Smart grids and network regulation:
“The regulatory framework is still not in place”

A webinar for the Clean Energy Solutions Center

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Introduction

- About Enerdata:
  - Independent Information & Consulting firm specialising in the global energy industry and carbon market
  - 25 years of experience in political, economic and technology issues related to climate and energy
  - Analysis founded in advanced forecasting models, robust methodologies and quantitative databases
- About the “smart grids regulation project”:
  - Project carried out by Enerdata and 3 other partners (ISIS, IZT and Tecnalia) for the European Parliament (STOA - Science and Technology Options Assessment)
  - Enerdata was in charge of “The financial and regulatory implications of smart grids deployment”
  - Workshop held in Brussels in April 2012 – Forthcoming publication

Webinar agenda

1. From vertical integration to network unbundling
2. Network regulation needs to adapt
3. Smart grids imply new costs for grid operators
4. Existing regulatory frameworks do not favour smart grids
5. Regulatory framework favourable to smart grids
6. Smart grids and the enabling of demand response
7. Concluding remarks

1. From vertical integration to network unbundling

1.1. The large scale centralised generation model dominates

- The vertically integrated monopoly was the dominant business model in Europe until the 90's:
  - National or regional monopolies (French vs German model)
  - Generation, transmission, distribution, balancing, dispatch, wholesale, retail: all activities integrated in a single company
- Model based on large-scale centralised generation:
  - Large power plants ➔ Long distance HV transmission ➔ Local medium and low voltage distribution ➔ End-customers
  - Mostly unidirectional "top-down" electricity flows
  - No consumer participation except for the larger ones (e.g. interruptibility)
- Today, electricity networks still operate in a passive way:
  - Supply and demand balancing through adjustment of generation
  - The electricity system's dimensions are calibrated on maximum peak load
  - Inelastic, time-critical electricity demand from mostly passive customers
  - Adapted to statistically predictable supply and demand patterns, not stochastic ones

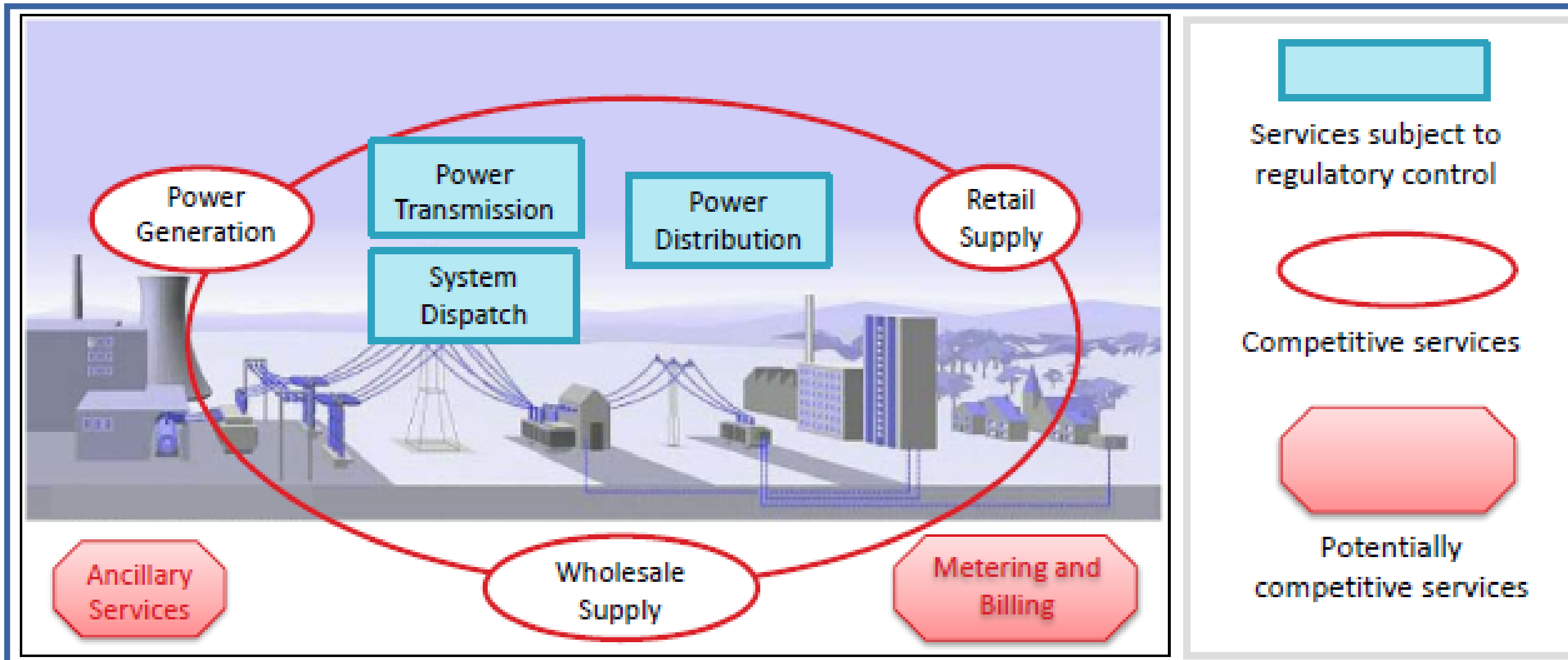
1. From vertical integration to network unbundling

