Residential electricity tariffs in Europe: current situation, evolution and impact on residential flexibility.

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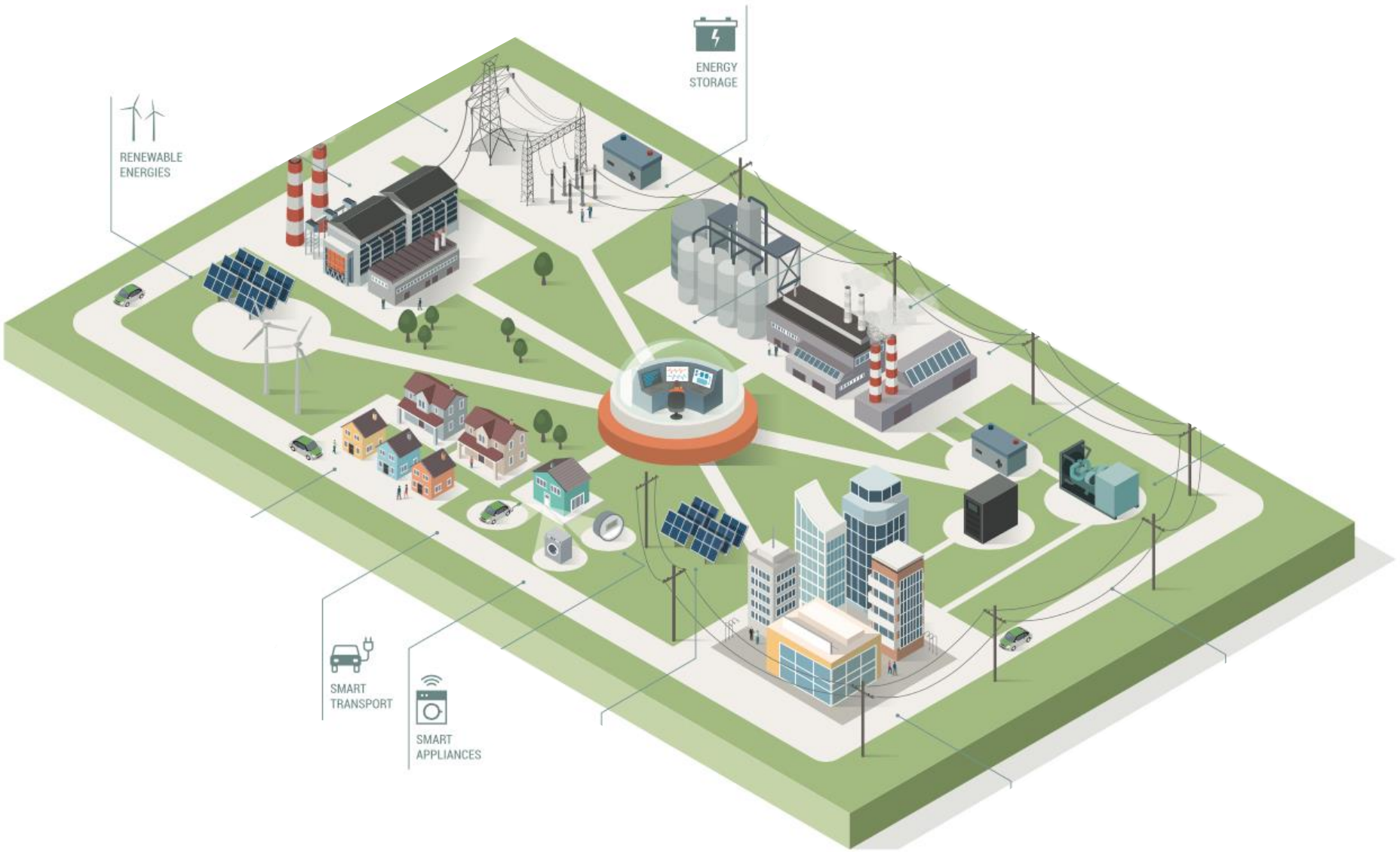
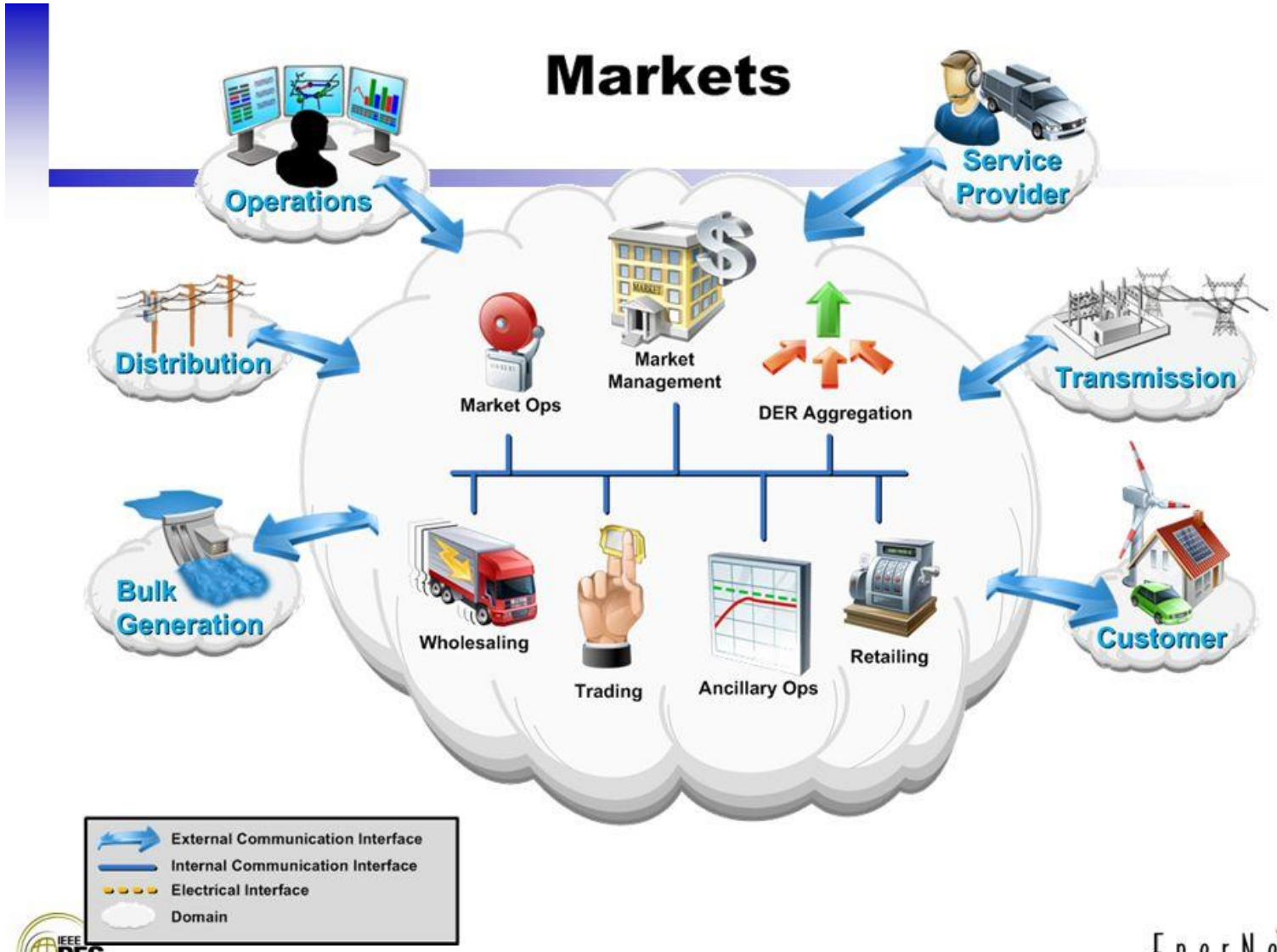
Content

