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Distribution charges: review of experiences on tariff structure and new challenges

"Energy markets, policy and regulation: evolution and revolution"
EPRG Spring Seminar

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Outline of the presentation

Context and objectives of network tariffs

Methodologies for distribution network tariff design

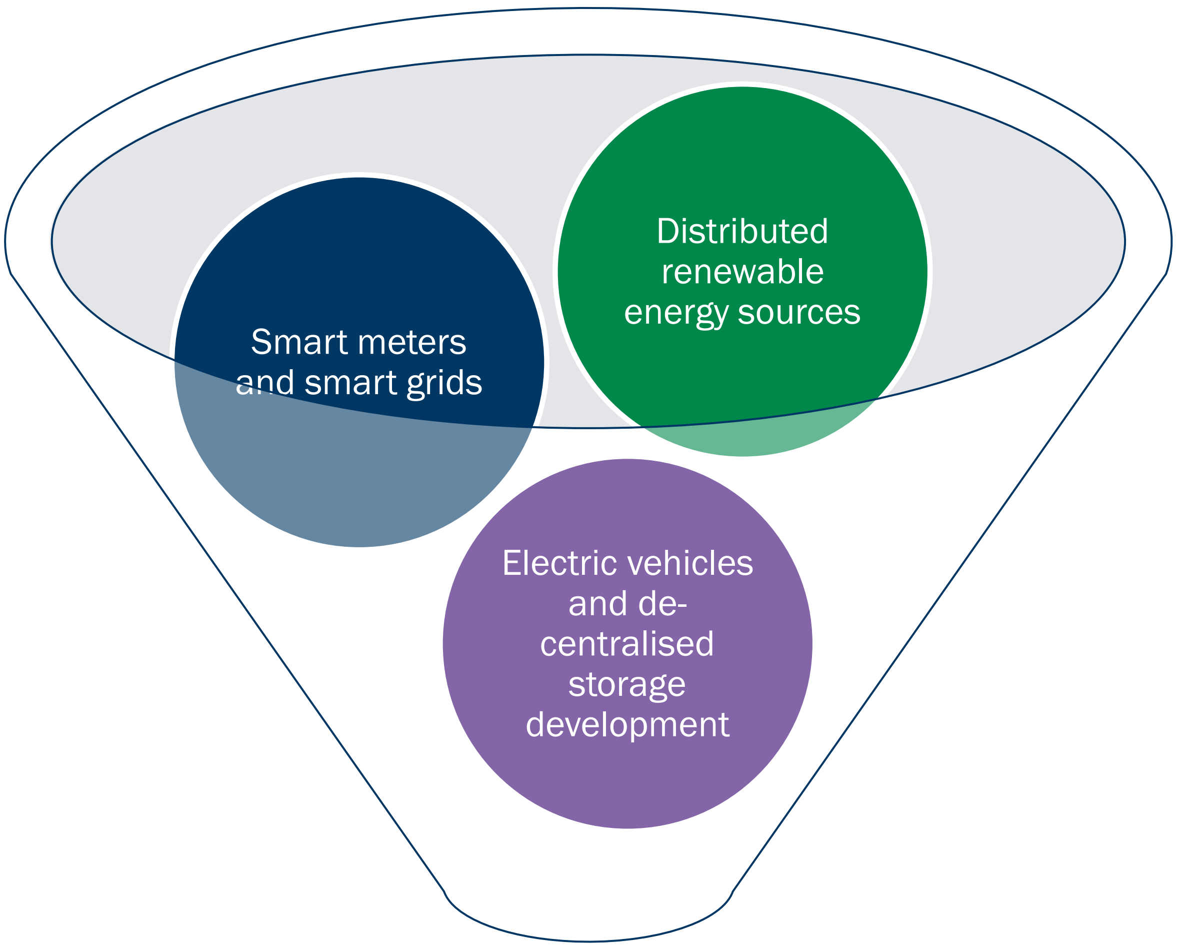
European overview of distribution tariffs

Conclusions

NB : part of the materials presented here is based on a study done for ERDF on methodologies for distribution charge design

Context and objectives of network tariffs

New challenges for distribution system operators in Europe



- Networks, and especially distribution networks, at the core of energy transition
- Major challenges for distribution systems
- Increasing consumer engagement: consumers become prosumers and are generators or flexibility providers as well (demand-side response, de-centralised PV generation…)
- Smart grids / meters as enablers

- System operators, through network charges, send price signals to grid users
- The network tariff structure more specifically is a key tool to give incentives to consumers to adapt their usages and behaviours, in order to minimise / optimise costs in the network

Objectives of network charging methodologies

- The network tariff design primarily aims at:
  - **Cost recovery**: network charges are financing transmission and distribution system operators' costs
  - **Efficient operation of the system**: network tariffs should provide adequate incentives for system operators to manage the system and invest more efficiently
  - **Efficient use of the system**: network charges should provide price signals to grid users (a) to optimise the dispatch and consumption and (b) to make more efficient investment in order to minimise network costs in the short- and long- term

