Contributing to a Carbon-Free Economy with Smarter Homes

The European Experience

2014 EU-US Frontiers of Engineering Symposium
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CODA STRATEGIES - 1 rue des Gâtines- 75020 Paris —France
Tél: 33 (0)1 30 30 74 68 Fax: 33 (0)1 30 30 34 40
Internet: www.codastrategies.com Email: contact@codastrategies.com

0_ What we'll be talking about

1_ INTERMITTENCY AND THE NEED FOR GREATER FLEXIBILITY

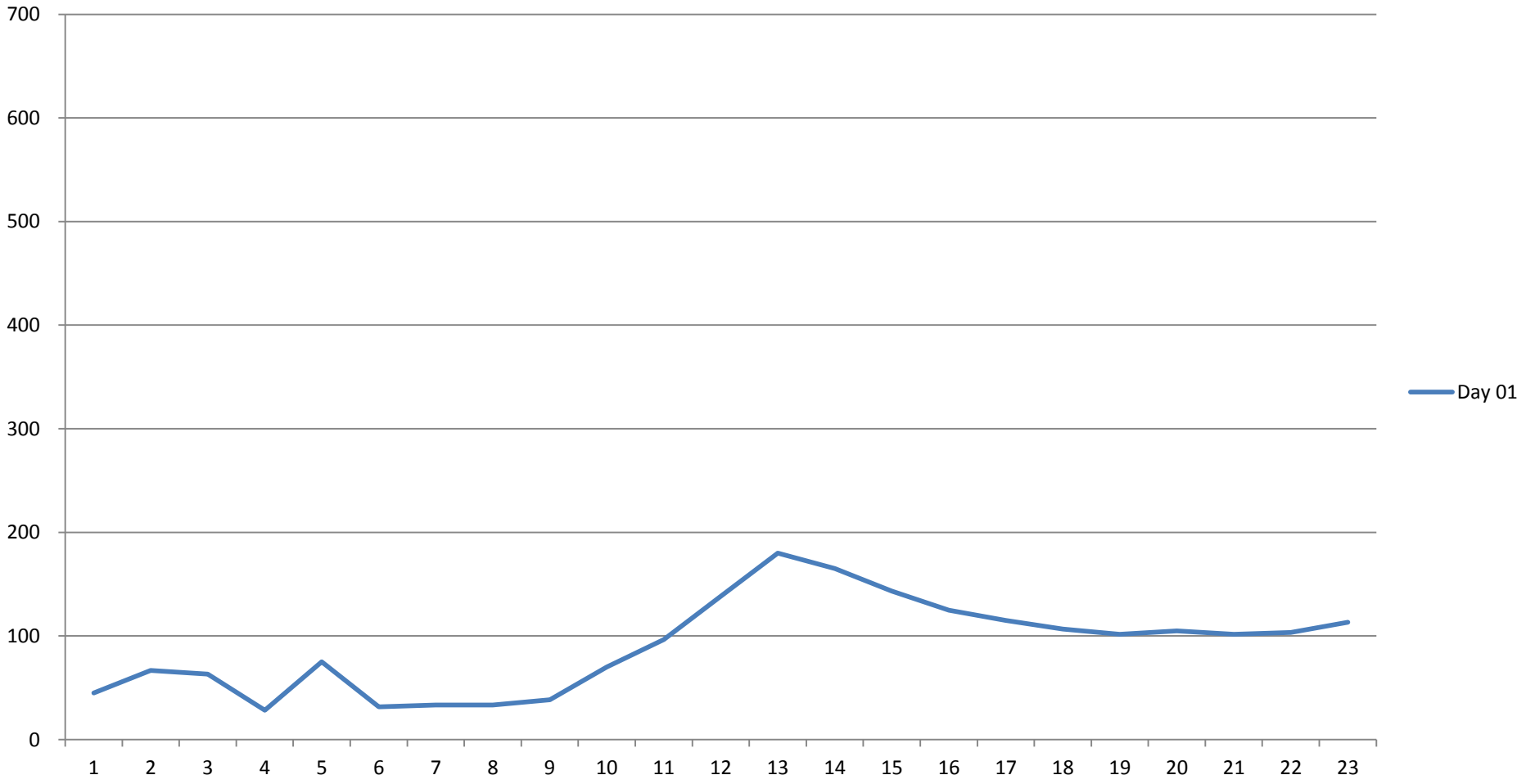
2_ SMART HOMES AND RESIDENTIAL FLEXIBILITY

3_ RESIDENTIAL FLEXIBILITY: QUANTITATIVE POTENTIALS

4_ BARRIERS / DRIVERS + RESIDENTIAL OPPORTUNITIES

1_ Intermittency is a major factor in all EU countries

1_ The Tehachapi example: wind farm output



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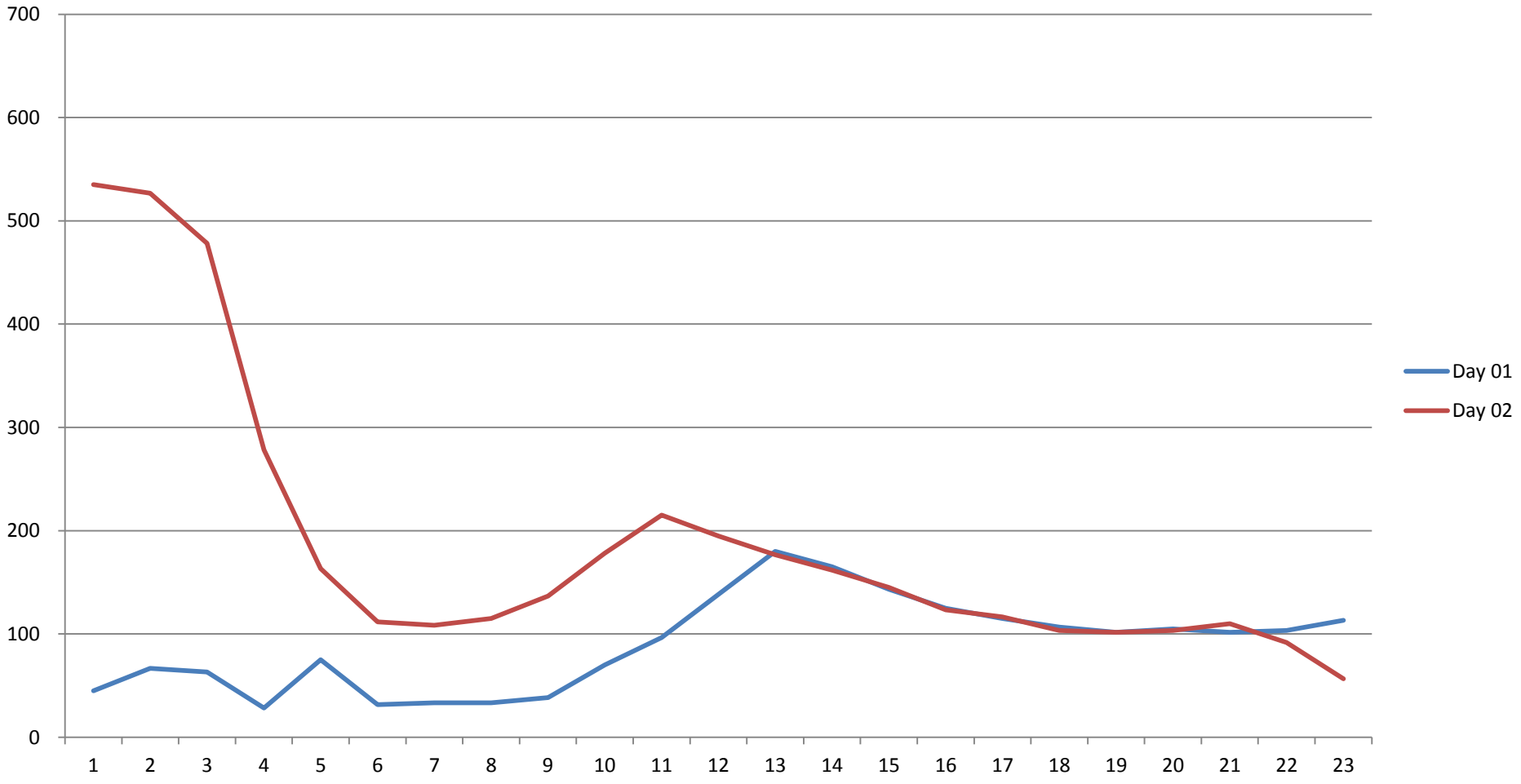