1. Introduction
2. Components of residential electricity bills
3. Drivers for electricity tariff evolution
4. Examples of tariff for residential demand response
5. Challenges and conclusions

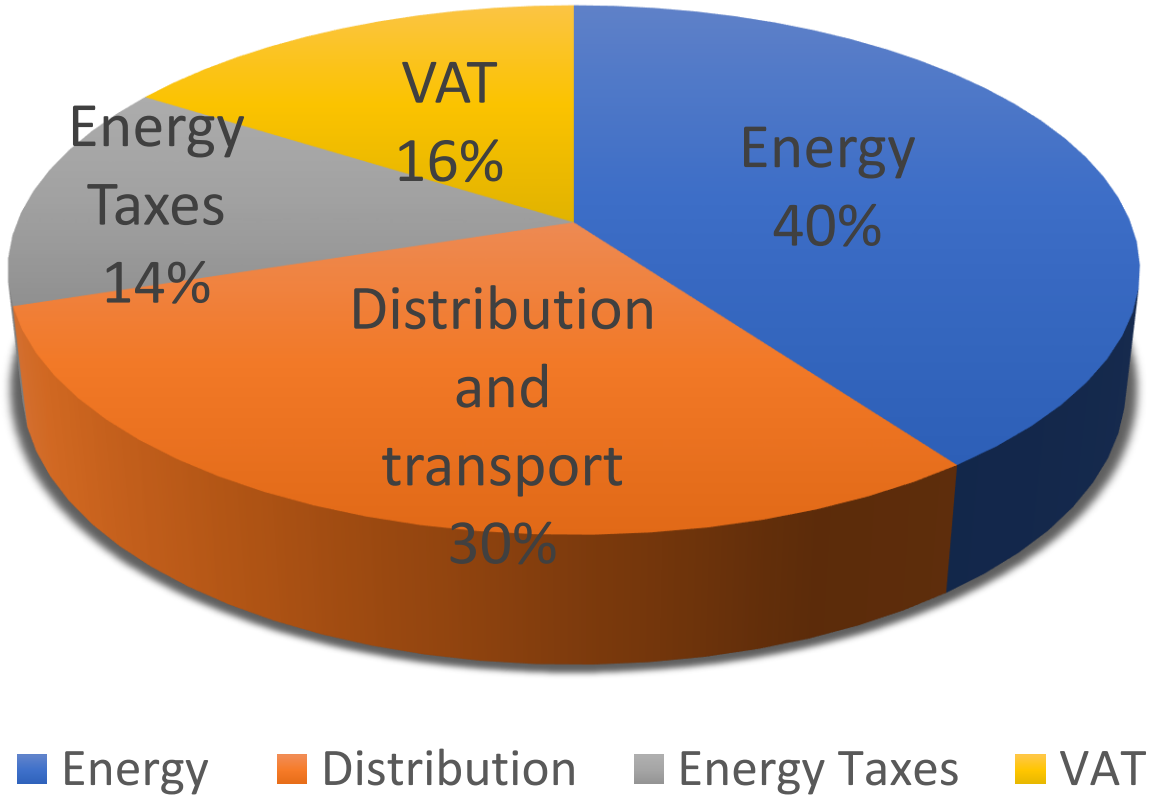
The energy system trend



Electricity Market



Components of the residential electricity bill



	Energy		Distribution		Energy Taxes		VAT	
	Min	Max	Min	Max	Min	Max	Min	Max
Percentage %	13	82	3	55	0	46	5	21
Country	Denmark	Malta	Croatia	Portugal	Bulgaria	Denmark	U.K	Hungary