1.2. Market liberalisation and grid unbundling

- Market liberalisation is the new paradigm:
  - Initiated in the US and the UK in the 80's and 90's
  - In continental Europe, various energy "packages" in the 00's
- Liberalisation includes a mix of privatisation, unbundling, introduction of competition in generation and retail, consumer choice, etc.
- Grids have become stand-alone regulated businesses:
  - Natural monopoly characteristics: high capital cost, barriers to entry, network effects
  - Revenues of TSOs and DSOs stem primarily from a regulatory formula
  - In Europe, supervision by national energy regulators
- Traditionally, the focus of grid regulation is on cost-efficiency:
  - Minimisation of OPEX
  - Rationalisation of investments (to avoid "gold plating")
- Regulation is also designed to meet non-economic objectives: security of supply, power quality, grid integrity, non-discriminatory third-party access, etc.

1. From vertical integration to network unbundling

1.3. The electricity value chain has regulated and competitive elements



Market participants

- Producer (generator)
- Trader
- Supplier (retailer, marketer, load-serving entity etc.)
- Consumer

Market facilitators

- Transmission System Operator (e.g. Tennet)
- Market Operator (e.g. APX)
- Distribution System Operator

Products and services

- Energy (commodity, MWh)
- (Generation) capacities (MW)
- Transport capacities
- System / Ancillary services

Source : Enerdata, adapted from Kema, "Training on regulation", a webinar for the European Copper Institute, Leonardo Energy

2. Network regulation needs to adapt

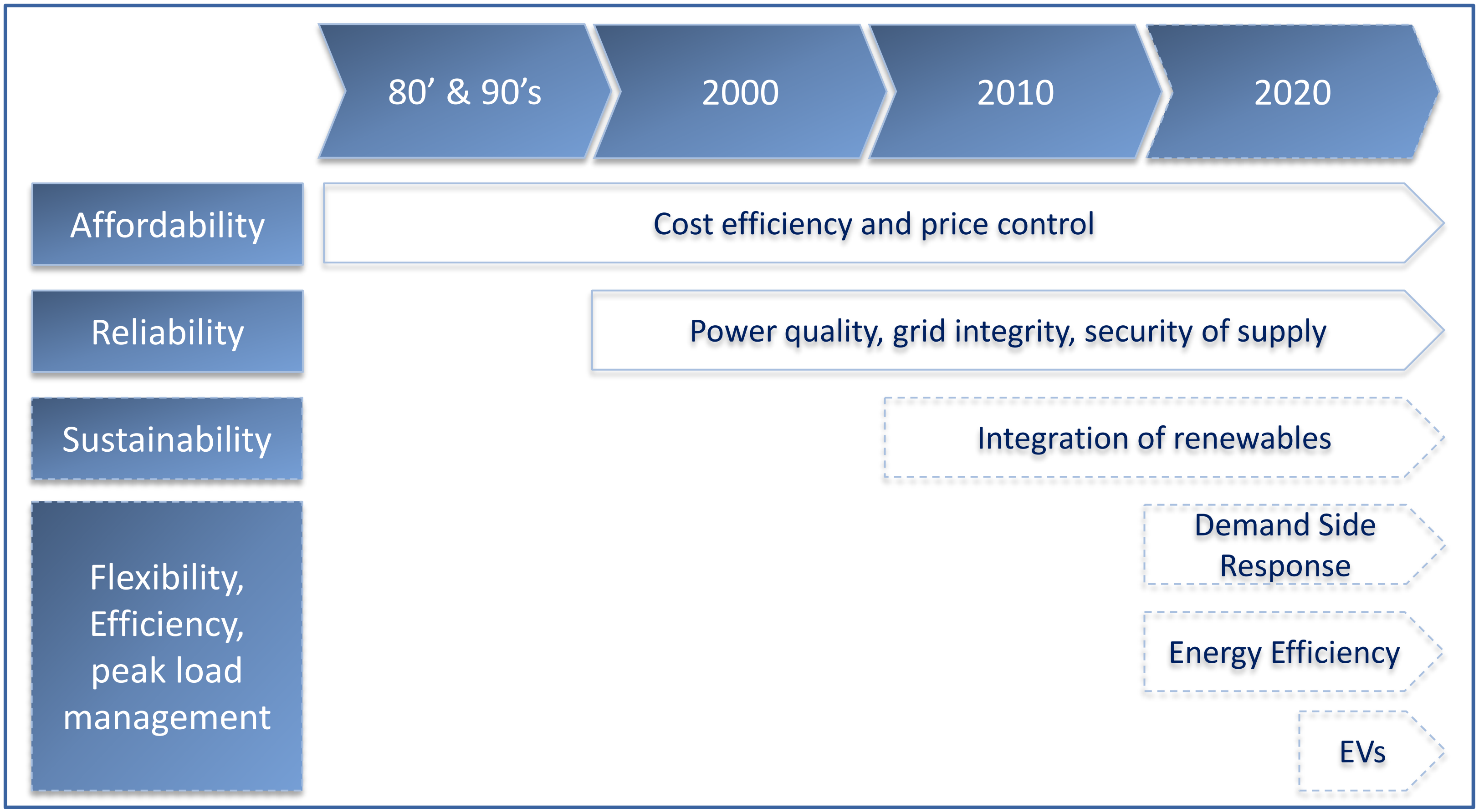
2.1. Grids face new supply-side and demand-side challenges