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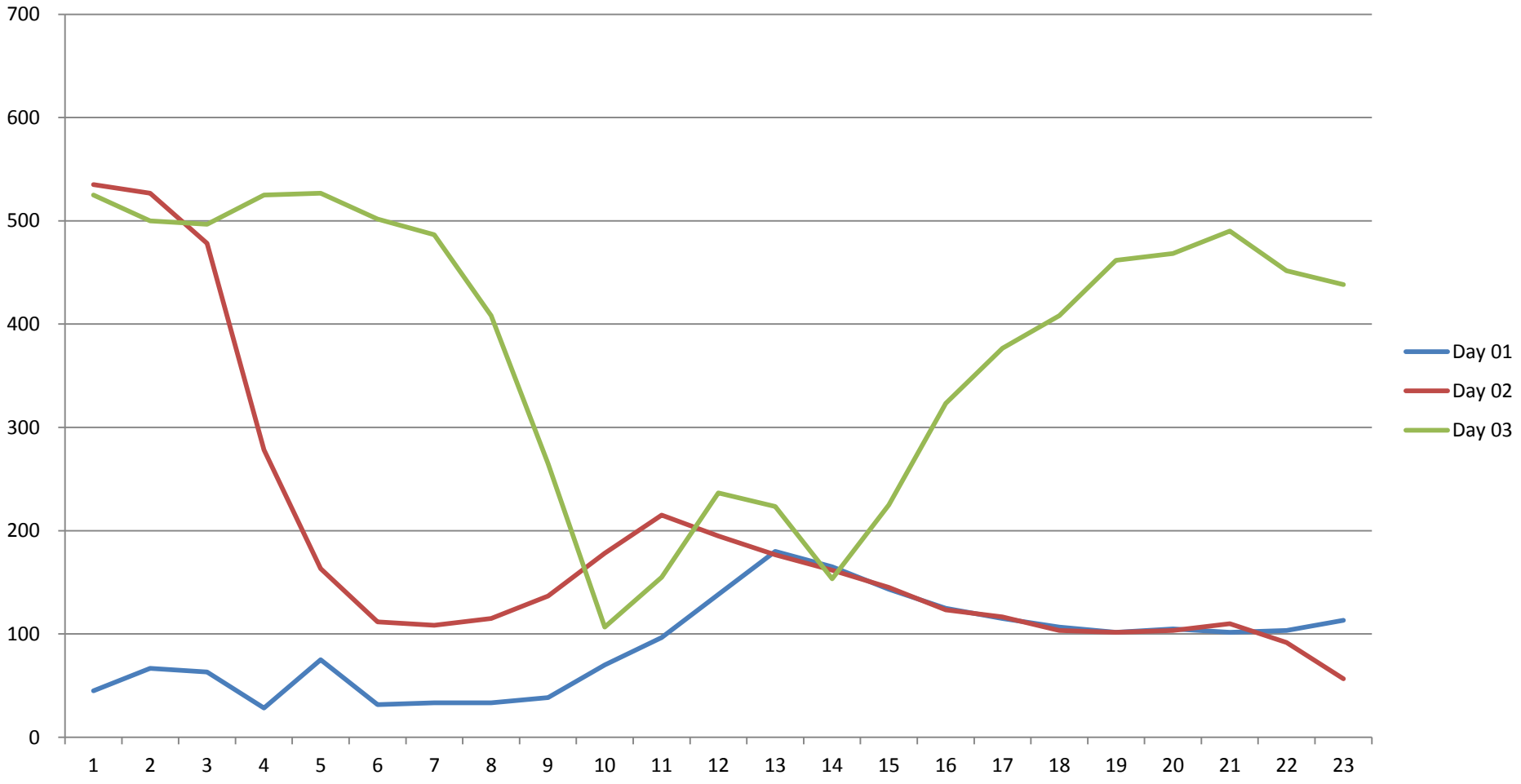
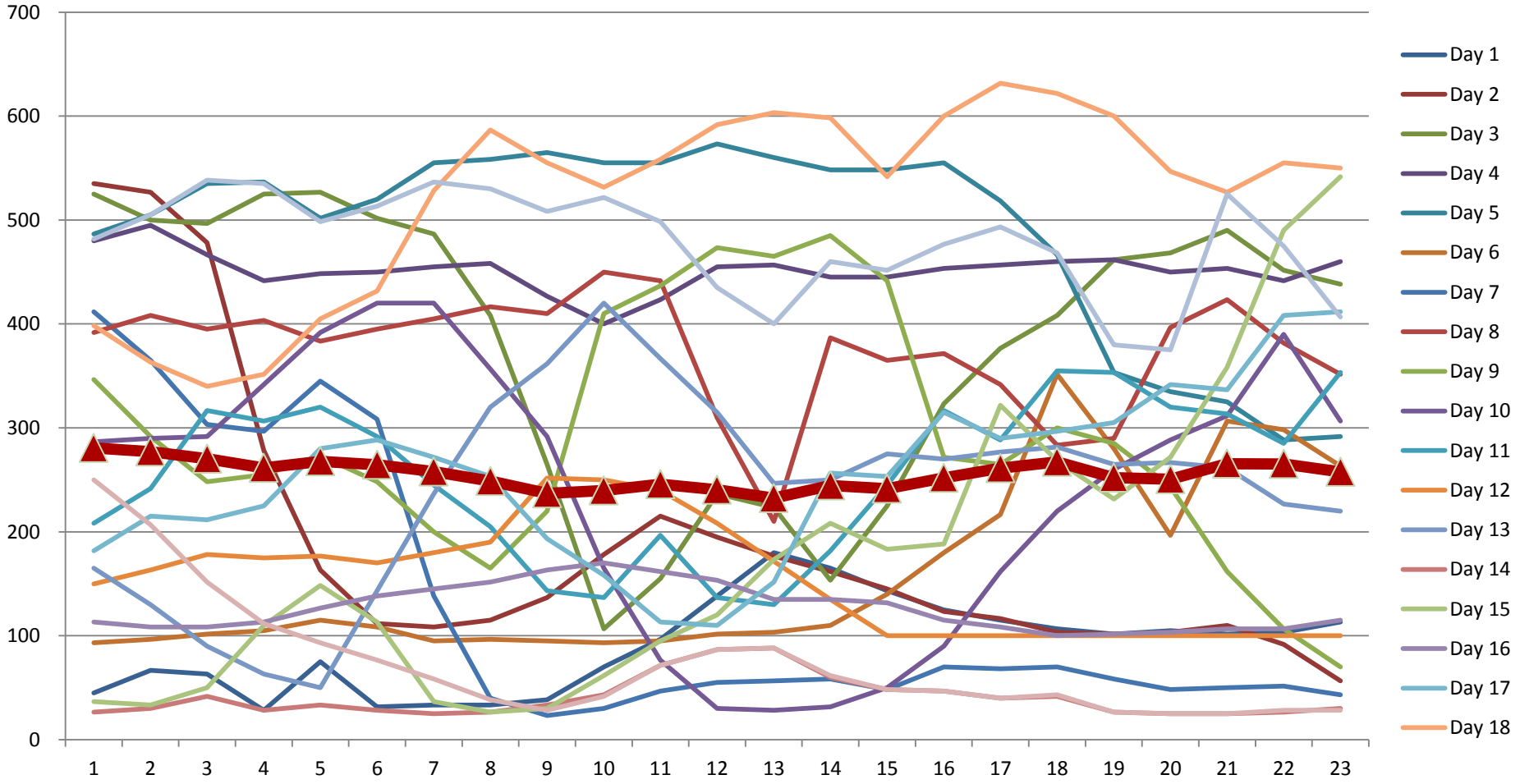