The Electricity Bill explained

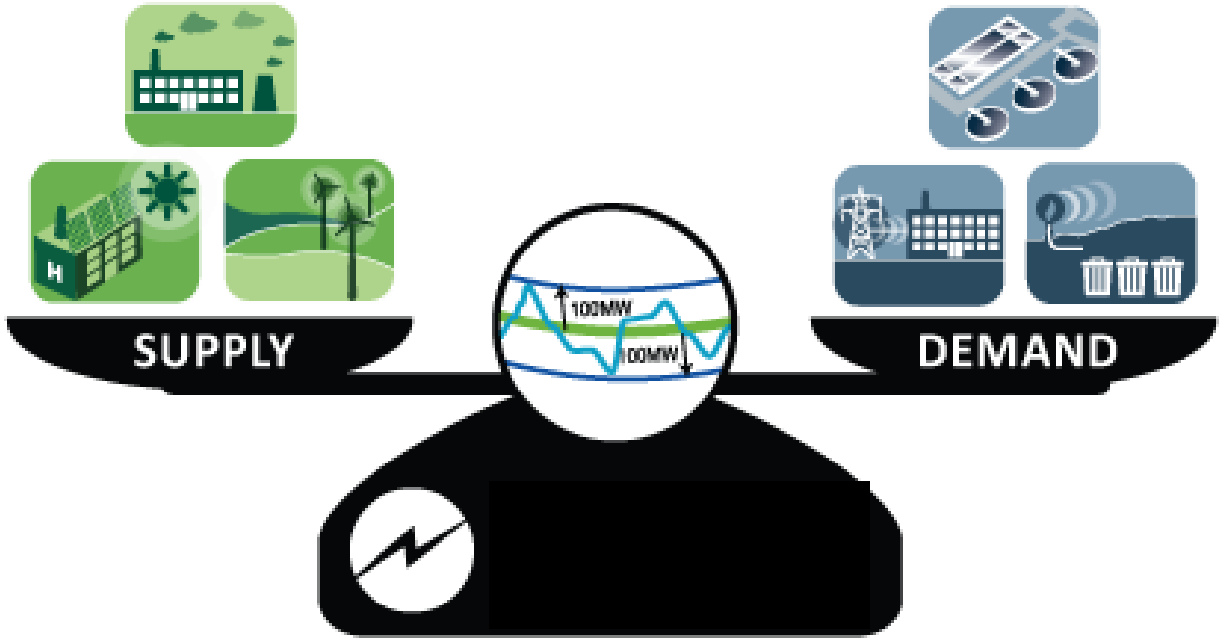
Component	Type of rates included	Specific costs included
Energy	- Fixed rate (€/year) - Variable rate (€/kWh) with possibility to have ToU tariffs	- Cost of energy - Cost for balancing and ancillary services - Commercialization - Other related to energy
Distribution and transport	- Fixed rate (€/year) - Power rate (€/kW*year) - Variable rate (€/kWh) without possibility to have ToU tariffs	- Cost of transmission - Cost of distribution - Cost of metering - Other related to transport
System charges	- Fixed rate (€/year) - Variable rate (€/kWh) without possibility to have ToU tariffs	- Cost of incentives for renewables and others - R&D - Authority and regulators costs - Other common costs
Taxes	- Fixed rate (€/year) - Variable rate (€/kWh)	- VAT - OtherTaxes