- Supply-side: system costs are on the rise
  - Increasing share of non-dispatchable intermittent generation (wind, PV)
  - Growth in distributed generation connected to the distribution network, the least resilient part of the grid
  - Emergence and diffusion of new technologies or concepts: heat pumps, micro-CHPs, micro-grids, distributed storage (e.g. EVs), virtual power plants, etc.
- Demand-side challenges: coordination and optimisation are needed
  - Growth of electricity demand caused by the advent of digital society, wealth effects and the superiority of electricity as an energy carrier
  - Increased "peakiness" of electricity demand: new uses are peak-load rather than base-load, peak to base ratio increase
  - Possibly, the large-scale diffusion of electric vehicles (EVs) in the future (which can't be left unmanaged)
- Traditional grids have not been designed to cope with these challenges and need to be "smartened"

2. Network regulation needs to adapt

2.2. Electricity networks face new challenges

Evolution of network regulation objectives



Source: Enerdata

2. Network regulation needs to adapt

2.3. Smart grids have the potential to transform the electricity industry

- Low level of automation (remote monitoring and control, automatic fault detection…) of medium and low voltage networks in Europe
- Grid balancing still lacks a dynamic optimisation of supply and demand
  - Demand side: need to unleash full potential of demand response
  - Supply side: shift from a centralised control and balancing system to a configuration that allows two-way flows of electricity and the coordination of a large number of players and a myriad of decentralised dispatching and load-shedding decisions
- Smart grids will increase the value of renewables:
  - Limitation of wind curtailment and back-up costs
  - Reduction in frequency of negative or zero electricity prices
- By allowing dynamic pricing, smart grids will improve load factors and utilisation rates and lower average costs
- Multiple objectives: intermittency, DG, customer proactivity, peak load shaving, energy efficiency, security of supply, enhanced competition, etc.

2. Network regulation needs to adapt

2.4. Smart grid components

- No universally accepted definition or scope for “smart grids”
  - A diverse portfolio of technologies (under development or existing)
  - Not a blank page but new layers / new components added incrementally to an existing electricity grid
  - Many technical and organisational configurations are possible and are being tested around the world
- Convergence of new information and control technologies:
  - New electro-technical control devices (sensors)
  - ICT hardware and software for grid management and operation
  - SCADA (Supervisory Control And Data Acquisition) and GIS systems
  - Increased computational capacity to deal with vast new data flows
  - Charging equipment, storage devices, inverters
  - Smart meters
  - Smart appliances and home energy management systems, etc.
- The implementation of smart grids technologies will increase network costs