1_ The Tehachapi example: wind farm output over 20 days



1_ The effects of intermittency are visible throughout the value chain

Generators

LOWER CAPACITY FACTORS + DT

TSO

INCREASES IN BALANCING COSTS

DSO

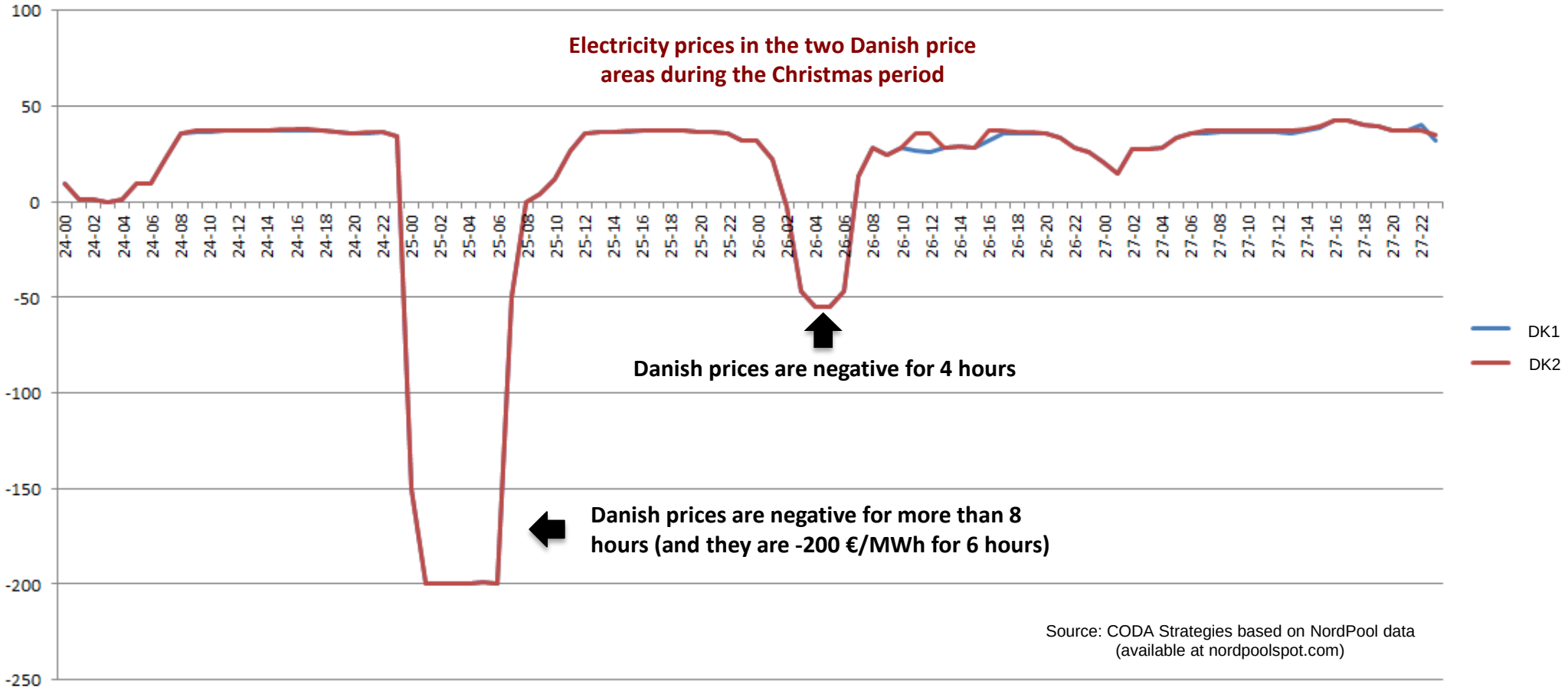
MANAGEMENT OF ELECTRICITY FLOWS

Markets

VOLATILITY AND NEGATIVE PRICES

1_ The effects of intermittency are visible throughout the value chain: the market

→ Significant market impacts (intermittency leading to over- or under-supply)



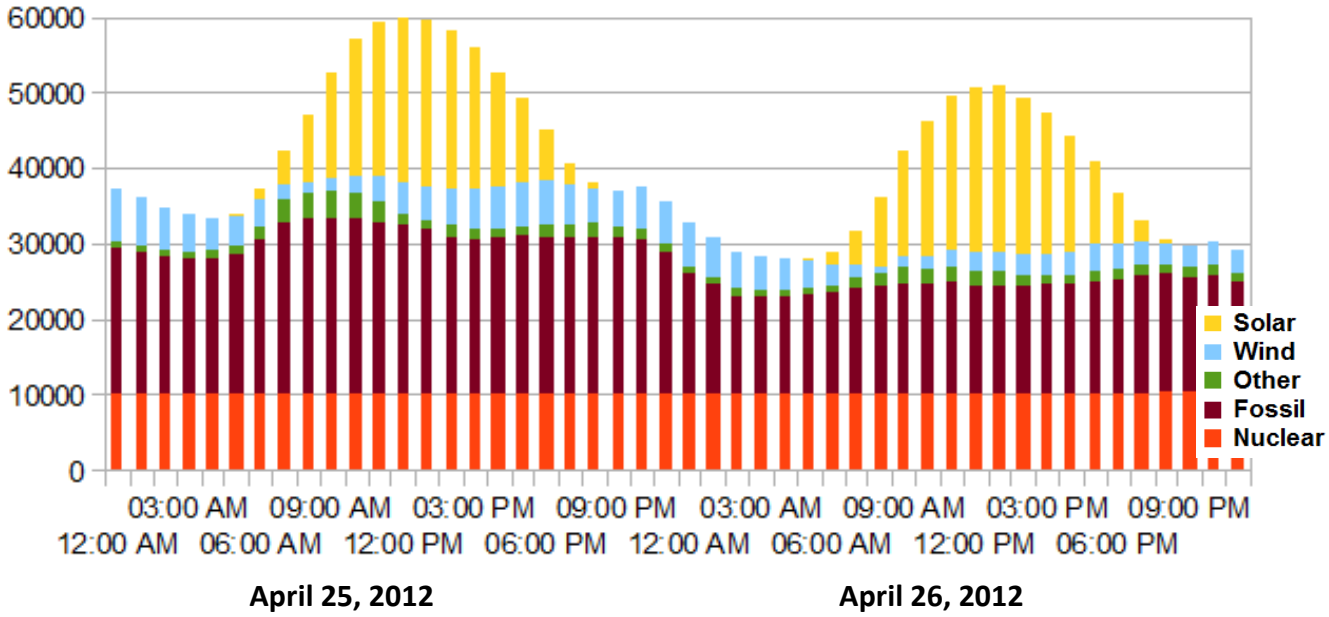
1_ The effects of intermittency are visible throughout the value chain: generation

→ Impacts not only on off-peak periods, but also during on-peak periods

→ All players on the electricity supply value chain must adapt

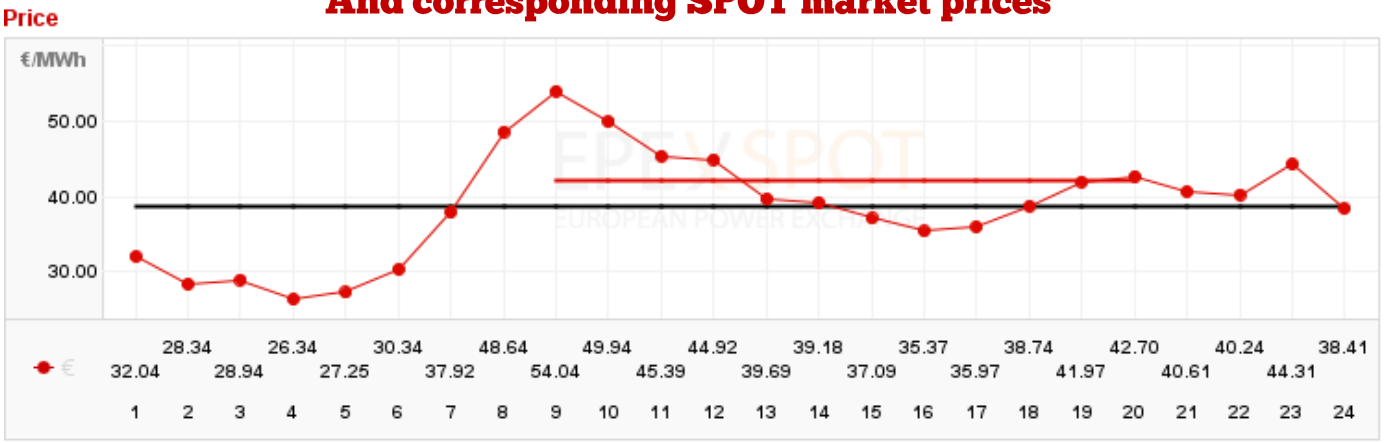
→ Some are already feeling the brunt: e.g. peak generators

Generation on two consecutive (sunny) days in Germany, 2012



April 25, 2012 **April 26, 2012**

And corresponding SPOT market prices



1_ The effects of intermittency are visible throughout the value chain: generation

Peakers cannot make a living.