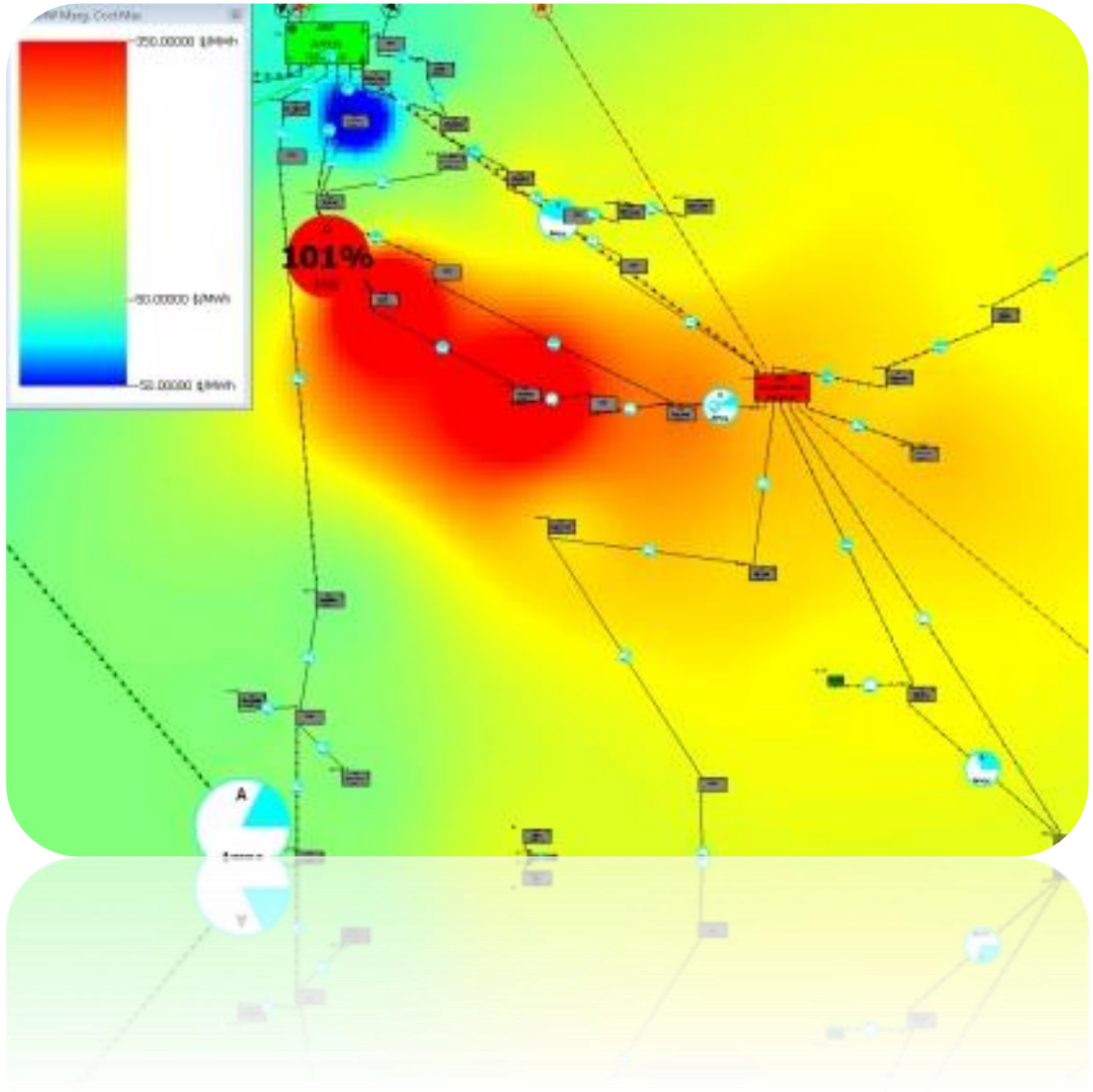
Tariff components and options for tariff design

	1. Tariff categories	2. Billing components	3. Time	4. Location	
Component Options	1.Consumer, Generation and Prosumer tariff 2.Consumer and Generation tariff 3. Consumer and Prosumer tariff 4. Solely Consumer tariff	1. Two-fold charge: Energy + Capacity charge (€/kWh and (€/kW)) 2. Capacity charge (€/kW) 3. Energy charge (€/kWh) 4. Yearly charge (€/year)	1. Real-Time-Pricing (RTP) 2. Time-of-Use (TOU) 3. Flat rate (time independent)	1. Nodal pricing 2. Zonal pricing 3. Uniform pricing (location independent)	*Increasing Complexity* ↑↑↑↑↑↑ / *Reducing Cost-causation* ↓↓↓↓↓↓

Tariff components and options for tariff design (Eid et al., 2013).