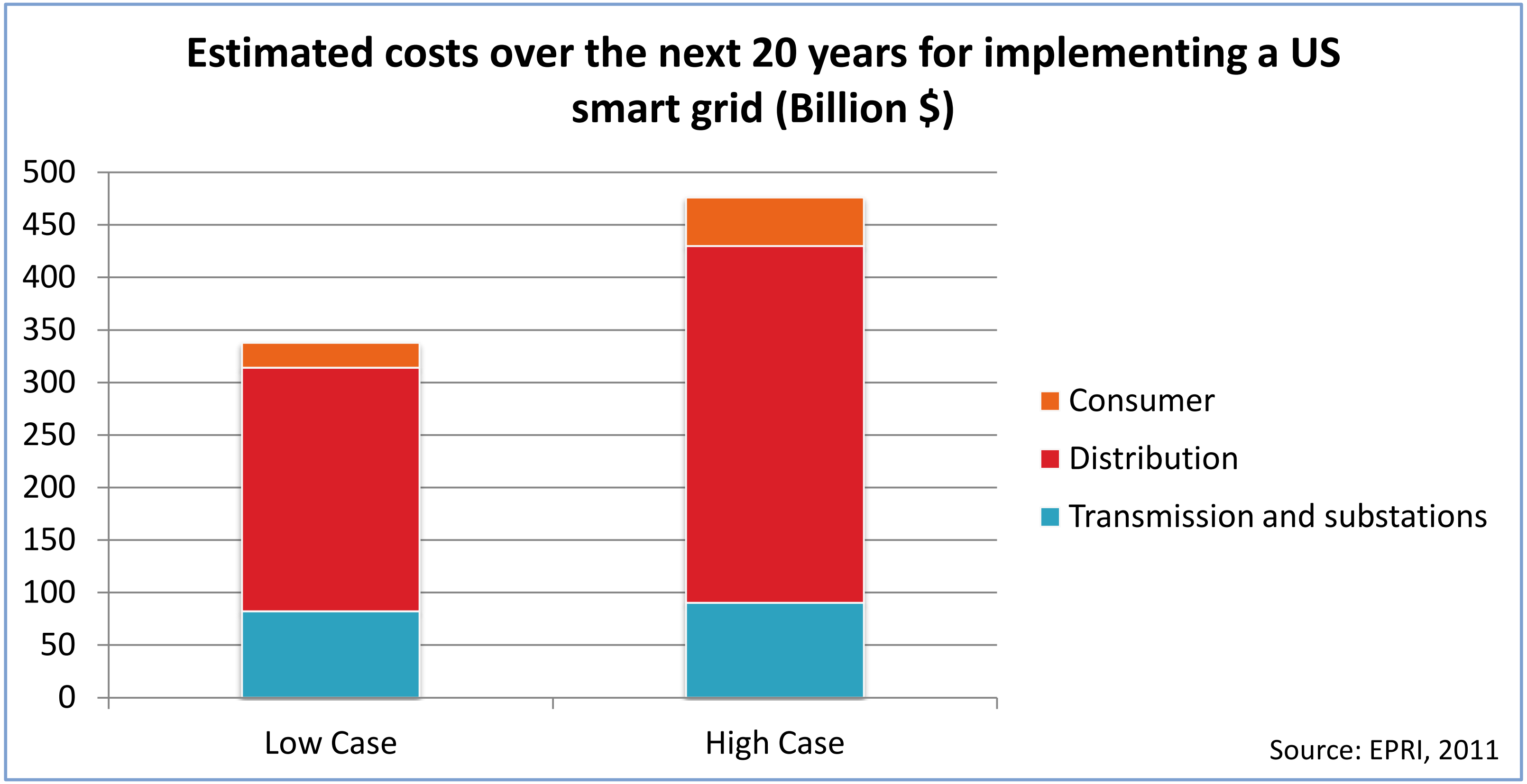
3. Smart grids imply new costs for grid operators

3.1. EPRI's smart grid costs assessment

- 2011 EPRI study "Estimating the costs and benefits of the smart Grid"
  - Most comprehensive attempt to evaluate smart grid investments costs and benefits
  - US focus but results remain a good proxy for European markets and others
    - US: fix an ageing grid, focus on peak load management through DSM
    - EU: emphasis on integration of renewables and energy efficiency (decarbonisation)
  - Costs assessed include infrastructure costs required to integrate DG and costs to achieve full customer connectivity (e.g. smart meters)
  - B.A.U. costs are excluded:
    - Generation costs
    - Transmission lines needed to add renewables and meet load growth
    - Some (but not all) customer costs for smart grid ready appliances and devices
- Smart grids costs and benefits are difficult to assess and generalise:
  - Boundaries and components may vary across geographies and projects
  - Some smart grid technologies are still in their infancy with cost, performance and longevity still uncertain
  - ICT costs decrease faster than cost of conventional grid technologies

3. Smart grids imply new costs for grid operators

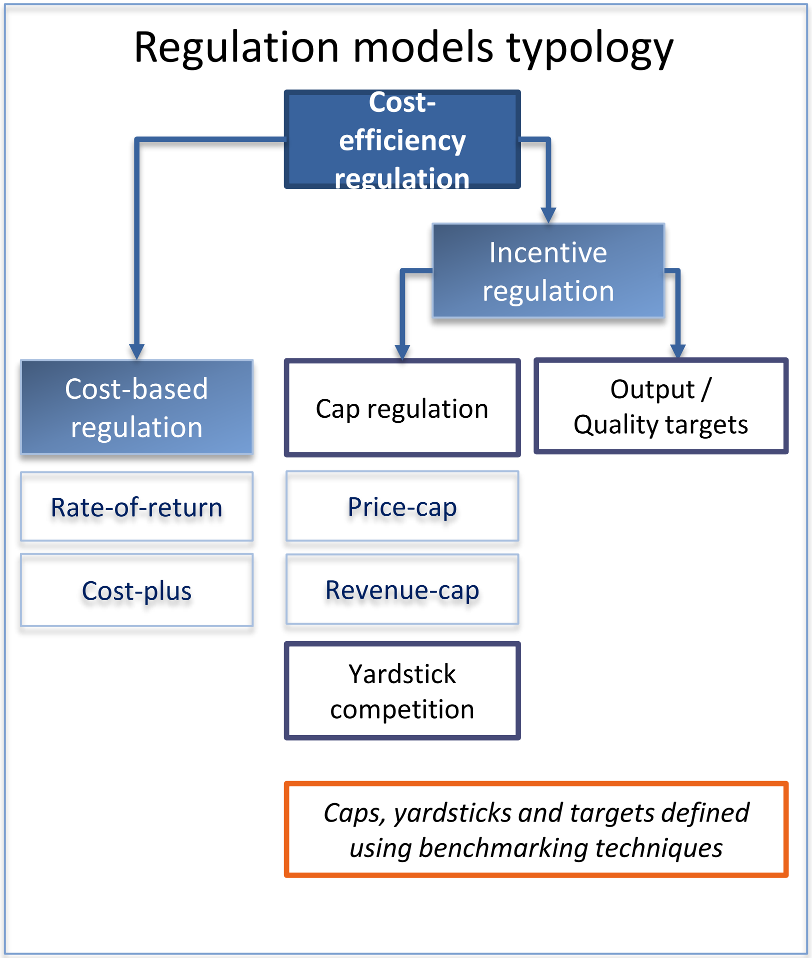
3.2. Approx. 70% of smart grid costs go to DSOs