LOW CAPACITY FACTORS:

Germany, Spain, France, the Czech Republic, the Netherlands

25%

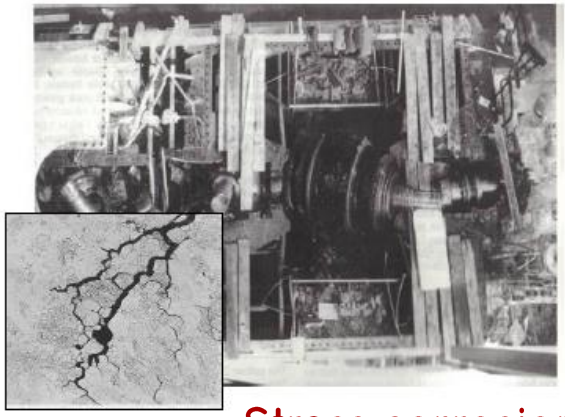
23%

26%

Mothballed powerplants

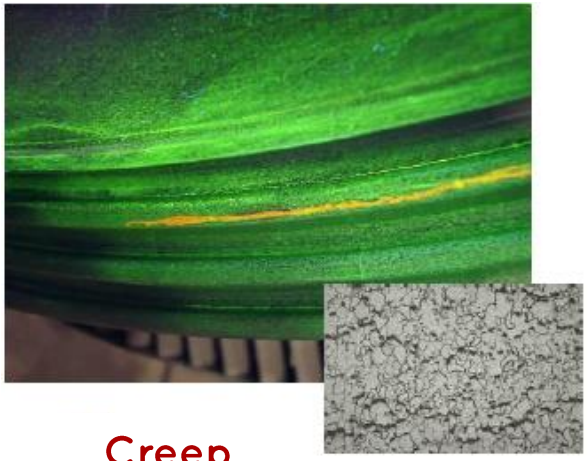
Irsching 5 | E.On
€ 400 million investment
Running for close to 4 years
Spark spreads at a record low-18 €
Negotiations on the future of the plant between E.On and local stakeholders
+ more emissio ns - flexibility

2_ The effects of intermittency are visible throughout the value chain: generation



Stress corrosion cracking

Corrosion Fatigue

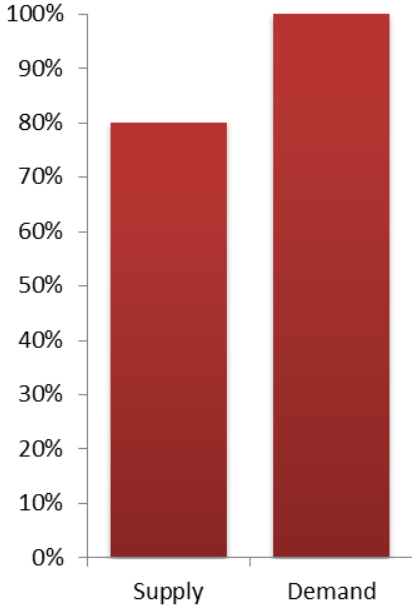


Creep

Fatigue

2_ Demand Response as an alternative

Supply demand inbalance



Option 1: Increase Supply

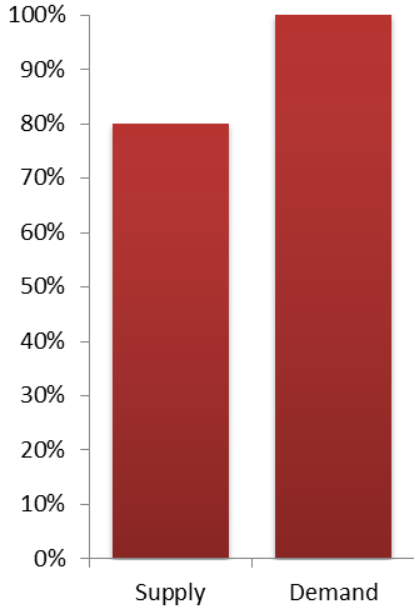
Option 2: Lower Demand

2_ Demand Response as an alternative

> Changes in electric usage by demand-side resources from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

FERC Demand Response Definition

Supply demand inbalance



Option 1: Increase Supply

Option 2: Lower Demand

2_ Demand Response as an alternative: residential vs commercial&industrial

Up to now, focus mainly on C&I capacities, due to the high costs per kW in the case of residential. Thermosensitive systems however, may provide interesting opportunities.

Increase in €/kW of capacity

Non-essential, industrial processes, usually providing several MW of flexibility
Highly represented sectors: water treatment, chemical industry, wood / pulp / paper
At least 150 kW per consumer, and usually considerably more

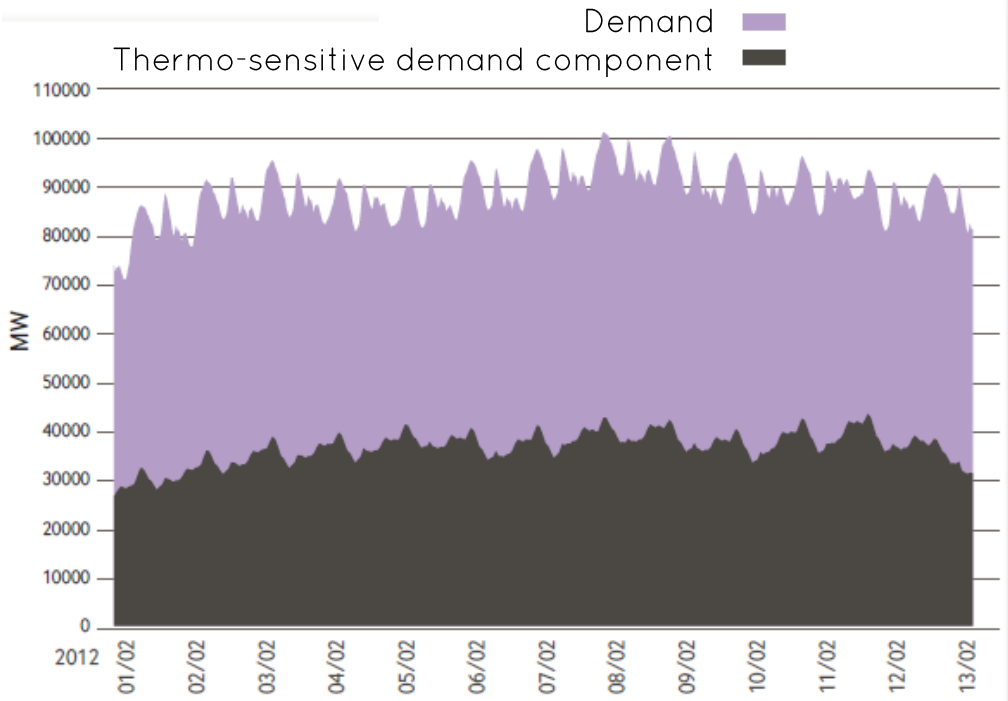
HVAC, non-essential lighting, escalators, use of elevators, etc.
Can only be controlled economically if BMS system installed.
Significant investment may otherwise be required.
100+ kW per building owner/manager

In Europe, potential mainly with heating, although cooling also possible in some Southern countries
Requires at least a load/switch thermostat or a smart "energy box"
Between 1 and 2 kW per consumer, in most households