Drivers for electricity tariff evolution





Drivers for electricity tariff evolution

Energy Mix

Evolution of the grid

Regulatory changes

Smart meter roll out

Societal changes

Impact on the grid

	Positive impact for the grid	Negative impact for the grid
Balancing	**Lower needs for balancing services** **Energy mix** • Flexible generation (i.e. gas) • High penetration of storage • Good combination of PV/wind incl. smart inverters **Demand response** • Demand response for households appliances • Smart charging for cars **Billing** • Volumetric consumption ToU • Incentive for self-consumption (e.g. FiT < retail tariff) **Interconnections** • Better electrical interconnections with the outside Regulatory • Higher proportion for the consumed volumetric component compared to capacity	**Higher needs for balancing services** **Energy mix** • High penetration of PV and wind • Decommissioning of power plants **Billing** • No Time of use **Regulatory** • No deployment of smart meters • Net metering for PV

Impact on the grid

	Positive impact for the grid	Negative impact for the grid
	Lower needs for balancing services	**Higher needs for balancing services**
Balancing	**Energy mix** • Flexible generation (i.e. gas) • High penetration of storage • Good combination of PV/wind incl. smart inverters	**Energy mix** • High penetration of PV and wind • Decommissioning of power plants
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	Billing • Volumetric consumption ToU • Incentive for self-consumption (e.g. FiT < retail tariff)	**Regulatory** • No deployment of smart meters • Net metering for PV
	Interconnections • Better electrical interconnections	

Impact on the grid

	Positive impact for the grid	Negative impact for the grid
Congestion	Lower needs for congestion services **Energy mix** • More widespread generation (distributed generation) **Regulatory** • Simplification to change contractual power • Billing based on actual power vs contractual power • Congestion markets **Societal changes** • Energy efficiency (e.g. LED, more energy efficient fridges, etc). • Storage	Higher needs for congestion services **Energy mix** • Large deployment of PV (congestion because of overproduction and possibly overvoltage) **Societal change** • Increase in electrification of heating (electrical heating + heat pumps) and transport (electric cars and 2-wheelers) with no smart charging/use

Impact on the grid

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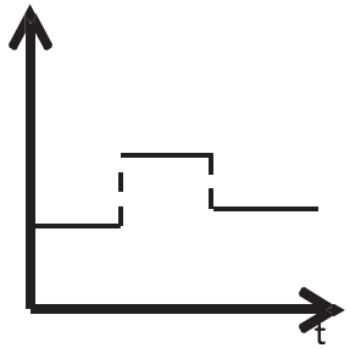
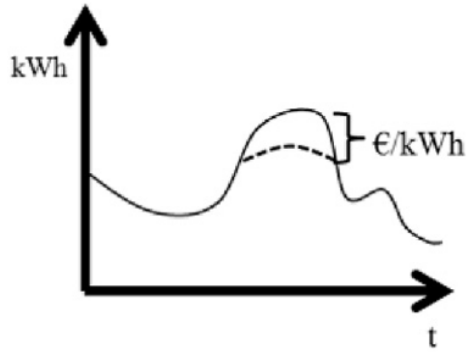
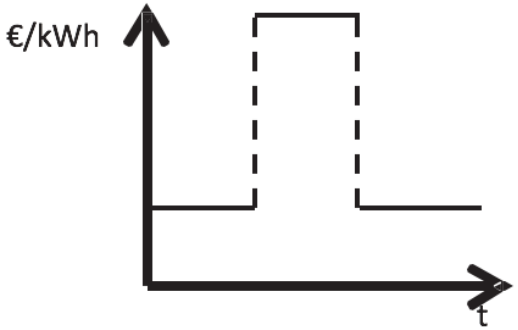
Possible time-based pricing options for DER

Basic time-based pricing options			Specific incentives for baseline adjustment		
Time-Of-Use (TOU)	Fixed electricity prices for different time blocks within a time period		Peak time rebates (PTR)	A rebate when electricity is reduced compared to baseline consumption, within certain hours in a year.	
Real-Time-Pricing (RTP)	An hourly rate depending on the day ahead real-time price of electricity		Interruptible Capacity Program (ICAP), Interruptible load	Arebate when electricity is reduced below a baseline value.	
Critical Pricing (CPP)	High electricity price periods for certain (fixed) days of time within a year		Emergency Demand Response	Mandatory commitment to reduce load, with penalties if not supplied.	

