Congestion management in distribution network

Which market design to integrate local flexibility assets considering information and investment incentives issues ?

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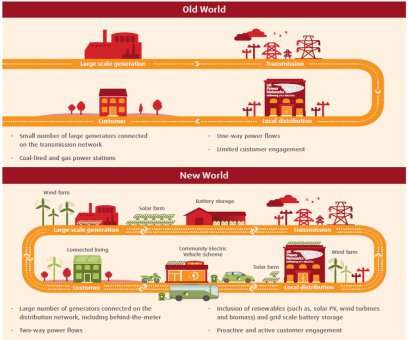
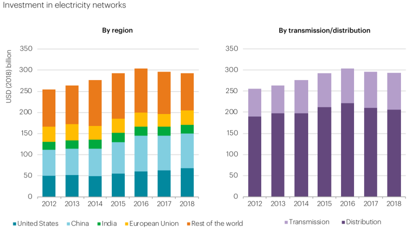
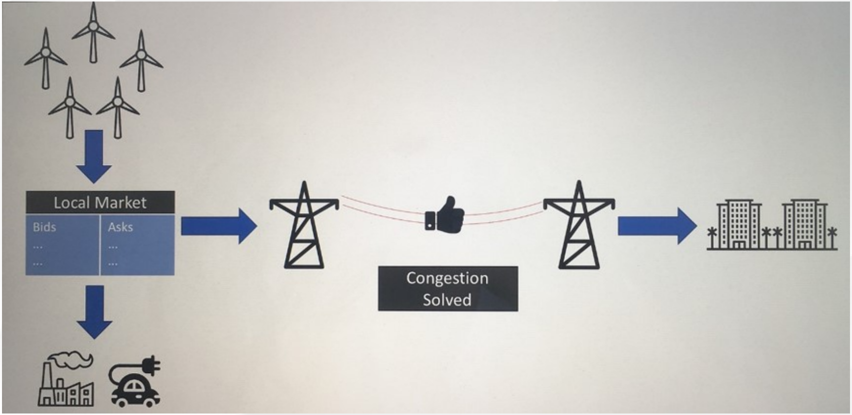
Context

Decentralisation of electricity production and evolution of uses would solicit more and more distribution network.. **And will necessitate deep evolution and investment to accommodate these transformations.**





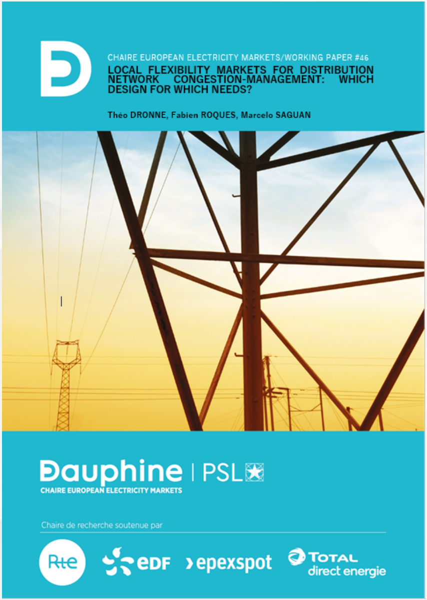
- One of the main problematic will be **congestion**. [1]
- Alternative of network development to solve congestion are gaining interest, especially with using flexibility.
- Several ways emerge to use flexibility,we analyse one them : ***local flexibility market.***



[1] Congestion in distribution network will have a broader definition than in transport

Short reminder of my first article

- First article focus on the different possible local flexibility market-design according to the specificity of the situations.
- We have especially notify the need of flexibility assets development in some areas, but *without exploring deeply the complexity of these development.*



State of the art

Information issues and investment on flexibility are still a partly uncovered subject...

- *Complexity in coordination between network development and assets investment* in an unbundled framework have also been covered (Conejo et al. 2016, Rious 2007) mainly on transport perspective.
- *Diversity of local flexibility market-design's* possibility to remunerate flexibility mobilized for DSO needs have been explored in literature (Ramos et al. 2016, Schittekatte and MEEUS 2019, Dronne, Roques and Saguan 2020) but it doesn't cover investment incentives.
- *Distribution locational marginal prices to optimize network development* and incentives DER location have been treated (Bai et al. 2018, MIT 2016) and the impact on investment process depending on local-price signal have been investigated, mainly on their location choice (Pechan 2017, Ruderer and Zöttl 2018, Wagner 2019).
- *Risk for investment on electricity generation* and the impact of policy measures and market-design to answer to these risks have been well covered. (IEA 2019, Roques and Finon 2017, Finon 2008, Peluchon 2019, de Maere d'Aertrycke, Ehrenmann, and Smeers 2017, Roques 2020).