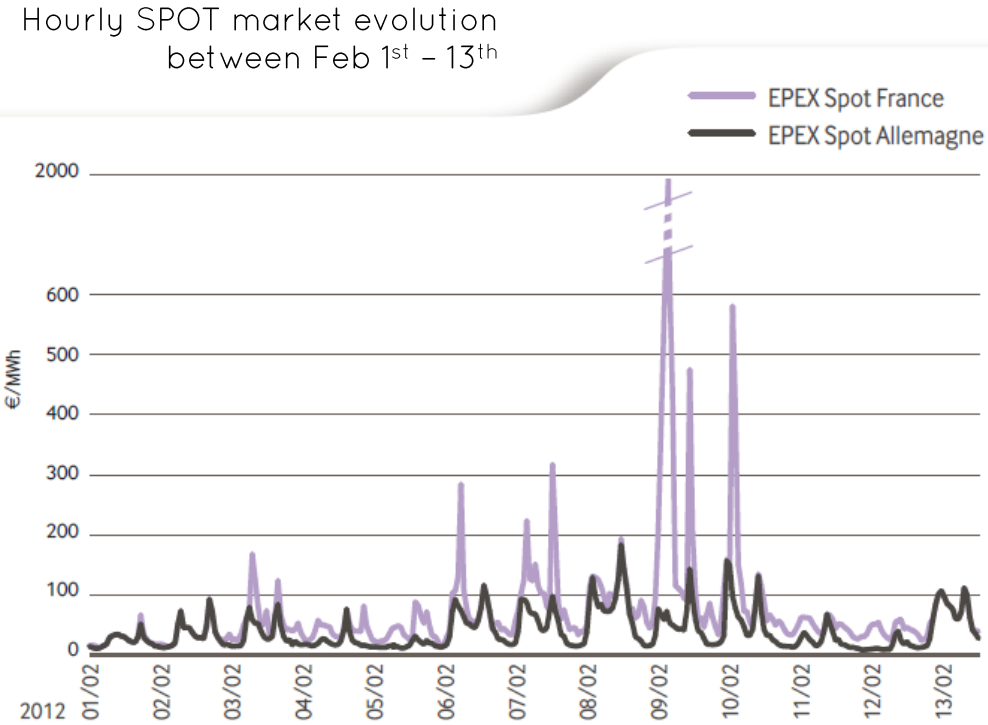
2_ Demand Response as an alternative: residential potential

→ The economics of residential DR are more favorable on thermosensitive systems. Residential DR can have a strong impact on grid stability.

A highly thermo-sensitive system (France, Feb. 2012)



And its effects on SPOT prices (France, Feb. 2012)



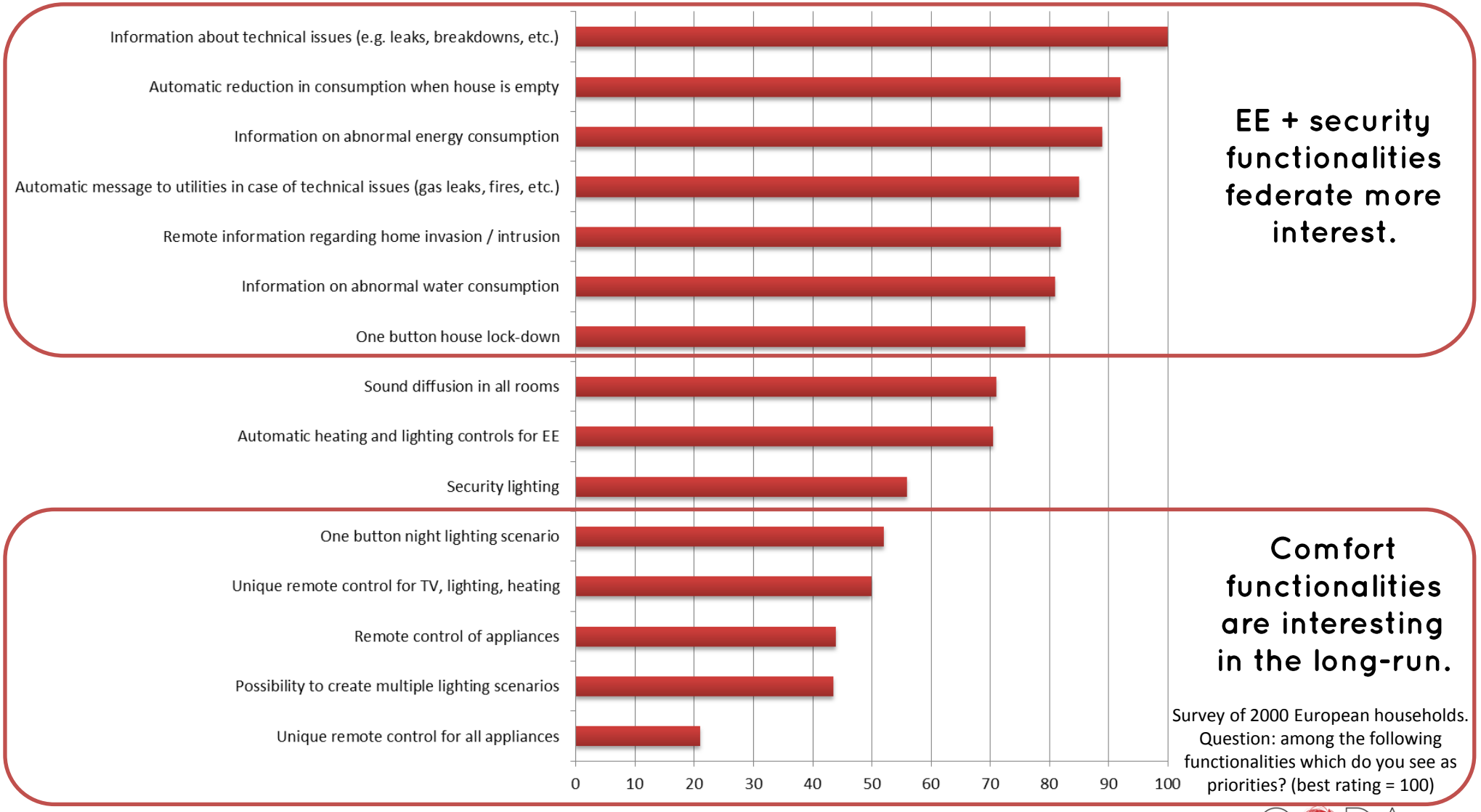
Source: RTE

2_DR as an alternative: residential potential

- → French example clearly showing the potential or residential DR
- → Dynamic tariffs + "specialized equipment" since the 60s – ERDF's legacy DR program
- → However, despite the water heating program experience, low residential capacity valuation in other field
- → No new developments: most smart home equipment commercialized on the promise of greater comfort, not greater EE or smart energy use

A significant share of France's residential water heaters are remotely controlled by the National DSO through relays. The service is offered in association with a Day-Night tariff The program practically provides 20 TWh of energy storage on a yearly basis

2_ Expected Smart Home functionalities



Survey of 2000 European households.
Question: among the following functionalities which do you see as priorities? (best rating = 100)

2_ Smart Home Demand Solvability

- Consumers are not really interested in paying for a service
- 9 € appears as the price at which demand is most solvable
- Price segmentations tend increase market turnover, indicating that wealth of services will be crucial

ONE PRICE

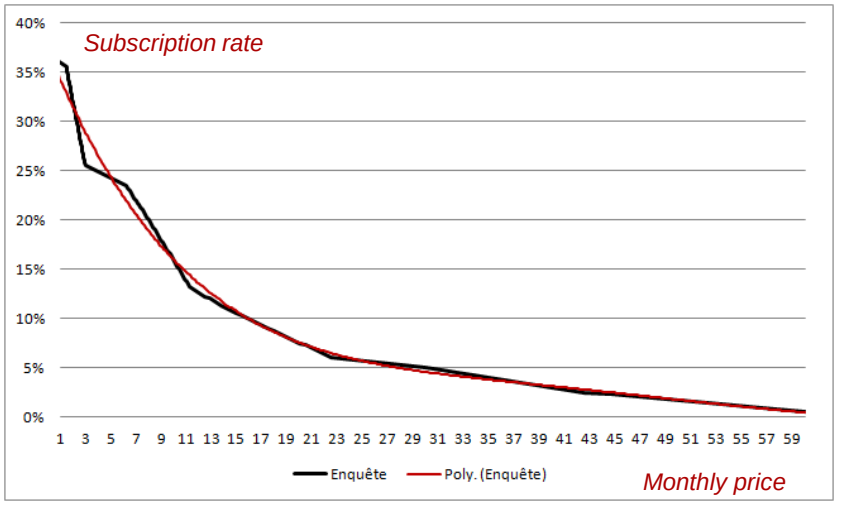
Unique Price **9 €**

Turnover **116 M €**

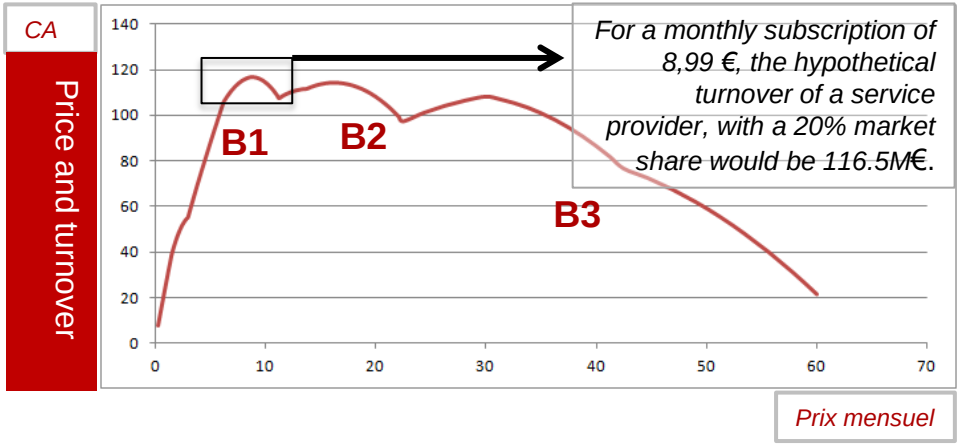
SEGMENTATION

B1 40 €	**B2** 20 €	**B2** 9 €
86 M €	**62 M €**	**70 M €**

Price levels and corresponding subscription rates



Price and turnover



2_ Smart Home: Financing the Investment

Initial investment from the end-user

Installation by qualified installers Practically a niche market, in Europe

→ **Socialization of the investment:** e.g. through the deployment of a system providing aid or assistance to the elderly