Possible time-based pricing options for DER management (David and Lee, 1989; Faruqui and Sergici, 2009; Hakvoort and Koliou, 2014).

Pricing to promote residential DR

- Permanent signals reflecting variations in price related to time, location, size, and direction are mostly used for higher costs categories, such as those related to generation and transmission constraints.
- Transient signals can be used to reflect variations in distribution costs. Thus, if a zone is congested during only some hours of the year, non-permanent punctual signals such as CPP can be used in that zone
- Time-based and dynamic pricing can furthermore be obligatory or voluntary, with and without opt-in or opt-out methods

Tariff option	Tools			
	In-home pricing display	Real-time-metering (Smart metering)	Access to baseline consumption curve	In-home demand control
Direct Load Control	Optional	Required	Not required	Required
Real-Time-Pricing	Required	Required	Not required	Optional
Critical-Peak-Pricing	Required	Required	Optional	Optional
Peak-Time-Rebates	Required	Required	Required	Optional
Time-of-Use pricing	Optional		Not required	Optional

Examples of tariffs for residential DR

France, a combination of CPP and TOU pricing is applicable for customers that apply for the **Tempo Tariff**

- 22 red days from November 1st till March 31st from Monday to Friday (Saturdays, on Sundays and holidays are never red and he can have no more than 5 consecutive red days there),
- 43 white days that are spread over the year mainly between October and May except on Sundays
- 300 blue days all the rest of the year (every Sunday is blue).

Signed Power (kVa)	Annual subscription TTC (€)	Blue HC	Blue HP	White HC	White HP	Red HC	Red HP
		For 1 kWh (€ TTC)					
9	131.33	0.0967	0.1147	0.1336	0.1585	0.2402	0.6207
12	210.34	0.0967	0.1147	0.1336	0.1585	0.2402	0.6207
15	243.46	0.0967	0.1147	0.1336	0.1585	0.2402	0.6207
18	267.10	0.0967	0.1147	0.1336	0.1585	0.2402	0.6207
30	667.74	0.0967	0.1147	0.1336	0.1585	0.2402	0.6207
36	819.60	0.0967	0.1147	0.1336	0.1585	0.2402	0.6207

