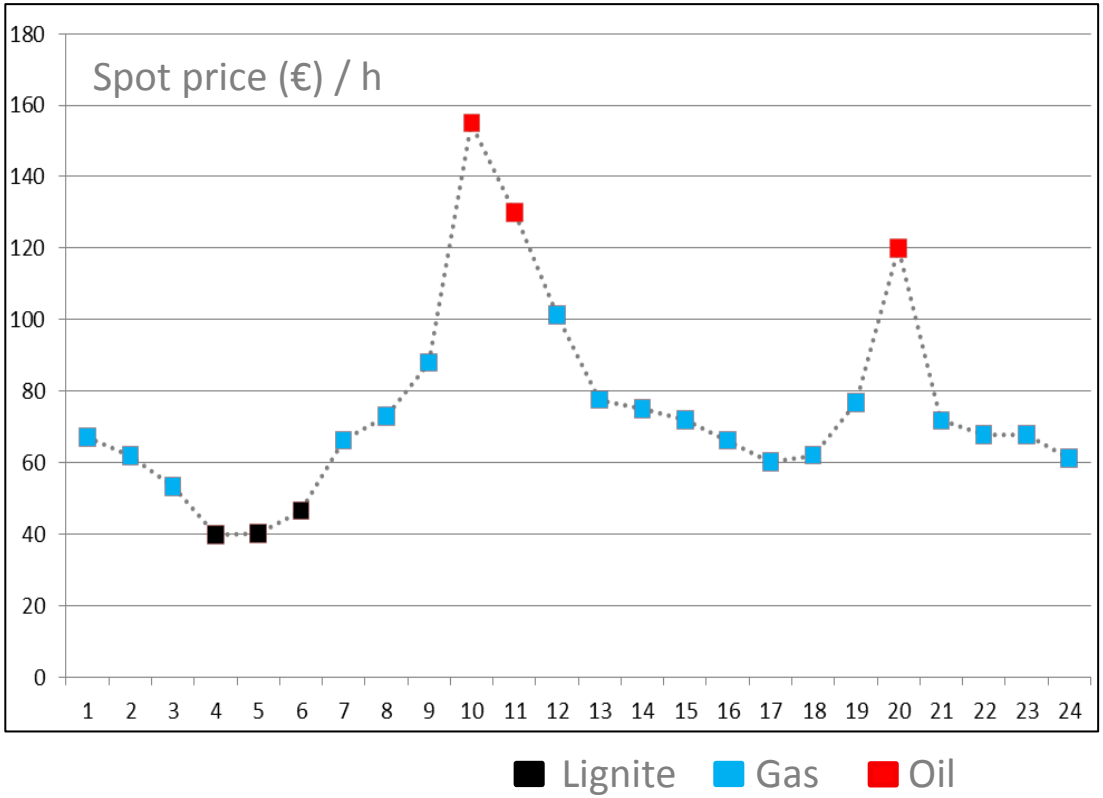
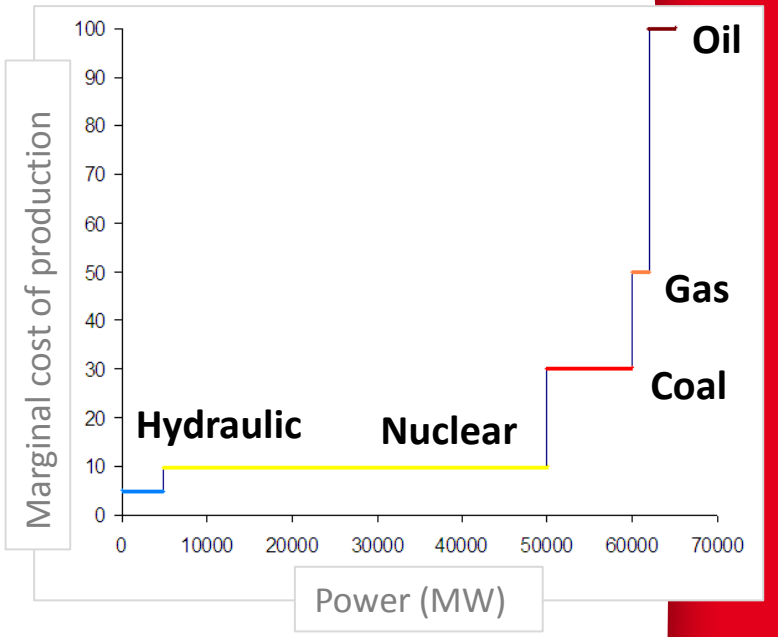
Methodology