→ **Financing through valuation of EE and flexibility:** Deployment and valuation of home energy management systems, with the valuation of the energy efficiency and the residential flexibility (DR) paying in part, or fully, for the equipment

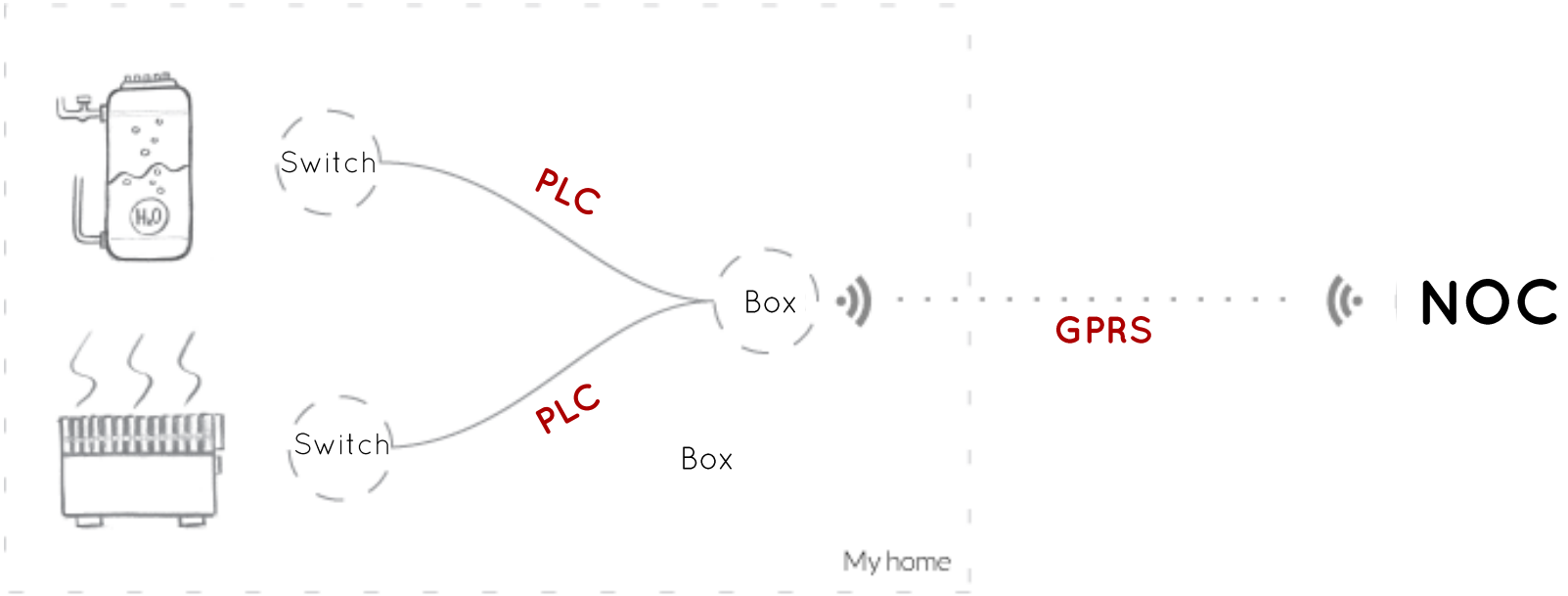
→ **Extension of the perimeter of one application:** funding for the equipment mutualized with one major application, usually security – the ADT model

2_ Smart Home: the Current Technology Models - Independent

→ Several independent aggregators reflections, mainly in countries with strong use of electrical heating

→ "Simple" equipment – communicating load switches – aimed at valuating DR capacity, and commercialized as providers of EE for the end-consumer.

→ No rewards for participation, outside "promised EE"



2_ Smart Home: the Current Technology Models - Utilities

- → Utilities are still sticking with the "invest then save" model, where consumers pick up the tab
- → Market is not really developing
- → As is the case with individual aggregators, service mutualization is not possible
- → EE is expected to be the major source of "revenue" for the customer

3_ Determining the potential for residential DR in Europe: the methodology

Development of a residential DR potential model, focusing on 8 countries
(Fr, De, E, It, UK, Benelux, Se)

Evolution of the housing stock

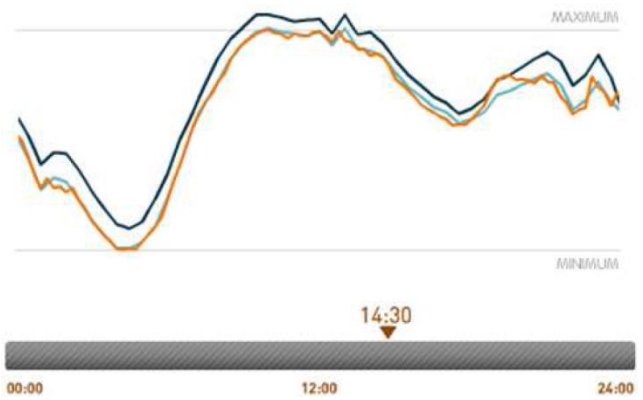
Heating, cooling and household appliances

Evolution of the equipment park

Demand + consumption

Yearly, monthly, daily, hourly

Distribution per hour per scenario



Potential and expected valuation of DR

→ Several demand penetration scenarios

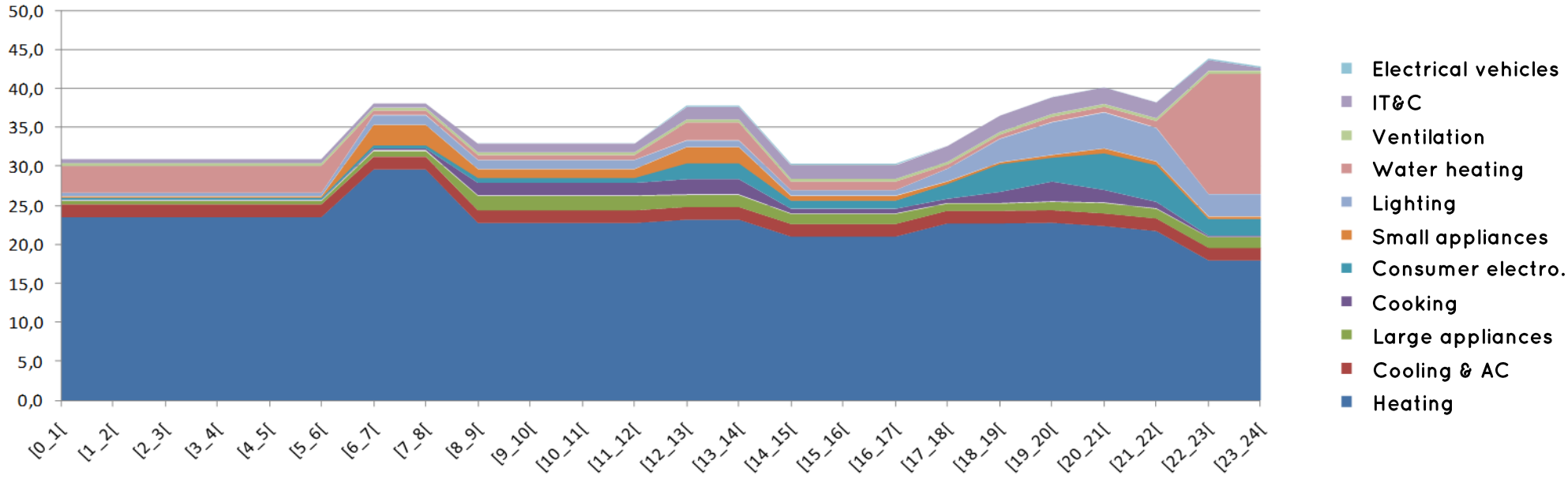
→ Potential for DR on an hourly basis, per type of curtailment