- → Residential and commercial customers will bear most of the new costs
- → Bills expected to increase by approx. 8% to 13%. (overnight cost increase)
- → Little or no impact on industrial users

4. Current regulation does not favour smart grids

4.1. Regulation models

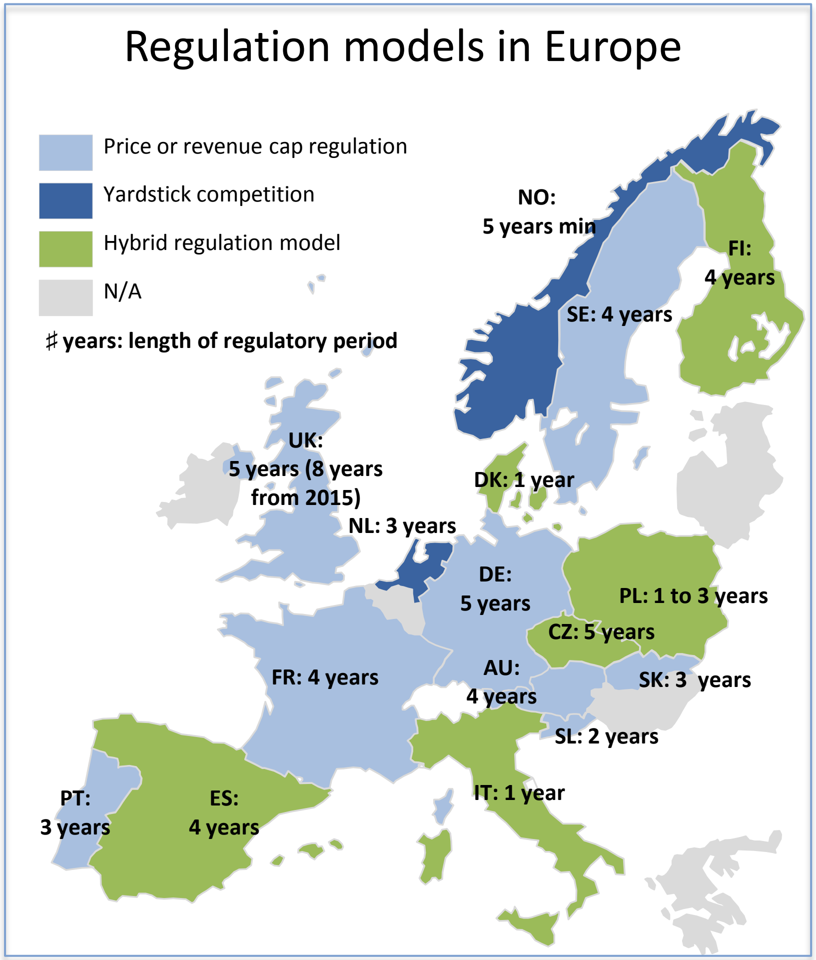


Source: Enerdata

- Cost-based regulation:
  - OPEX and CAPEX fully recovered (audits)
  - CAPEX: “fair” RoR applied to RAB
  - Costs passed through to customers
  - Profits are capped in relative terms
  - But no incentive to be efficient or thrifty
- Cap regulation:
  - Prices or revenues (+CPI) are capped ex-ante for a regulatory period (3 to 5 years)
  - Minimum efficiency target (-X) set by regulator
  - Extra profit retained if firm more efficient than X
  - Efficiency gains passed through to customers at the start of the next regulatory period
  - Risk of lower quality of service, under-investment & lack of innovation
- Yardstick: Revenues function of average costs or productivity improvements of a peer group of similar companies
- Output regulation: Quality targets, rewards & penalties, gains and losses capped

4. Current regulation does not favour smart grids

4.2. Regulation models in Europe



Source: Enerdata from Eurelectric and other sources

- Most countries have moved away from cost-based regulation
- In practice, often a mix of of cost-based, incentive and output regulation elements
  - CAPEX: Cost-plus
  - OPEX: Efficiency target (X)
  - Output/Quality targets
- Complex learning-by-doing process: fine-tuning the regulation model takes years and is country specific
- Incentive model showing signs of fatigue: efficiency gains not inexhaustible
- Plus, it encourages investment conservativeness
- Time to rebalance the focus of regulation from cost efficiency towards investments and innovation?