How to assess environmental benefits of Smart Grids?

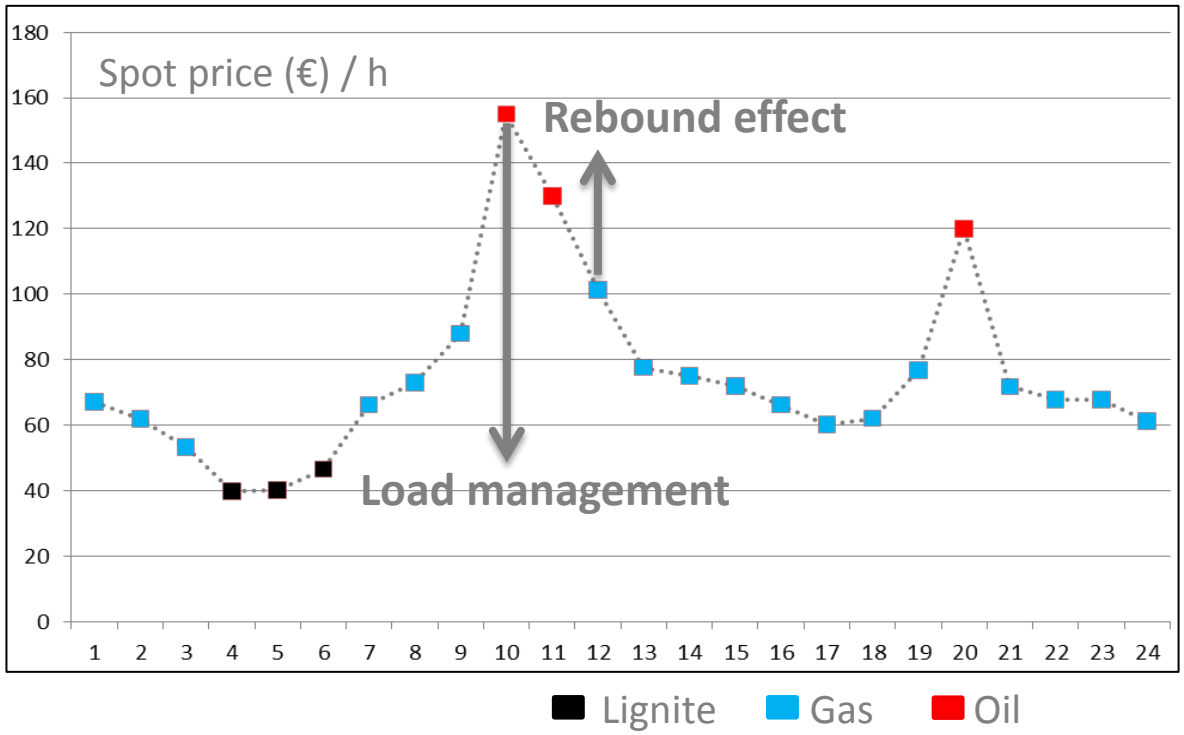
Electricity market

- Based on the ***merit order* logic**: in order to face demand, means of production are called regarding crescent marginal cost (French market production)
- Electricity mix varies over time