- In addition, when designing network tariffs, regulators should bear in mind that these should:
  - **Be acceptable and equitable**: grid users should be treated in a non-discriminatory and equitable manner, in order these charges to be acceptable
  - **Provide understandable and predictable signals**: grid users must be in a position to decrypt these signals to adapt their behaviours and trust these signals will be stable
  - **Not be too complex to implement**: e.g. tariff structures must be consistent with metering possibilities
  - **Be fit with overarching policy objectives**

Methodologies for distribution network tariff design

Principles for efficient network charging

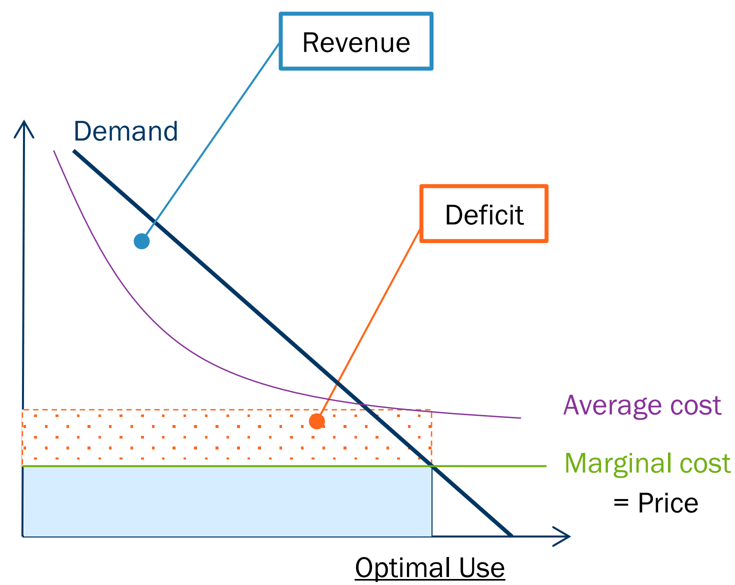
- Economists have long identified key principles for an efficient network charging methodology:
  - **Time variation:** Network charges should reflect that costs vary over time
    - E.g. be higher when the network is congestion and lower otherwise
  - **Locational:** Network charges should be different depending on the location of the grid users in order to reflect the costs to transmit electricity from generation to load
    - E.g. be higher where network costs are higher (congested areas)
  - **Marginal costs:** Marginal costs (congestion, losses etc.) provide efficient signals for grid users
    - E.g. marginal costs reflect the value which is induced by a marginal increase in consumption or which could be saved by a marginal decrease in consumption

<u>Sources</u> *(non-exhaustive)*
Marginal pricing: Nelson(1964), Turvey (1964 – 1968 -1977), Mann(1980), Boiteux(1964), Saunders (1976), Faruqui (2014), Boyer (2006), Joskow (2007), Wilson (1993), Willig (1978), Brown (1986).

Difficulties in applying these principles for efficient network charging

- These basic principles confront to key difficulties:
  - Marginal pricing does **not allow full cost recovery**, because of the lumpiness of investments in networks

Marginal cost charging



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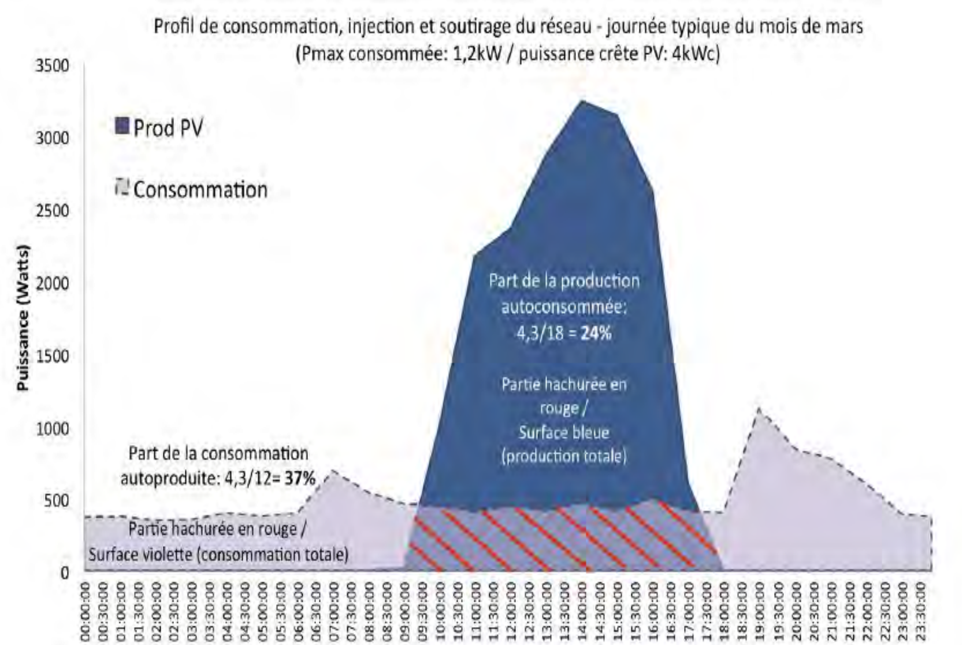
Difficulties in applying these principles for efficient network charging