Research Question

Which market design to integrate local flexibility assets considering coordination and investment incentives issues ?

Main messages

In a dynamic perspective first-best for the arbitrage between flexibility uses and network development is not fixed.

In real world, arbitrage is even harder to realize because **network development is made by network operators and flexibility sources' investment is made by deregulated investors.** We highlight two central problematic:

- Asymmetric information
- Lack of commitment

We propose an additional element to short term local flexibility market:

- Long-term capacity auction

Regulation aspects are also to be enhance (better communication of keys information and TOTEX approach).

Methodology

1. We develop the grid analysis based on institutional economic.
2. We illustrate how arbitrage between network development and flexibility uses will be realized by a social benevolent planner and we demonstrate complexity of coordination to reach first-best for congestion management in a liberalized framework.
3. We give market-design and regulation recommendations to answers to coordination issue highlighted in part two

Institutional economic framework

		Asset specificity	
		No	Idiosyncratic
Uncertainty	Low	Pure market (neoclassical contracting)	
	High	Bilateral governance	Unified governance

Table 1: Williamson contracting issue depending on uncertainty and asset specificity (Williamson, 1981).

Transactions in a flexibility market will therefore have two main characteristics:

- Specific assets impacted by the lack of commitment.
- the uncertainty linked to the asymmetry of information.

Lack of commitment with specific assets

- The importance of the lack of commitment from DNO will be particularly important because flexibility asset would be **specific for network congestion.**
- In case of investment value for investment deferral lack of commitment would create a risk of **opportunism.**
- In the case of flexibility assets for network congestion this risk is even stronger because there is **only one buyer**, the DNO.

Asymmetric information for market actors

Several characteristics are leading to asymmetric information on network cost for market actors :

- **Network cost and data not transparent**
  Moreover network development cost would be hardly predictable for market actors because:
- **Network cost not uniform and highly variable**
- **Network development different from social optimum (unappropriated incentives from regulation)**

Lack(s) of current market-design and possible answers will be presented in the next section.

Social benevolent planner : simplified example

Objective function

Objectives will be to minimize the objective function CT[2]=

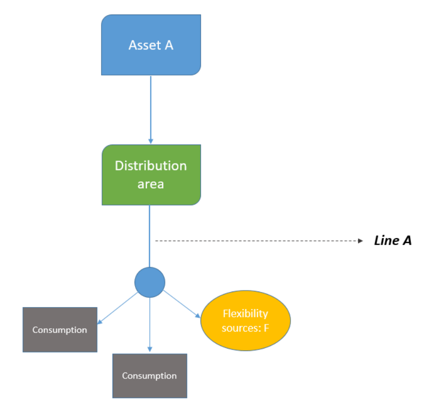
$$(P_(a_y)*Cm_a+P_(f_y)*Cm_fl+shed_y*VOLL)*h_y+$$

$$CaNet_y * C_r + Iflex * CaFle_y(1)$$

With constraints:

- $P_a + P_f + shed =$ fixed local demand
- $Capa - P_a \geq 0$
- $P_a \geq O$
- $P_f \geq 0$
- $shed \geq 0$

Simplified network representation



[1]Formula for one year but real objective function is over an horizon of 5 years.

Variables and assumptions

Variables	Definition
Pa	Prod of asset A
Pf	Prod of asset F
shed	Load shedding
CaNet	Network capa
CaFle	level of flex capa

Table: Variables

Names	Definition	Assumptions
Cma	Marginal cost of asset A	30€/MWh
Cmf	Marginal cost of asset F	300€/MWh
VOLL	Cost of load shedding	1000€/MWh
LPD	Local peak demand	1,5 MW
Iflex	Investissement flex	15000€/MW
Cr	Cost of network development	*see scenarios*

Table: Assumptions

[2] We consider the cost of generator defined in (RTE 2017)

Peak local demand during five years

	Year 1	Year 2	Year 3	Year 4	Year 5
Hours	20	40	200	200	200
Consumption on area (MWh)	30	60	300	300	300

Table: Hours and MWh of congestion

Congestion-management with reference scenario

Social benevolent planner firstly considers a reference scenario with **Cr1 = 35 000 €/MW.year.**

		Year 1	Year 2	Year 3	Year 4	Year 5	Total cost
Cr1	Network capacity (MW)	1	1	1	1	1	331 000€
	Asset F capacity (MW)	0,5	0,5	0,5	0,5	0,5	
	Asset A production (MWh)	20	40	190	190	190	
	Asset F production (MWh)	10	20	95	95	95	

Table: First-best with reference scenario (scenario 1)

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Table: First-best with reference scenario (scenario 1)

Flexibility asset is used during the five years to solve remaining congestions.