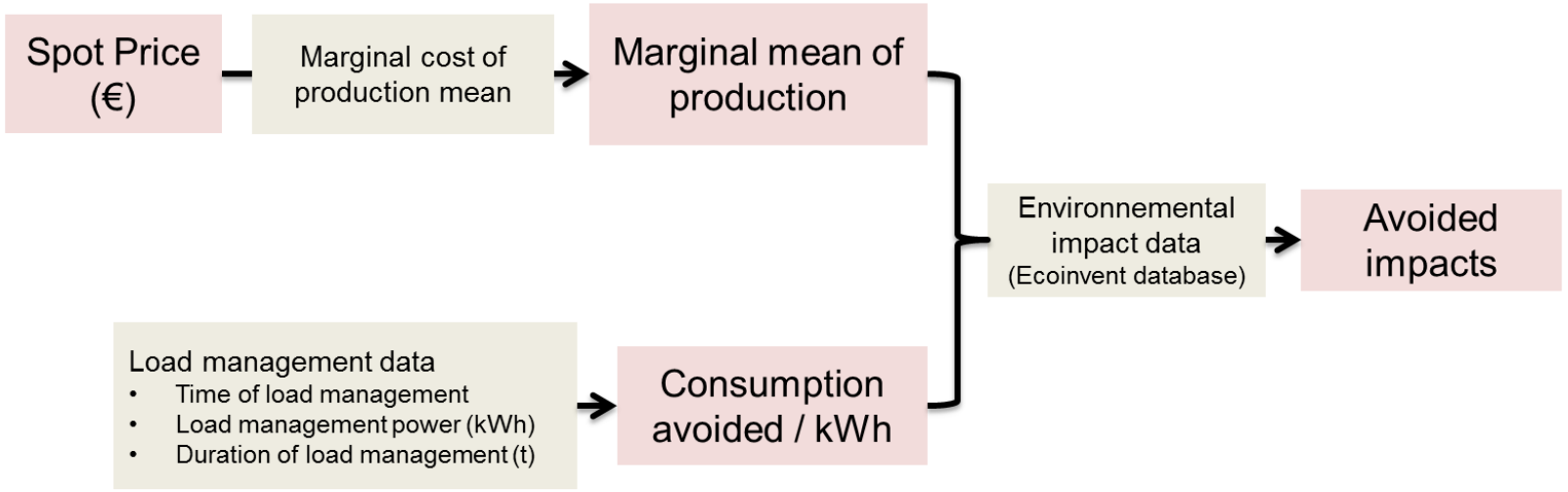


Electricity market



- As the electrical mix varies over time, environmental impacts associated with load management scenario will depend on its planning time schedule.
- Rebound effect taken into account
  - « Rebound effect » is significative within the hour following the load management. The compensation is +100%.
  - Based on observed conditions on site (Reflexe project)

Methodology – How to assess environmental benefits of Smart Grids?



- French electricity market data
- Ecoinvent 2.2, Impact 2002+
- Damage impact categories: Climate Change, Ecosystem Quality, Human health, Natural Resources
- Focus on emissions categories: CO2, NO2, SO2, Particulates