→ Potential per type of equipment and overall potential

→ Expected DR capacities

3_ Determining the potential for residential DR in Europe: French example

Residential demand during a typical (t1) November evening, 2010



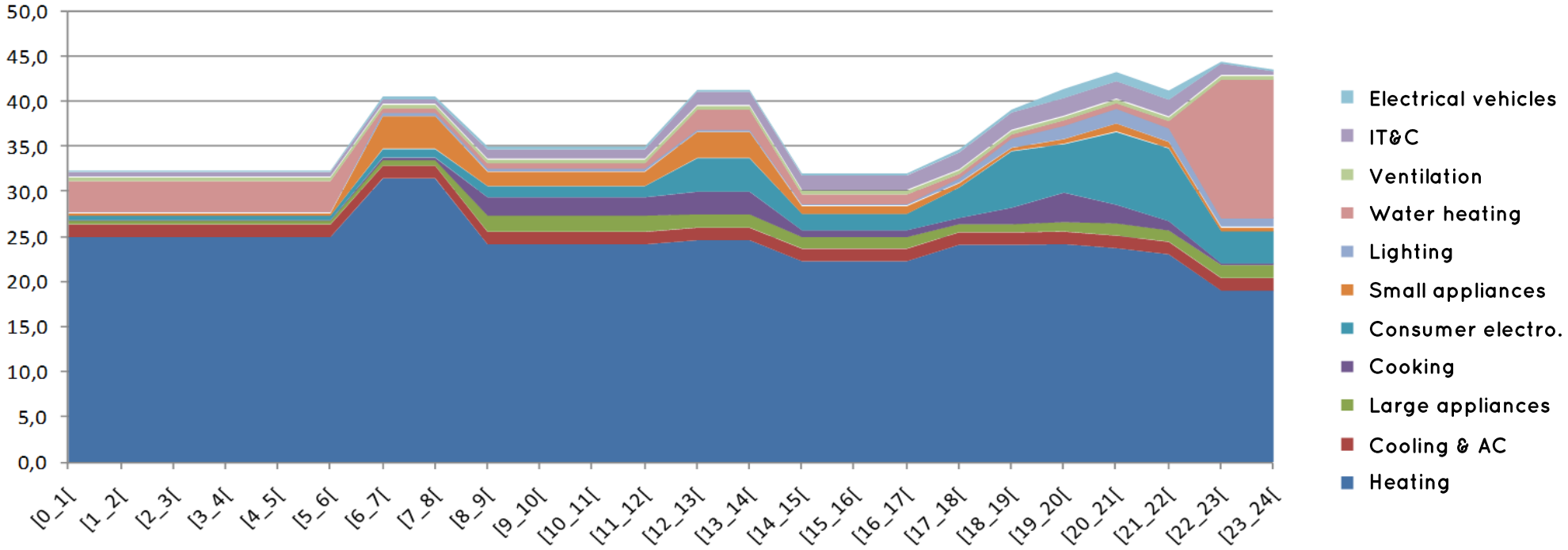
Significant capacity of relatively curtailable, heating loads

Can be used as fast DR for ancillary services, valued on capacity markets, etc.

Significant DR potential is thus available when most required

3_ Determining the potential for residential DR in Europe: French example

Residential demand during a typical (t1) November evening, 2015

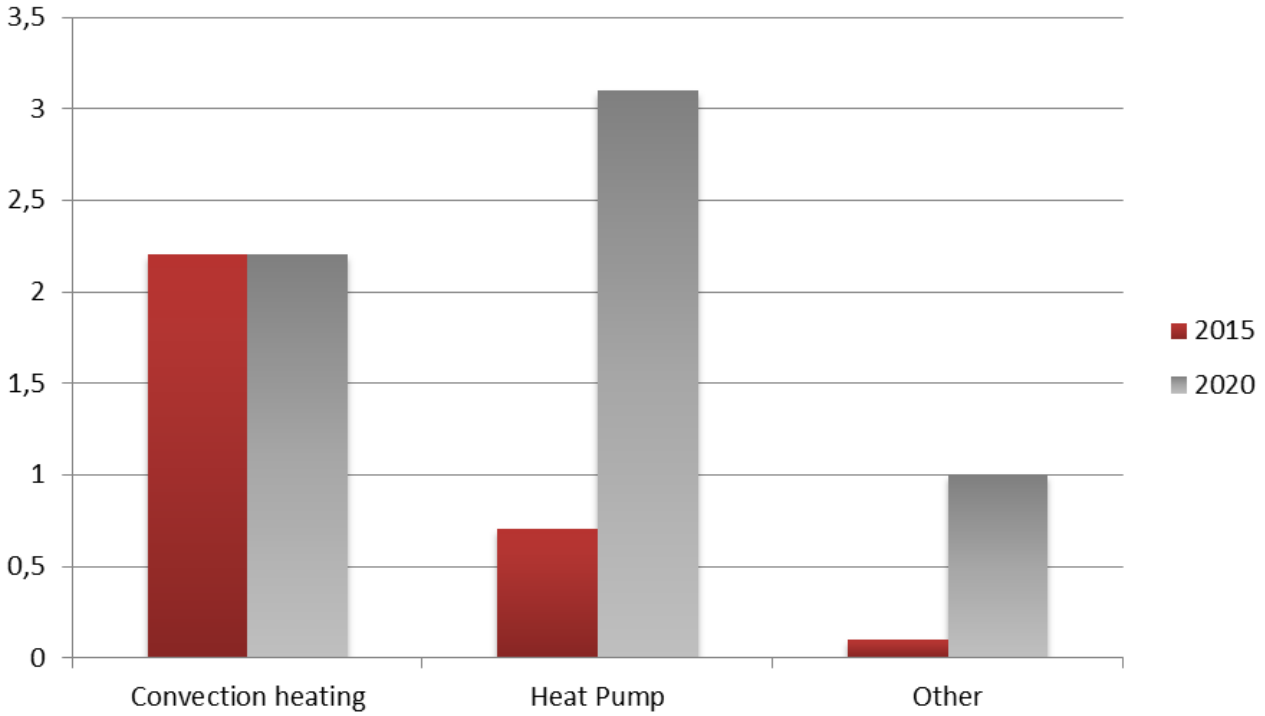


Some increase in thermosensitivity (mainly from heat pumps)