Examples of tariffs for residential DR

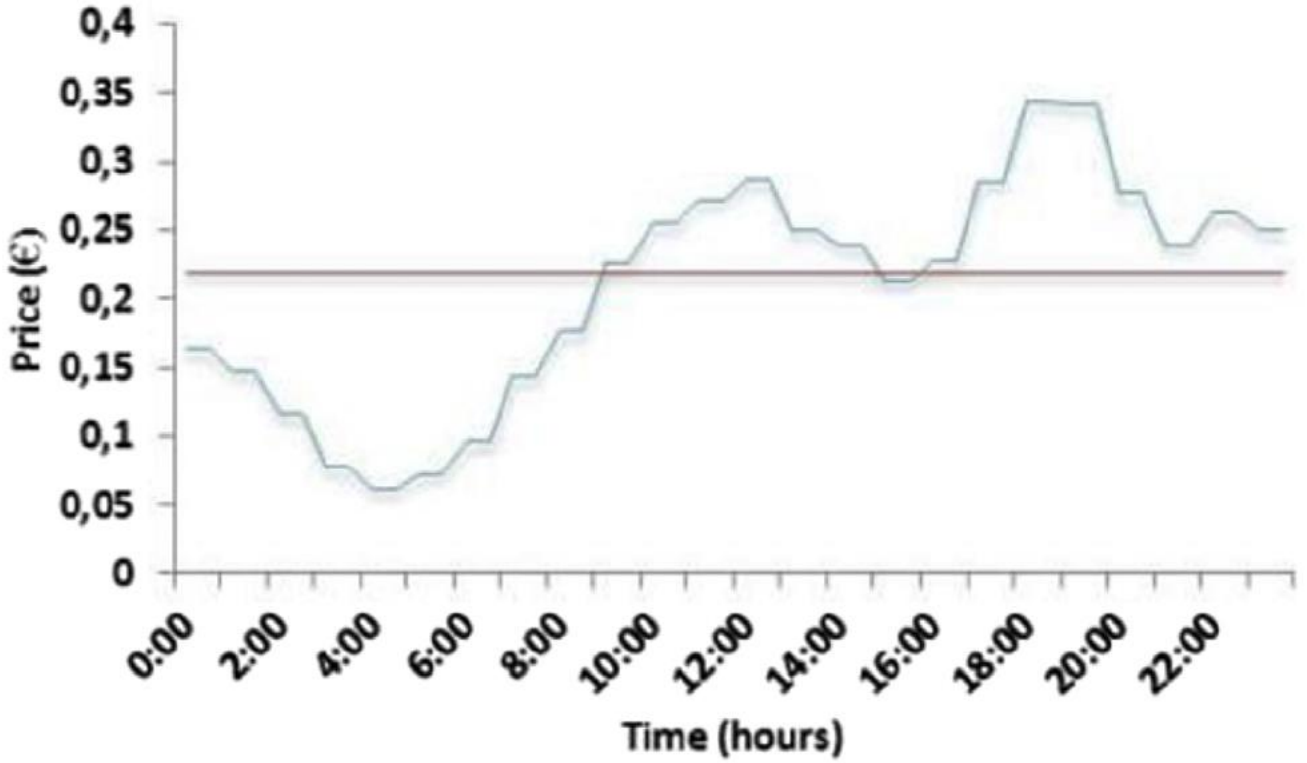
Sweden tested a tariff for network congestions. The clients receive a demand-based time-of-use electricity distribution tariff.
The demand-based tariff consists of the fixed access charge (SEK/yr.) and a variable distribution charge (SEK/kW) that is calculated based on the average of the five highest hourly meter readings during peak hours. In off-peak hours, electricity distribution is free of charge.

Resulting in:

- Peak demand reduction between 7.5% and 9.3% .
- The total shift from peak to off-peak hours was between 2.4 and 0.2 h
- Individual households saw a decrease from 14% to 41% in costs

Examples of tariffs for residential DR

The Netherlands tested dynamic retail, distribution, and local production pricing for household consumers.
The retail tariff is based on the day-ahead price resulting in a retail price fluctuating between 0.06 €/kWh and 0.36 €/kWh each day



Challenges for the evolution of DR tariffs

Initial technology investments

- Installation of smart meters, in-home displays, and other devices for enabling DR is costly
- Without any clear business model for investments, no actor will make the first move

Coordination problems

- Actors involved in electricity supply could require the demand to be adjusted downward, while others could actually require upward demand adjustments.

Flexibility and traditional markets

- New rules for balancing, ancillary, and real-time trading should be adjusted to accommodate aggregated load flexibility.
- Need for a compensation mechanism that guarantees that electricity suppliers are not penalized for imbalances caused by activities of (independent) aggregators

Side-effects of DR: shifting peaks and increasing emissions

- A relevant issue with DR tariff schemes is that instead of peak reduction and valley filling, a shifted peak is frequently observed.

Conclusions

- Currently no urgency for demand response from the residential sector due to overcapacity in the distribution grid and therefore the evolution of promoting tariffs is moving slow
- In a liberalized electricity sector, taxes, network charges, and retail charges are separately defined and this affect price clarity for the end-user
- New rules for balancing, ancillary, and real-time trading should be adjusted to accommodate aggregated load flexibility.
- Clear business models for residential flexibility

Thank you

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