4. Current regulation does not favour smart grids

4.3. A disconnect between requirements and incentives

- Time-inconsistency: discrepancy between CAPEX time horizon and regulatory period (upfront costs vs delayed uncertain revenues)
- Investments are vetted ex-ante or ex-post: grid operators tend to choose equipment and solutions well understood and recognised by regulators
- According to Eurelectric, a significant share (> 75%) of European DSOs have a ROIC lower than their WACC
- Smart grid investments will make it even more difficult for grid operators to recoup CAPEX through the regulation formula
- Overall, European electricity networks have performed well in terms of reliability → smart grids will need to demonstrate their economic and social added value (cost-benefit analyses)
- Many European countries have initiated a review of their network regulations:
  - UK: pioneer and leader (RIIO model)
  - Work in progress in Germany, the Netherlands, Italy, Nordic countries…
  - Slower process in France

5. Regulatory framework favourable to smart grids

5.1. Key measures to make smart grid investments attractive to DSOs

- Ensure regulatory stability and clarity:
  - Regulatory risk is a strong deterrent to capital-intensive investments
  - Incentive schemes and benchmarking techniques often too complex
  - Legal technicalities may prevent experimentation (e.g. dynamic pricing, distributed interruptibility,…)
- Better recognition of smart grid investments:
  - Include smart grid related CAPEX into the RAB and take into account their specifics (higher cost of smart components, shorter economic lifetime, etc.)
  - Extend the regulatory period (e.g. from 5 to 8 years in the UK)
  - Ensure higher RoR for DSOs on smart grid investments: RoR adders, removal of X factor (Italy)
- Introduction of "output regulation" objectives:
  - Quality regulation vs KWh : decouple revenues & volumes
  - Possible KPIs: MW of DG connected, level of losses, SAIDI (System Average Interruption Duration Index), % of customers on dynamic pricing, etc. (Italy)
- Regulation should remain "technology neutral"

5. Regulatory framework favourable to smart grids

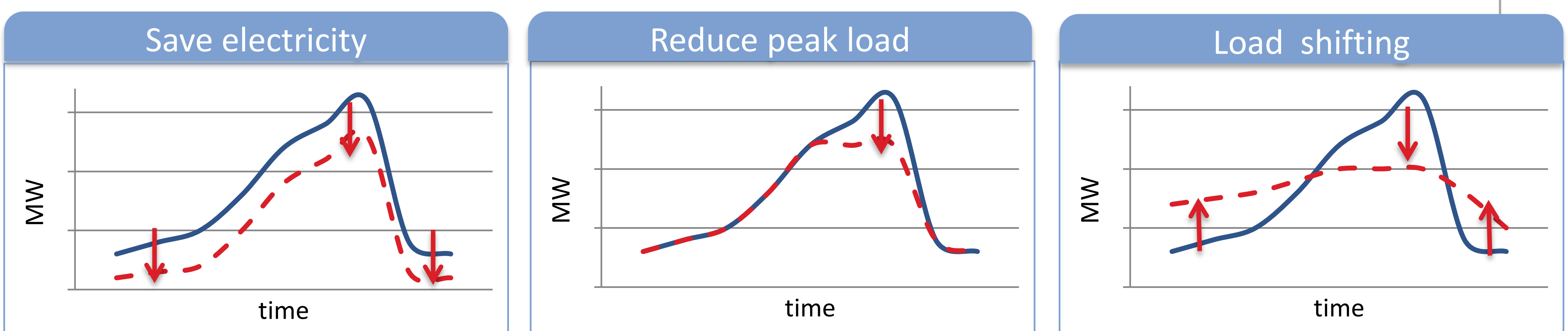
5.2. The specific case of R&D

- Smart grid not a fully proven concept yet: R&D, demonstration project and large-scale pilots are needed to test technologies and new business models under real-world conditions
- Deregulation and unbundling of network activities are generally followed by a significant drop in R&D spending
- Incentive regulation alone is not sufficient to generate sufficient R&D spending
- R&D expenditure differs from CAPEX:
  - R&D offers no direct, quick and measurable benefits for the customer
  - It should not be considered as a recoverable cost through regulated tariffs
  - But case of Italy where R&D component allowed in the network tariff
- Output-based regulation is difficult to apply to R&D (what indicators?)
- Regulators and policy-makers may design ad hoc innovation and R&D funding schemes for smart grids (UK, Italy)

6. Smart grids and the enabling of demand response

6.1. Why demand response?

- Demand response (DR) aims at smoothing electricity load curve through changes in the electricity use pattern of end-use consumers at peak time in response to price signals or incentive payments. In case of critical situation, direct information sent to customers can also be used for DR.
- DR aims at making demand more elastic.
- Usually considered for electricity, DR can also be applied to gas.
- Three main effects of DR