- These basic principles confront to key difficulties:
  - Marginal pricing does **not allow full cost recovery**, because of the lumpiness of investments in networks
  - Marginal pricing is **not sufficient to provide incentives for optimal investment location** (lumpiness of investment in generation)
  - Is this approach **applicable to distribution?**
  - The definition and the evaluation of marginal costs are not straightforward: should we use **short-term or long-term marginal costs**?
  - Does this approach allow to **price all services provided by the network?**



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Different methodologies for network charging

- To overcome these issues,
  - **Non-linear pricing**, introducing different charging components (€/MWh, €/MW, €/yr), can be used; and
  - **Several cost allocation approaches** have been suggested or implemented:
    - **Ramsey-Boiteux**: it uses price-elasticity to increment tariffs based on marginal costs to ensure cost recovery (charge more grid users / charging components which are the least likely to induce changes in their behaviours compared to marginal pricing)
    - **Cost allocation based on game theory**: Network costs are allocated to grid users and/or to charging components based on game theory, supposed to determine an equitable allocation between users
    - **Reference network models**: These network models might be used to allocate costs to grid users and to charging components
    - **Ad-hoc cost allocation methodologies**: In practice, in many cases, ad-hoc rules are used (proportional etc.)

Sources (non-exhaustive)
Marginal pricing: Nelson(1964), Turvey (1964 – 1968 -1977), Mann(1980), Boiteux(1964), Saunders (1976), Faruqui (2014), Boyer (2006), Joskow (2007), Wilson (1993), Willig (1978), Brown (1986).
Game theory: Young(1985), Boyer (2004), Shapley (1952), Shubik(1962), Aumann(2015).
Reference network models: Peco (2000), Larson (2003), Perez-Ariage (2008).

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Illustration of the Ramsey-Boiteux methodology

- **Ramsey-Boiteux:** it uses price-elasticity to increment tariffs based on marginal costs to ensure cost recovery (charge more grid users / charging components which are the least likely to induce changes in their behaviours compared to marginal pricing)

- Let's assume we have 2 grid users:
  - User 1 is elastic, meaning that he/she will reduce its use if the price increases
  - User 2 is inelastic, meaning that he/she won't change its use whatever the price variation is

- What the Ramsey-Boiteux methodology suggests is that:
  - The price for user 1 remains at the marginal price: thus he/she won't change its use
  - All uncovered costs are charged onto user 2 as he/she will maintain its use anyways

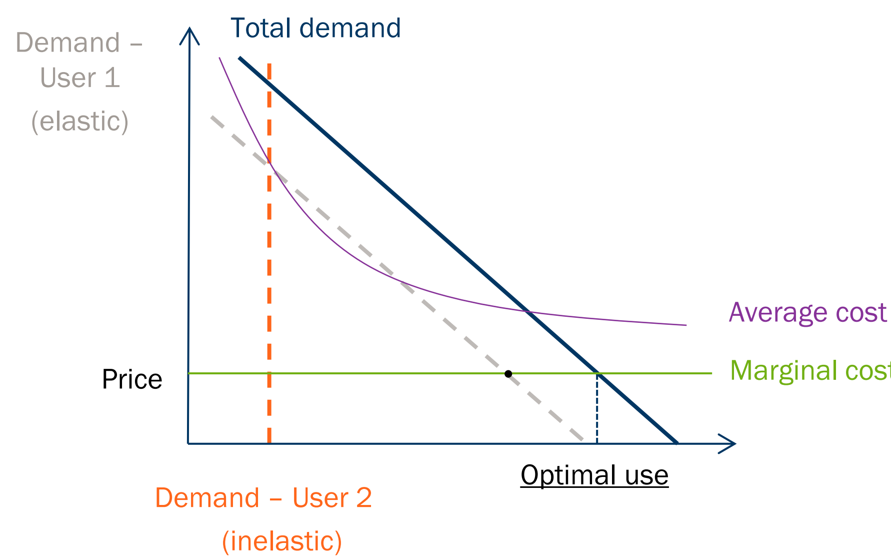

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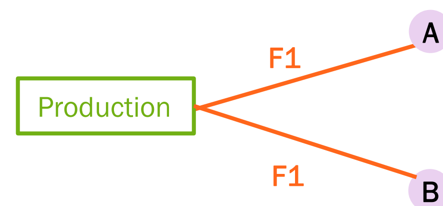
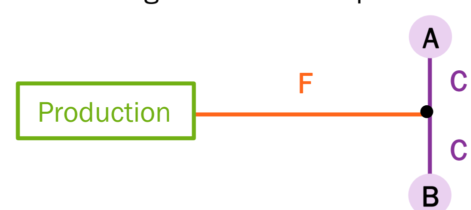
Illustration of the Game Theory methodologies