Functional Unit (FU) = 1 MW of network flexibility

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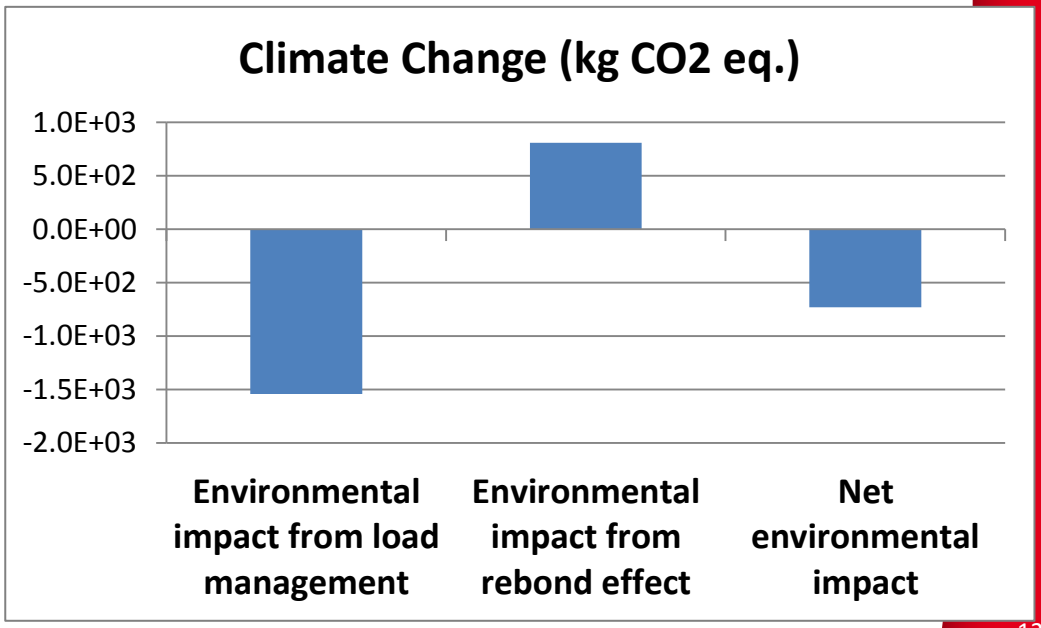
Examples and results

Peak period scenarios

- Average winter peak (9 – 11 am)
  - Load management of 1MW during 2 hours (i.e 2MWh)

	Nuclear	Coal	Gas	Oil	Lignite
Mix load management	1,6%	52,4%	38,9%	2,4%	4,8%
Mix rebond effect	1,6%	58,7%	38,1%	1,6%	0,0%

- $EI_{net} = EI_{load\ management} + EI_{rebond\ effect}$
- If EI_{net} negative, the scenario allows avoiding impacts
- If EI_{net} positive, the scenario is creating more impact than the reference



Results – Winter and summer peak

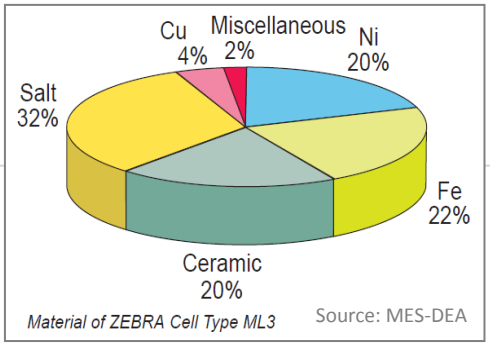
- Impact calculated per MWh

Impacts indicators	Winter peak hour 9-11 am	Summer peak hour 12-14 pm
Climate change (kg CO2 eq./MWh)	-3,7E+02	-4,5E+02
Ecosystem quality (PDF.m2.yr/MWh)	-4,9E+01	-7,4E+01
Human Health (DALY/MWh)	-2,1E-04	-3,1E-04
Natural resource depletion (MJ primary/MWh)	-4,9E+03	-5,2E+03