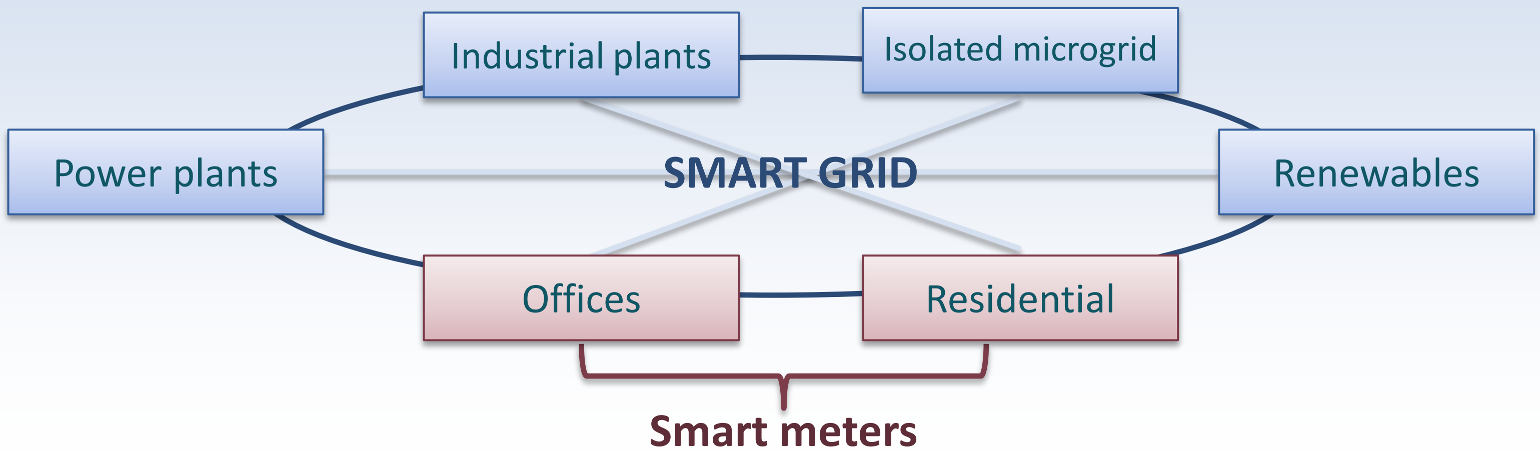


6. Smart grids and DR

6.2. Smart meters facilitate DR

SMART GRIDS

Smart meters are the tools by which the smart grid send signals or information to consumers … but smart meters can also provide information to consumers on their behaviors



MANAGEMENT of ENERGY SUPPLIERS

- Integration of renewables, etc.

DEMAND RESPONSE

- Information on price & consumption
- Peak load shaving

6. Smart grids and DR

6.3.A variety of DR products proposed

Price-based DR	Time of Use rate TOU	Rate with different unit prices during different blocks of time ~ average cost of generating and delivering power per block
	Real Time pricing RTP	Retail rate : price for electricity typically fluctuates hourly reflecting changes in the wholesale price of electricity (spot market)
	Critical peak pricing CPP	Combine TOU & RTP: basic rate structure is TOU + higher pre-determined critical peak pricing event under trigger condition
Incentive-based DR	Ancillary services market programs	Customers receive payments for committing to restrict load on very short notice
	Capacity market programs	Accept bids from customers to curtail load as an alternative to procuring conventional generation (payment/penalty)
	Emergency DR	Customers receive incentive payments for load reductions when needed to ensure reliability
	Direct load control and Automation	Allows the utility some degree of control over equipment, e.g. switching-off non critical loads or modifying devices' parameters
	Interruptible/curtailable	Customers receive a discounted rate for agreeing to reduce load on request
	Demand bidding & buybacks	Customers make bids to curtail based wholesale market price - with metering equip. (monitoring and verification of real time)

Source IEA-DSM

6. Smart grids and DR

6.3. New products with different effects in terms of DR

Types of DR

Price-based DR

Time of Use rate TOU	Rate with different unit prices during di… average cost of generating and delivering p…
Real Time pricing RTP	Retail rate : price for electricity typically flu… changes in the wholesale price of electrici…
Critical peak pricing CPP	Combine TOU & RTP: basic rate structu… determined critical peak pricing event unde…

- 1-energy savings
- 3- load shifting
- 2- peak clipping

Incentive-based DR

Ancillary services market	Customers receive payments for committin… hen needed to support operation of the elect…
Capacity market programme	Accept bids from customers to curtail… procuring conventional generation (payment…
Emergency DR	Cus… payments for lo… when neede…
Direct load control and Automation	All… e of cont… switching… loads or modify…
Interruptible/curtailable	Cu… rate for ag… n reques…
Demand bidding & buybacks	Cu… based wh… mete… nd verification

- 1-energy savings
- 2- peak clipping
- 3- load shifting

Targeted audience

- Residential/small consumers
- Industrial/ commercial
- Large consumers

6. Smart grids and DR

6.4. new regulatory framework to enable DR

After promoting the diffusion of efficient equipment, the regulatory framework is aiming at transforming consumers from *passive customers to responding customers.*

This means a change for utilities from a “volume-based” market to an “efficiency-based” business model.

➔ Many countries are starting Demand Response programs (e.g. USA-National Action Plan on Demand Response, 2010) and/or smart meter roll out programs.