Significant drop in demand from lighting systems

Relative increase in consumer electronics and IT&C

3_ Determining the potential for residential DR in Europe: French example



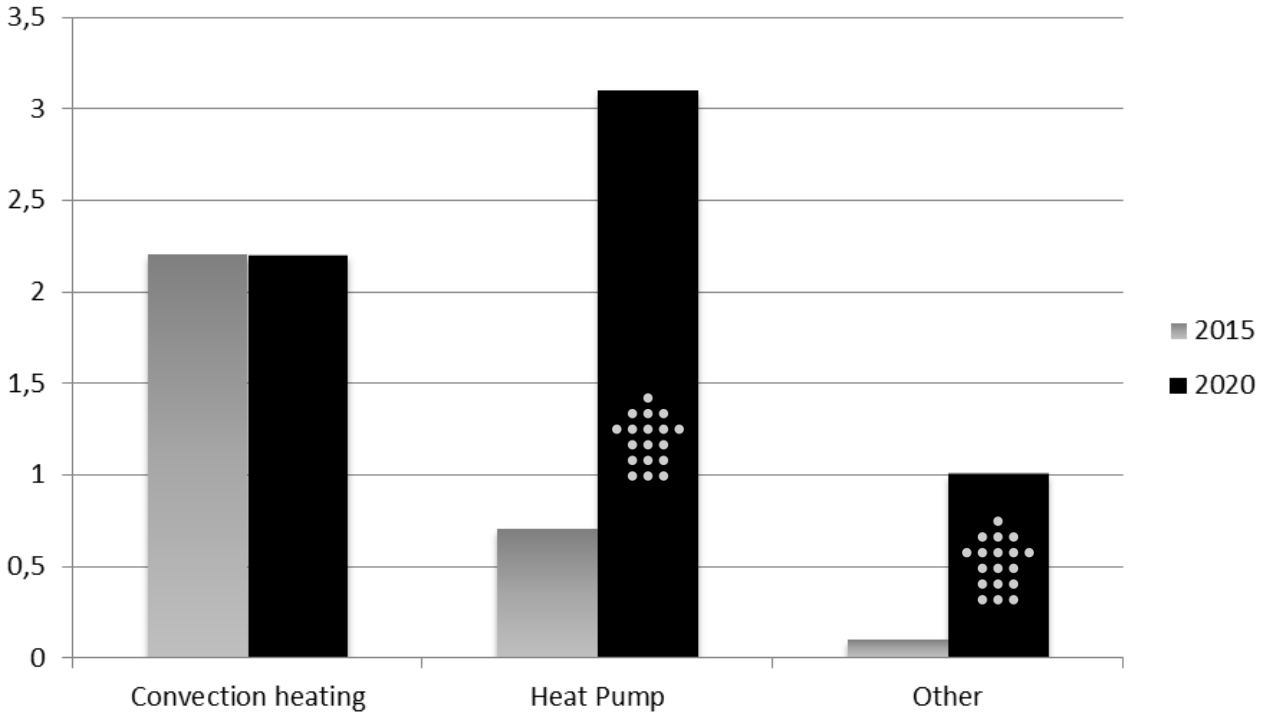
Total potential:
3 GW

Current curtailment:
0.05 GW

→ Convection heating provides the biggest potential for curtailment, although a significant chunk of the equipment park is not easily exploitable

→ Heat pumps also provide some potential, though the equipment park is still small

3_ Determining the potential for residential DR in Europe: French example



Total potential:
6.4 GW

Estimated curtailment:
1.2 GW

→ Convection heating potential is limited by the quality of the installations
→ As the heat pump park expands, the potential also increases rapidly, especially as heat pumps are easier to integrate within a DR scheme
→ Other includes contributions mainly from cooling (0.3 GW) + some smart EV charging

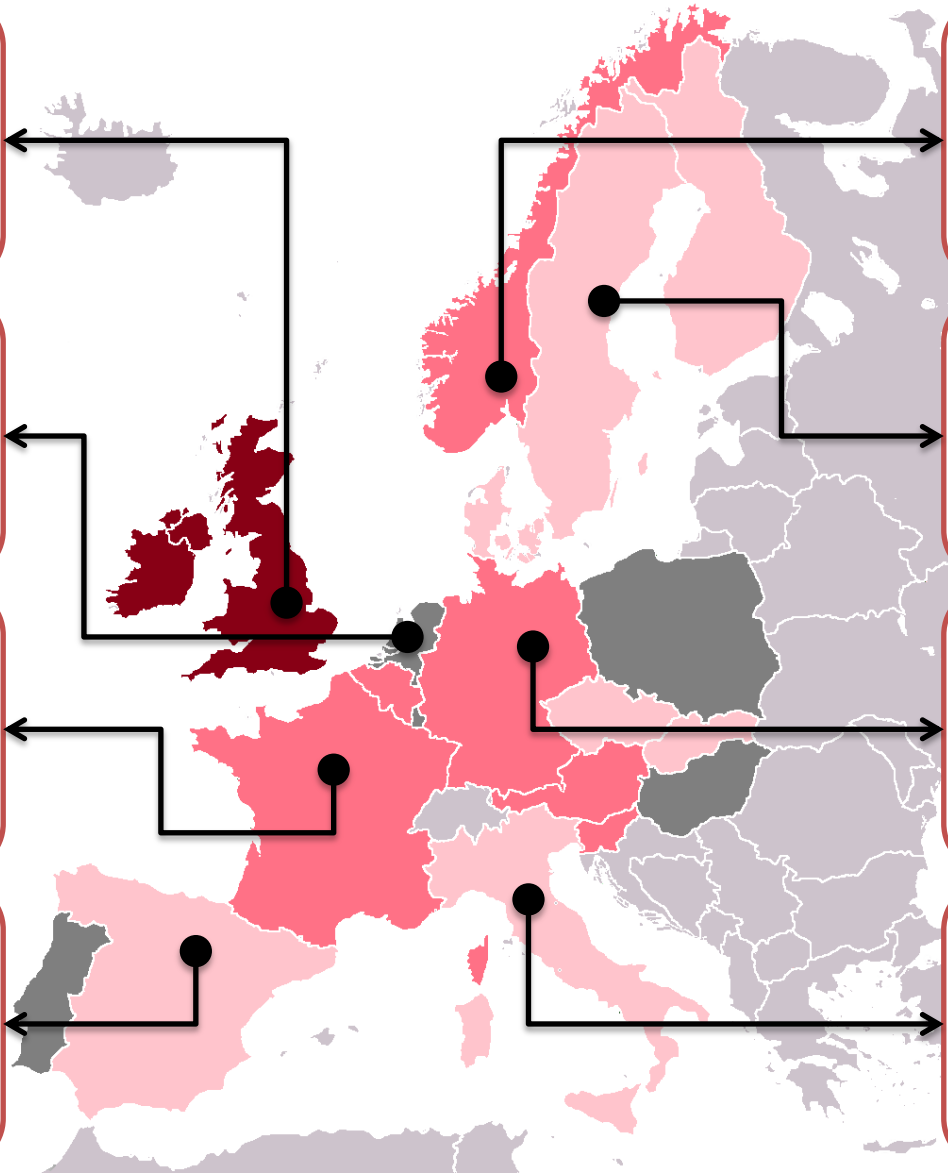
3_ Valuating DR throughout Europe: the potential exists

The UK
- 1.8 GW of STOR (Short-Term Operating Reserve)
- DR participation possible 3 other (less flexible) programs

Belgium
- Interruptibility service (261 MW) + participation in retailer portfolios (retailers use DR to settle imbalances)

France
- Voluntary bids on the "Mécanisme d'Ajustement"
- 1000 MW of "primary" reserve (13 minute response) + 500 MW of "supplemental" reserve (30 minute response)

Spain
- 2 GW of interruptible contracts from 144 industrial consumers
- Resources pushed towards the capacity market for future valuation



Norway
- RKOM reserve service, on top of NordPool capacity
- 2000 MW during winter months

The NordPool area
- Regulating power purchased at pool area + localized requirements
- Danish System interesting as it procures different types of reserve for its two parts

Germany
- Participation possible both for secondary reserve (difficult) and tertiary reserve
- Currently little participation due to low prices (tertiary) and program design (secondary)

Italy
- 3.6 GW of interruptible contracts
- Seen as subsidies by the EU Commission
- Little transparency of compensation and excessive curtailment

4_ Current residential DR barriers

LOW CAPACITY PER CUSTOMER

Usually, no more than 1-2 kW can be actually curtailed

Significant number of customers required to achieve significant capacities

+

HIGH DEPLOYMENT COSTS

Even if equipment costs come down, installation costs will stay up and do-it-yourself installation still not feasible. This may change on a long-term basis.

+

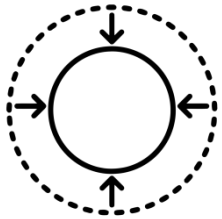
BUSINESS MODEL IMMATURITY

Significant capacities required for participation in some services

Measurement & verification challenging

Considerably more decentralized flexibility will be needed on a medium-term basis, increasing the overall value of residential demand response.

4_ Opportunities for a new technology model

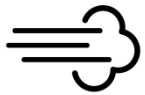


Unique technology platform supporting multiple services and allowing connection to different residential equipment

Service gateway
allowing access to different energy and non-energy services (potentially from multiple providers)

Equipment gateway
Allowing the connection of different service-related equipment

4_ Opportunities for a new technology model



FAST FLEXIBILITY

Capacities which can be used both for peak management (tend to coincide with the peak) and fast ancillary services

Ability to draw higher value from the capacity (as high as 50 k€ / MW)

SUPPORT DEPLOYMENT COSTS

Self-financing at least from flexibility valuation.

Mutualization of deployment costs across several services. Potentially "do-it-yourself"

INTELLIGENCE FOR BETTER VALUATION

Measurement & verification are facilitated and more reliable. Aggregator can ensure greater compliance.

EE and other "flexibilities" can also be valuated. Higher benefit for consumer.

5_ Questions?

mihai.petcu@codastrategies.com