- **Cost allocation based on game theory:** Network costs are allocated to grid users and/or to charging components based on game theory, supposed to determine an equitable allocation between users
  - Without cooperation, each consumer (A & B) would connect individually to the production unit:
    - Each would bear a cost of F1
  - Cooperation could reduce costs by building a common line and individually connect to it:
    - F + 2C < 2 x F1
  - However, to recover these costs, a first come basis would lead A (if first) to pay for the common network line and B only for the connection to this line
    - A may no longer be willing to cooperate and build his/her own line if F1 < F + C
    - A may wait for B to connect first and conversely
  - Allocation rules based on game theory such as Shapley would split to cost between A and B simulating any order of arrival
    - In this simplified example, each would pay ½ F + C (< F1)

Network configuration without cooperation



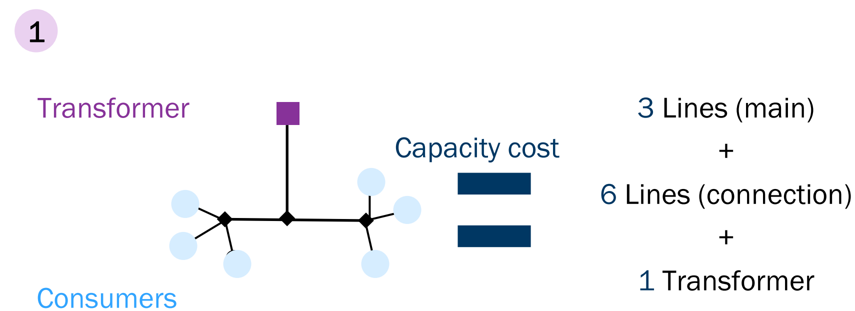
Network configuration with cooperation

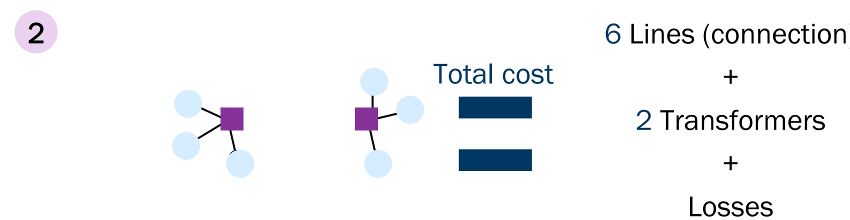


Sources (non-exhaustive)
Game theory: Young(1985), Boyer (2004), Shapley (1952), Shubik(1962), Aumann(2015).

Illustration of the Reference network models

- **Reference network models**: These network models might be used to allocate costs to grid users and to charging components
  - For each voltage level, gradually, the Reference Network Model algorithm would build the network to respond to a given request
  - The corresponding cost is allocated to the variable (energy / capacity / fixed, location, time etc.) assumed to induce the cost.
  - For instance
    - (1) Building optimal network to guarantee contracted capacity: the costs are allocation to capacity component
    - (2) Building optimal network taking into account energy flows (and losses and quality criteria): the additional costs compared to step 1 are allocated to energy component





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Reference network models: Peco (2000), Larson (2003), Perez-Ariage (2008).

Different methodologies for network charging

	PROS	CONS
Ramsey-Boiteux	▪ Most economically efficient approach	▪ Raise equity / discrimination questions ▪ Complex to implement properly as it requires evaluating elasticities of grid users
Game theory	▪ Aims *a priori* equity between grid users ▪ May provide stable signals, including time differences	▪ Further away from the economically efficient signal ▪ Complex methodologies possible, difficult to justify, potentially leading to various outcomes
Reference network models	▪ Aims at cost-reflectivity	▪ Further away from the economically efficient signal ▪ Depends on multiple assumptions, which may have a significant impact on the results ▪ Sensitive to modelling assumptions
Ad-hoc	▪ Simple	▪ Further away from the economically efficient signal ▪ Might be arbitrary

⇒ This very succinct assessment of the options shows that there is no perfect solution