➔ At EU level, a new directive on energy efficiency (EED) adopted in October 2012 aims at changing the market in that direction:

- Mandate the installation of smart meters for new connections and meters ‘replacement (Article 9)
- Minimum functionalities of smart meters in case of roll out (Article 9)
- Free & informative billing (by 2015) (Article 10)
- Access to metering & billing data (Article 11)

6. Smart grids and DR

6.5. Example of smart meter roll-out

- Italy and Sweden are among the most advanced countries with more than 90% (and 70% respectively) of households equipped with smart meters (5.1 million smart meters installed in 2009 in Sweden and 33 Million in Italy)
- British Colombia, Canada: BC Hydro was required to install smart meters for each of its 1.8M customers by end of 2012
- Victoria (Australia) and Texas in 2013 (respectively 2.4 and 7 million)
- Roll out planned in UK throughout the country by 2014;
- Installation of 10 M smart meters planned by in 2016 in Korea (over 50% of households).
- … opposition in some countries (The Netherlands, California) ~ *smart meter opt-out*

Source: MURE

6. Smart grids and DR

6.6. Who pays what? Which products/pricings are proposed today?

- Smart meter installation usually by utilities;
- Utility cost installation is generally smoothed over time through energy bills (➔Smart Meters finally paid by customers);
- Smart Meters mainly used for ToU pricing and automatic billing for the moment (e.g. Italy, Sweden)… and will be more sophisticated and offer new DR tariffs and incentives (e.g. California*, British Gas, Ontario, Texas) and enable customers to control energy use through energy management devices or smart appliances (eg Ontario, mandated in EED in EU countries).

***SDGE, San Diego gas & Electric** utility, is offering: Base Interruptible Pricing; Capacity Bidding Programm; Critical peak pricing

Concluding remarks

- Smart grid technologies are for the most part readily available but the advent of functional smart grids is far from straightforward:
  - More R&D and large scale demos are indispensable to experiment interplay between technology, regulation, business models, pricing and consumer behaviour
  - An equitable sharing of costs, benefits and risks across all stakeholders is key
- Complements to smart regulation:
  - Development of national and international technical standards
  - Dynamic pricing (energy), flexible and differentiated network charges
- Risks and opportunities:
  - Impact of economic crisis on deployment of smart grids
  - Competition with renewables:
    - Ability and willingness of consumers to pay higher bills
    - Rebalancing of subsidies?
  - Results of national cost-benefit analyses (to be published by the EC mid-2013) but only concern smart meters
- Smart grids regulation: Need for more research and tinkering
- Smart meters and DR are important components of smart grids

Thank you for your attention !

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Appendix 1: Bibliography

- Hans Auer, Gustav Resch, Reinhard Haas, Anne Held & Mario Ragwitz (2009): “Regulatory instruments to deliver the full potential of renewable energy sources efficiently”. European Review of Energy Markets - volume 3, issue 2, June 2009
- Dierk Bauknecht, Öko Institut e.V. (2010): “Network innovation: the role of network regulation”. Presentation
- ECN (2007): “Business models for DSOs under alternative regulatory regimes”
- Electric Power Research Institute (EPRI) (2011): “Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid”. Technical Report
- ERGEG (2010): « Position paper on Smart Grids ». Conclusion paper (Ref: E10-EQS-38-05)
- Eurelectric (2011): “Regulation for smart grids”
- European Smart Grids technology Platform (2006): “Vision and strategy for Europe’s electricity networks of the future”
- Vincenzo Giordano, Flavia Gangale, Gianluca Fulli, Manuel Sánchez Jiménez (2011): “Smart Grid projects in Europe: lessons learned and current developments”. JRC Reference reports
- International Energy Agency (2011): “Smart Grids Technology roadmap”
- MIT (2011): “The future of the electricity grid: an interdisciplinary MIT study”.
- Christine Müller (WIK, 2011): “New regulatory approaches towards investments: a revision of international experiences”. IRIN working paper.
- Ofgem (2010): “RIIO: a new way to regulate energy networks”. Final Decision
- Konstantin Petrov, Viren Ajodhia, Daniel Grote, Denis Resnjanskij; KEMA Consulting GmbH (2010): “Regulatory Incentives for Investments in Electricity Networks”. Third annual conference on competition and regulation in network industries, 19 November 2010, residence palace, Brussels, Belgium
- Juha Vanhanen, Iivo Vehviläinen, Elina Virtanen, Per Agrell, Peter Bogetoft; Gaia Consulting Oy and Sumicsid AB (April 2010): “Scientific Review on Regulation Models for Electricity Distribution Networks.” Final Report

Appendix 1: What are smart grids? Some definitions

- International Energy Agency - Technology Roadmap on smart grids:

  « A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end-users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimising costs and environmental impacts while maximising system reliability, resilience and stability.»

- Electrical Power Research Institute (EPRI):

  « The term "Smart Grid" refers to a modernization of the electricity delivery system so that it monitors, protects, and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage transmission network and the distribution system, to industrial users and building automation systems, to energy storage installations, and to end-use consumers and their thermostats, electric vehicles, appliances, and other household devices.»