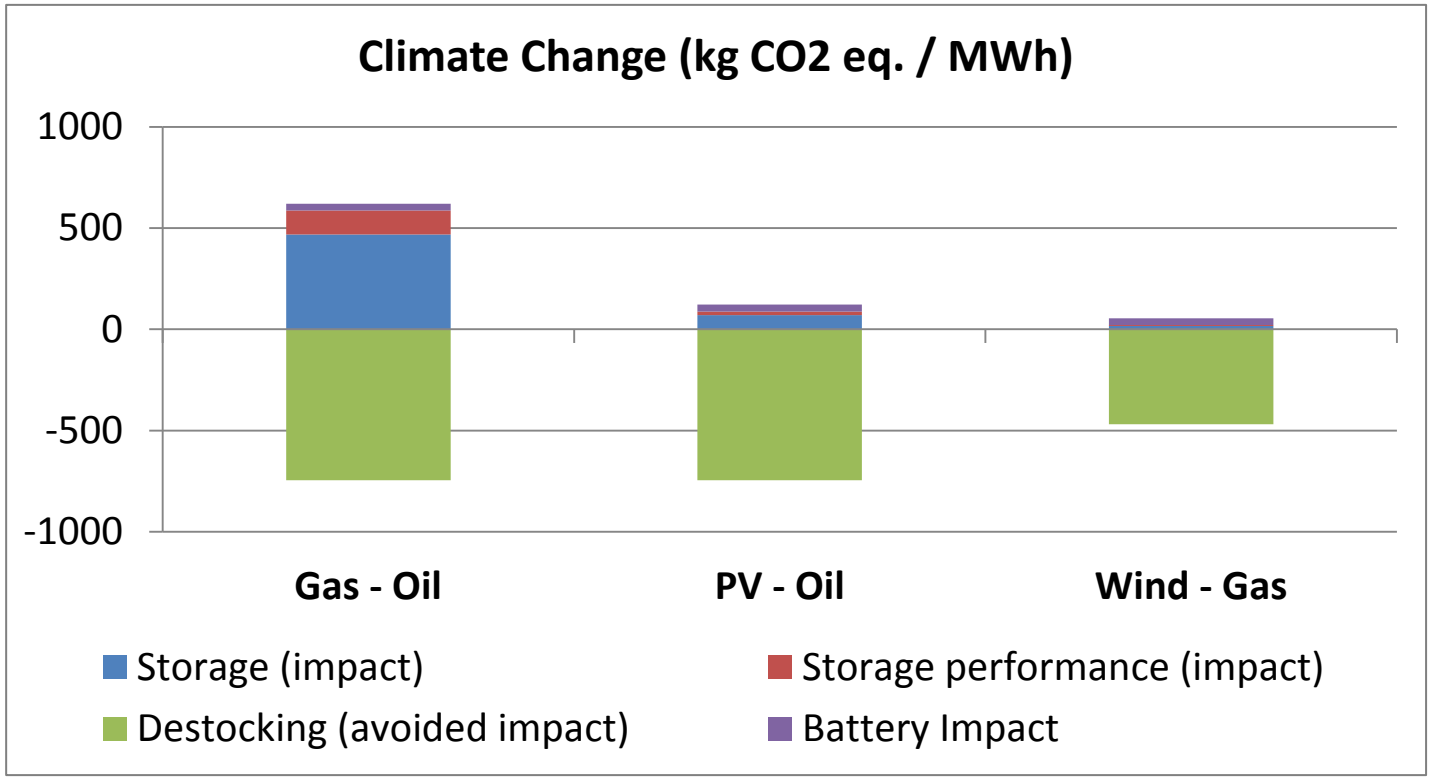
Emissions indicators	Winter peak hour 9-11 am	Summer peak hour 12-14 pm
CO2 (kg / MWh)	-4,1E+02	-5,2E+02
SO2 (kg / MWh)	-1,4E+00	-2,1E+00
NOx (kg / MWh)	-9,7E-01	-1,3E+00
Particulates (kg / MWh)	-4,6E-01	-7,5E-01

- Results are comparable for winter and summer peak
- **$EI_{net/peak\ consumption}$ ≈ - 450 kg CO2/MWh ≈ - 4,7 MWh average mix**

Storage/Destocking scenario



- Zebra batteries (sodium/ nickel chlorure) (storage performance of 80%)



- Energy produced during low demand period can be stored and used for peak demand as buffer stock

Take home message

- Significative impacts on CO2 reduction compared to a conventional grid
- Load management scenarios can benefit to the environment according to the marginal mean of production of the time of load management
- Need to implement environmental assessment tool into the aggregator

References

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