⇒ These methods are generally complex and sensitive to assumptions

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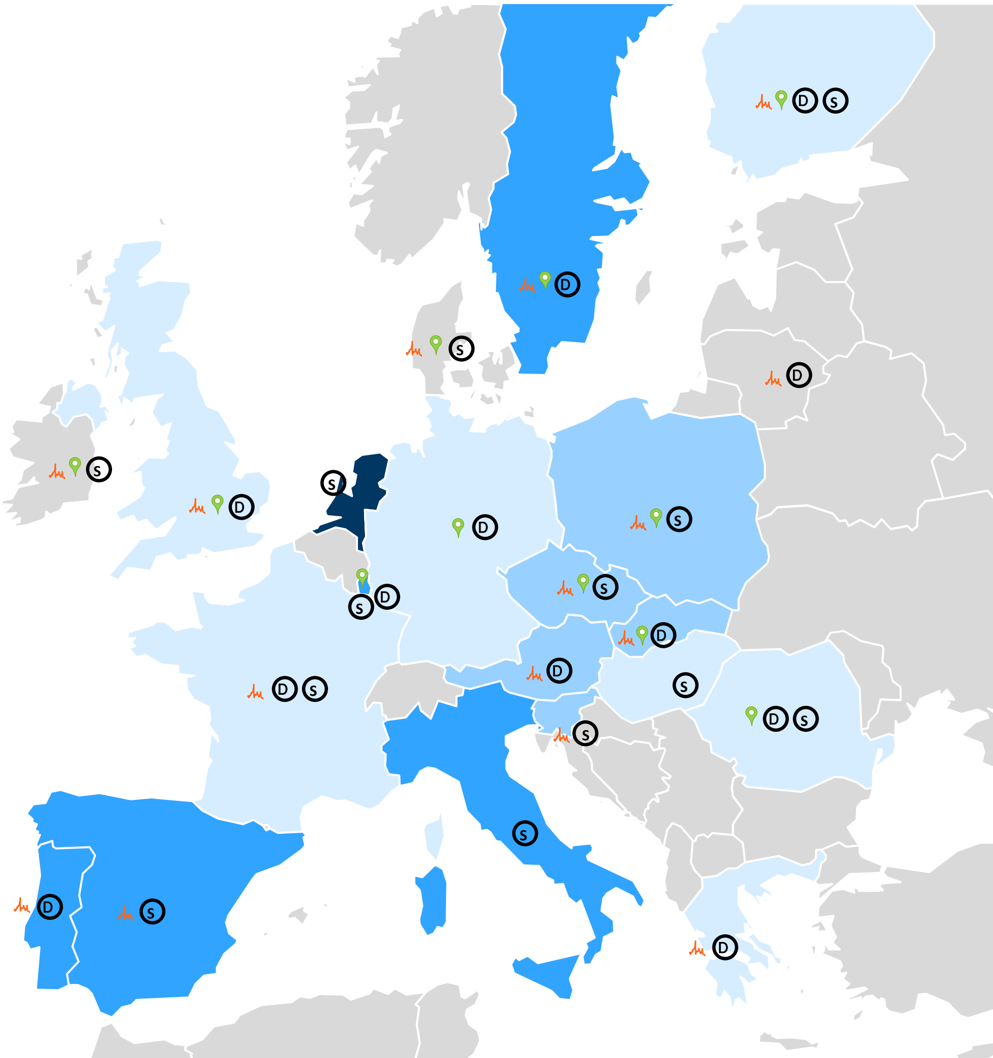
European overview of distribution tariffs

Overview of distribution tariff structures in Europe



Tariff structure

- Share of fixed/capacity costs in the distribution tariff:
  - > 80%
  - 50% - 80%
  - 30% - 50%
  - < 30%

Note: Average on all type of customers. It exists a significant discrepancy between different kind of customers (residentials/industrials)

- Structure of connection charges
  - S Shallow connection charges
  - D Deep connection charges