Congestion-management with second scenario

In a second time the social benevolent planner considers **Cr2 = 25 000 €/MW.year**

		Year 1	Year 2	Year 3	Year 4	Year 5	Total cost
Cr2	Network capacity (MW)	1	1	2	2	2	275 000€
	Asset F capacity (MW)	0.5	0.5	0.5	0.5	0.5	
	Asset A production (MWh)	20	40	285	285	285	
	Asset F production (MWh)	10	20	0	0	0	

Table: First-best with second scenario

Congestion-management with second scenario

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Table: First-best with second scenario

With considering different network development cost we observe than **flexibility assets would sometimes only be used during few years before network development.**

Analysing flexibility investments in an "energy-only" LFM[3]

In liberalized electricity system, there is no social benevolent planner.

- Congestion management and network development will be realized by network operators.
- Flexibility sources will be developed by deregulated investors.

Here we study the local flexibility market-design developed in (Esmat, Usaola and Moreno, 2018) in initiatives as ENERA: A separate order-books for localized flexibility offer with short-term focus and only energy remuneration.

[3] Local Flexibility Market

Illustration with different market-designs

1. Flexibility providers decide if they develop or not flexibility assets depending on the scenario they are expecting with 3 possibilities (Perfect information sharing and commitment, Information sharing without commitment or no commitment and no information sharing).
2. Network operator knowing than scenario 1 is the correct one decides network investment given flexibility availability.

First stage

- $R_f = 500\$ * MWh * y^4$
- $y \in [1, 5]$
- If $R_(f_i) \geq$ Total flex cost (TFC), Investment is realized
- $TFC = Cmf + Iflex$

Second stage : network reinforcement decision

Our objective function is still CT (1)
With the new constraint :

- If $R_f \leq MI_i$, $P_f = 0$

[4] Price based on Ecube 2017

Congestion-management with different market-designs

Information	Commitment	Income	TFC	Social cost
Good	Good commitment	66 000€	37 500€	325 000€
Good	No commitment	36 000€	37 500€	379 000€
Low	No commitment	6000€	37 500€	379 000€

Table: Congestion cost depending on uncertainty for investors

Congestion-management with different market-designs

Information	Commitment	Income	TFC	Social cost
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Table: Congestion cost depending on uncertainty for investors

Because they do not have specific information and face a lack of commitment, social-cost to resolve congestion would then be higher because flexibility assets have not been developed.

Long-term capacity Auction

We propose to add one element to solve these problematic.

Long-term capacity auction will :

- *Reveal information and willingness from network operators.* (Neuhoff and De Vries, 2004, Newbery, 2003,Vogel, 2009, Laffont and Tirole, 1988)
- *Flattens the opportunism of the network operator* (Vogel 2009).
- *Reduce market-risk and short-term income exposure*(Joskow 2006)

These auction would be combined with short-term energy market.

Evolution of regulation aspect

Beside the market regulation should also evolve to provide confidence to investors and reduce incomplete informations with:

- **Development of information sharing by the DSO**: To establish pre-contractual beliefs (Sappington, 1991) (Bolton and Dewatripont, 2006).
- **Equal approach for CAPEX and OPEX for network development**: Approach focus on TOTEX. (Brunekreeft and Rammerstorfer 2020)

Conclusion

A simplified local flexibility market-design, focus on short-term management and with only energy remuneration, would create lead to sub-optimal level on investment because of:

- ***Asymmetric information***
- ***Lack of commitment***

To answers to these risks, market-design and regulation should evolve, we propose to add several elements to local flexibility energy-only market:

- ***Long-term capacity auction***

We also advice two mains regulations' evolution to give better visibility of investors: Better communication of DSO's data and Better incentive between CAPEX & OPEX.

Thank You!

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