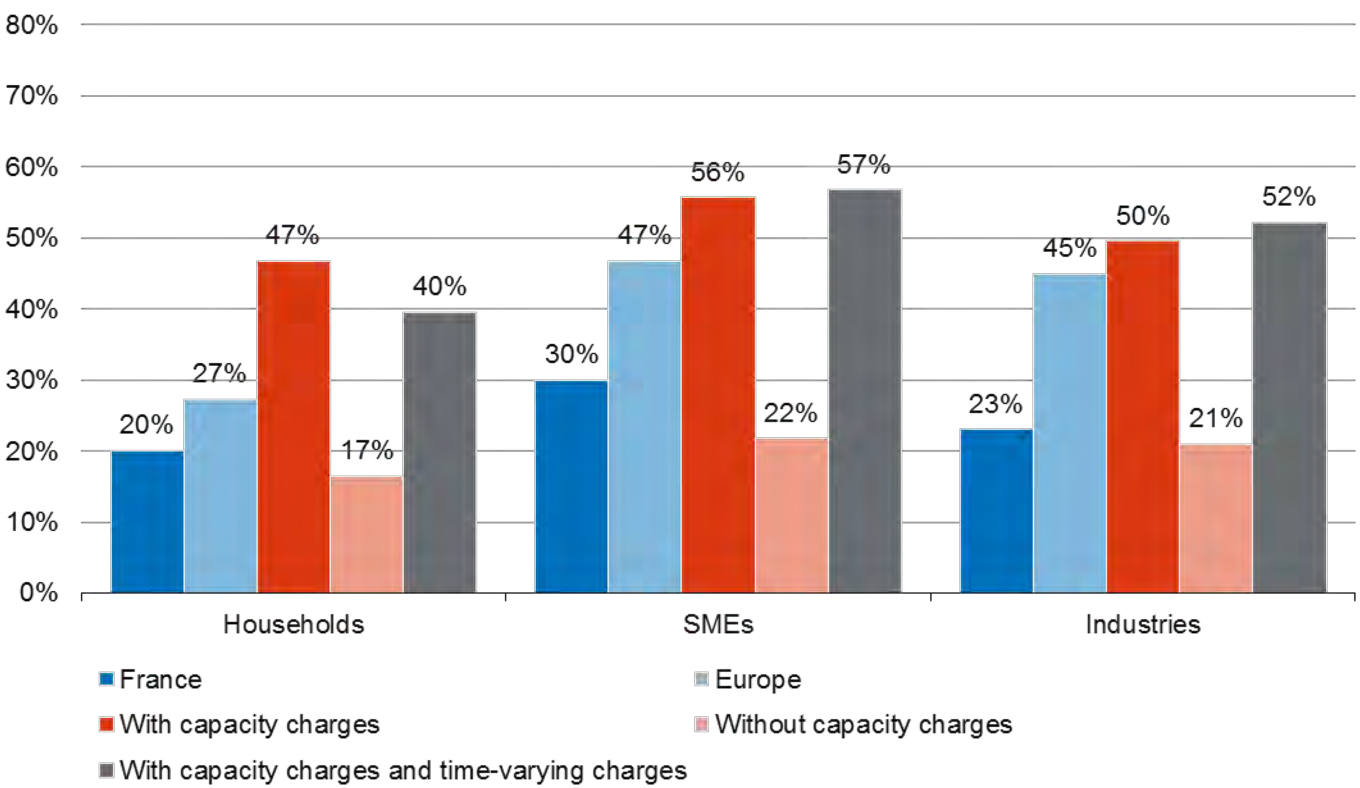
Note: Some countries allow for both shadow and deep connection charges depending on the type of customers. For those countries we show both symbols.

- Spatial and temporal tariff (for either or both households and industrials)
  - Geographic heterogeneity
  - Time of use tariff

Source: European Commission (2015), *"Study on tariff design for distribution systems"*
https://ec.europa.eu/energy/sites/ener/files/documents/20150313%20Tariff%20report%20fina_revREF-E.PDF

Share of fixed and capacity charges of distribution tariffs

Share of fixed / capacity charges in EU distribution charges, 2015



Source: European Commission (2015), *"Study on tariff design for distribution systems"*
Analyse: FTI-CL Energy

- Share of « fixed+capacity» amounts to 27% for households and 45-47% for SMEs and industries
- When capacity charging is possible, it raises to about 50%
- When capacity charging and time-varying charging are possible, it raises to about 40% for households and 52-57% for SMEs and industries

⇒ As methodologies and structures are not harmonised for distribution tariffs, the shares of fixed / capacity / energy components vary significantly

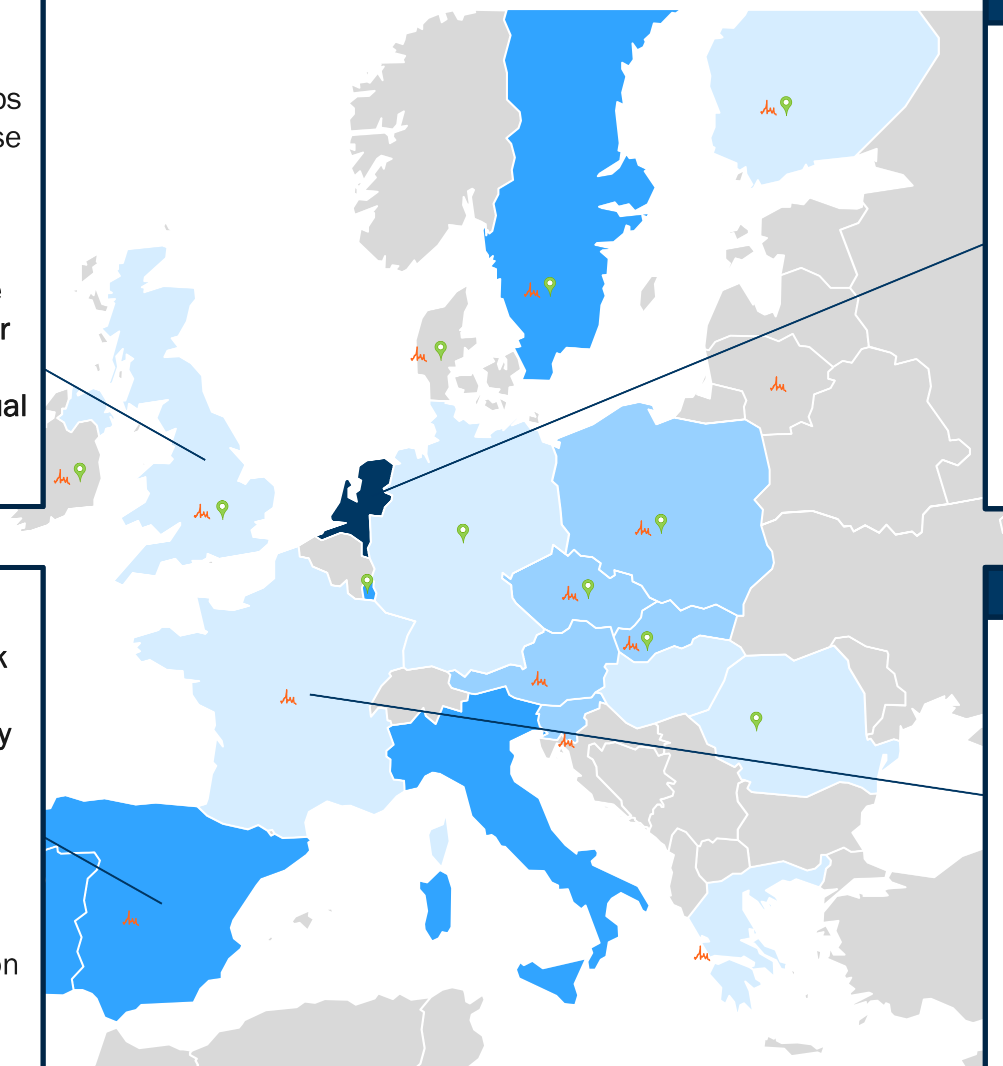
Focus on 4 case examples

UK

- Based on **incremental cost**
- Allocated on consumer groups mainly depending on their use of the network **during peak hours**
- **Capacity part** determined mainly based on **costs of the voltage level of the consumer**
- **Energy component** covering **higher voltage costs + residual costs**

SPAIN

- Based on **Reference Network Models**
- Split **connection and capacity guarantee on capacity component and losses and quality on energy**
- **Time-of-Use tariff based on peak load**
- Uncertainty on the application of the method



NETHERLANDS

- **Ad hoc methodology**: decision (in 2009) to **charge only on capacity** (+ fixed component) for households and SMEs
- Motivated by **cost reflectivity and simplification**
- **Gradual transition:** most consumers were able to reduce their contracted capacity; others indirectly benefited from tariff reduction for 2 years

FRANCE

- Based on **Shapley Value**: costs are allocated to hours depending on total load, then crossed with load profile
- **Menu of grid tariffs** depending on utilisation rates, with possibility to choose base or time-of-use
- Decision to introduce forms of **critical peak pricing for network charges**, activated in D-1 at national level

Source: European Commission (2015), "*Study on tariff design for distribution systems*", CRE, Ofgem, ACM, CNMC, interviews
https://ec.europa.eu/energy/sites/ener/files/documents/20150313%20Tariff%20report%20fina_revREF-E.PDF

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Conclusions

Main conclusions of the literature review and EU benchmark

- Economic literature provides clear principles:
  - Network charging should be based on marginal pricing
  - Residual costs should be covered minimising deviations to marginal pricing
  - Network charges should vary depending on periods within the year / day
- The benchmark shows:
  - High variety of tariff designs
  - Methodologies are generally of limited transparency
  - Academic approaches are hard to implement and might require sensitive simplifications
  - In many countries, grid tariff evolutions tend to increase the fixed / capacity components

⇒ **A perfect method is hard to identify but in a context of significant changes in the power system, it is important for consumers to get the adequate price signals**

⇒ **Further work would be valuable to identify better approaches for network tariff design, especially in distribution, and harmonise gradually approaches across the EU**

Thank you for your attention

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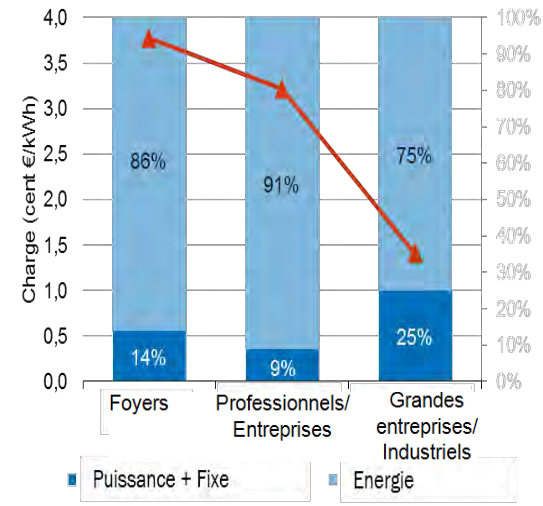
European trend towards a bigger share of the capacity component

- Some large countries have a high energy component, namely the **UK**, **France** and **Germany.**

- Recent developments towards a larger share attributed to the fixed and the capacity components:
  - **The Netherlands**, 2009: Tariff structure for households based exclusively on capacity with the goal of simplifying and reflecting costs more accurately
  - **Spain**, 2013-2014: Capacity component up from 32% to 60% within 7 months for households (excluding fixed component)
  - **Italy**, 2016-2018: Capacity component multiplied by 3 and increase of the fixed component by 66% for households
  - **Austria and the UK**: We heard that there were ongoing discussions towards more fixed or capacity component in order to increase cost reflectiveness and fairness; the UK may be considering Ramsey-Boiteux

- Even if several regulatory authorities already have increased the fixed component or the capacity component, and some others are considering it, a question arises about the share it should be given to and the underlying methodology
- Regulatory authorities and network operators also examine the possibility of increasing the fixed component, the capacity component (either based on contracted capacity or even reached capacity)

The United Kingdom



Key message

- Tariffs set up by reference to the cost of increasing demand during peak hours
- Allocation following an ad-hoc methodology between energy and fixed component

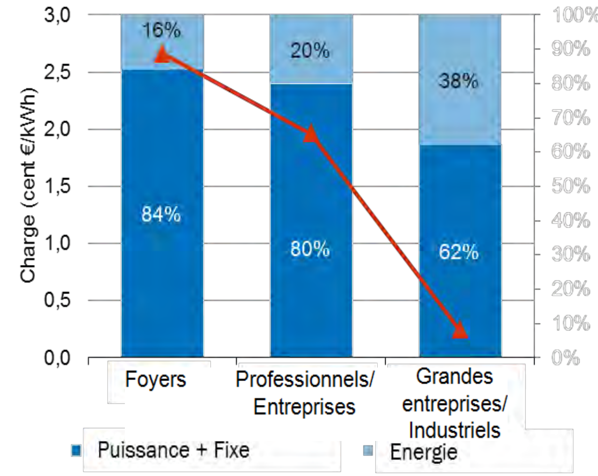
- The tariff structure is calculated by each network operator on the basis of a methodology developed by Ofgem
- Simplified cost estimation through an **incremental cost model**
- The cost allocation onto different customers groups and according to the time period is mainly based on **participation during peak hours**
- The **fixed share** of the tariff is determined by the **network costs** of the **voltage range to which the customer is connected**
- The **energy share** arises from the network costs for the **upstream voltage ranges** as well as the **allocation of residual costs**

Source: The Brattle Group (2014), "Structure of Electricity Distribution Network Tariffs: Recovery of Residual Costs" ; European Commission (2015), "Study on tariff design for distribution systems"; DCUSA, "Schedule 16 – 18".(CDCM); Interview Ofgem.

Spain

Key message

- Low transparency on the applied methodology despite a publication by NRA
- A strong rebalancing between capacity and power already took place in 2013
- Tariffs derived from the planned methodology probably not be implemented by the government



Methodology proposed by the regulator:

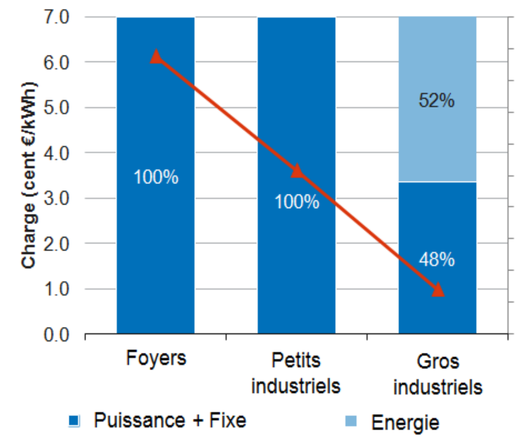
- Cost estimation on the basis of a **reference network model** which simulates the step-by-step sizing of the network: Connection and Capacity followed by Energy and Quality
  - Cost allocation to energy and capacity for each voltage range
- The **cost allocation** onto different customers groups and according to the time period is mainly based on **participation during peak hours**
- The allocation is performed **separately** for the **capacity** and the **energy** component:
  - Conservation of network costs

Source: The Brattle Group (2014), "Structure of Electricity Distribution Network Tariffs: Recovery of Residual Costs" ; European Commission (2015), "Study on tariff design for distribution systems"; CNMC(2014) : " Circular 3/2014 ", Interviews.

The Netherlands

Key message

- Tariff depending only on capacity
- Contracted and/or reached capacity
- Gradual shift with indirect subsidies during transition



- The **government** sets the **principles** of the tariff structure by law. The **network operators** then decide which **structure** to adopt, while the regulatory authority determines the authorised revenue
- **No energy component in the tariff** for low voltage consumers. **Two motivations** shared by the stakeholders:
  - Cost reflectiveness
  - Simplification of the administrative process
- The network tariff has two main components:
  - **Fixed charge**
  - **Contract and/or reached capacity** e ach month
- **A gradual shift**: During the first two years the impact on customers' bills was softened by a form of indirect subsidies.

Source: The Brattle Group (2014), "Structure of Electricity Distribution Network Tariffs: Recovery of Residual Costs" ; European Commission (2015), "Study on tariff design for distribution systems"; ACM, "Tarievencode Elektriciteit ", Interviews.