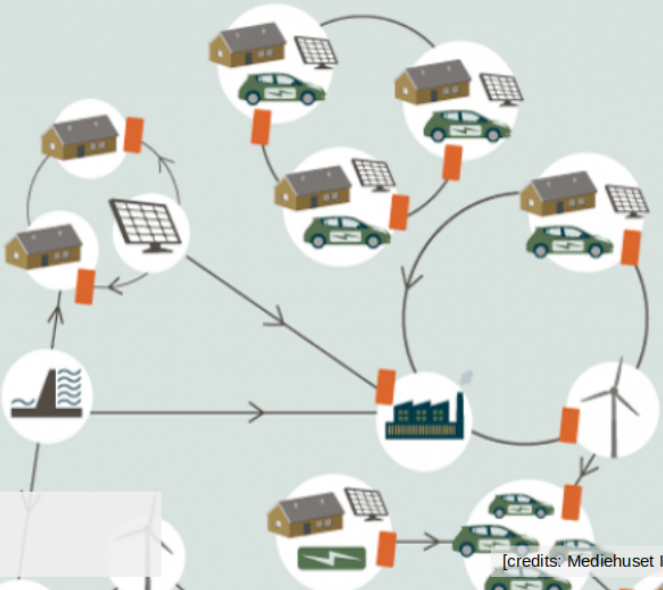
Module 2 – Electricity Spot Markets (e.g. day-ahead)

2.3 From prices to settlement



Pierre Pinson
Technical University of Denmark

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Settlement process

- After energy schedules and the system price are determined, comes the **settlement** process...

- Using everyday terms:
  - *who should pay what?*
  - *who should get paid, and what amount?*

  (Obviously, only those with energy production or consumption scheduled are concerned)

- *Any opinion?*

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- The two main approaches to **settlement** rely on
  - *pay-as-bid* pricing
  - *uniform* pricing

Our example auction setup

Supply: (for a total of 1435 MWh)

Company	Supply/Demand	id	P_j^G (MWh)	λ_j^G (€/MWh)
RT®	Supply	G_1	120	0
WeTrustInWind	Supply	G_2	50	0
BlueHydro	Supply	G_3	200	15
RT®	Supply	G_4	400	30
KøbenhavnCHP	Supply	G_5	60	32.5
KøbenhavnCHP	Supply	G_6	50	34
KøbenhavnCHP	Supply	G_7	60	36
DirtyPower	Supply	G_8	100	37.5
DirtyPower	Supply	G_9	70	39
DirtyPower	Supply	G_{10}	50	40
RT®	Supply	G_{11}	70	60
RT®	Supply	G_{12}	45	70
SafePeak	Supply	G_{13}	50	100
SafePeak	Supply	G_{14}	60	150
SafePeak	Supply	G_{15}	50	200

Our example auction setup

Demand: (for a total of 1065 MWh)

Company	Supply/Demand	id	P_i^D (MWh)	λ_i^D (€/MWh)
CleanRetail	Demand	D_1	250	200
El4You	Demand	D_2	300	110
EVcharge	Demand	D_3	120	100
QualiWatt	Demand	D_4	80	90
IntelliWatt	Demand	D_5	40	85
El4You	Demand	D_6	70	75
CleanRetail	Demand	D_7	60	65
IntelliWatt	Demand	D_8	45	40
QualiWatt	Demand	D_9	30	38
IntelliWatt	Demand	D_{10}	35	31
CleanRetail	Demand	D_{11}	25	24
El4You	Demand	D_{12}	10	16

Market clearing results

- After market clearing, the supply and demand schedules are:

Supply id.	Schedule (MWh)	Demand id.	Schedule (MWh)
G_1	120	D_1	250
G_2	50	D_2	300
G_3	200	D_3	120
G_4	400	D_4	80
G_5	60	D_5	40
G_6	50	D_6	70
G_7	60	D_7	60
G_8	55	D_8	45
G_9-G_{15}	0	D_9	30
		D_{10}-D_{12}	0

- The system price is of 37.5 €/MWh, corresponding to the price offer of G_8

Settlement with pay-as-bid pricing

- How does that work? For those scheduled,
  - *Consumption* side: $R_i^{DA,D} = -\lambda_i^D y_i^D$, $R_i^{DA,D} \leq 0$, (since being a payment)
  - *Supply* side: $R_j^{DA,G} = \lambda_j^G y_j^G$, $R_j^{DA,G} \geq 0$ (since being a revenue)

Payment and revenues for our example market clearing

- *Consumption* side (payments):
  - D_1 pays $250 \times 200 = 50000$ €, $(R_1^{DA,D} = -50000)$
  - D_2 pays $300 \times 110 = 33000$ €, $(R_2^{DA,D} = -33000)$, etc.
  - D_9 pays $30 \times 38 = 1140$ €, $(R_9^{DA,D} = -1140)$
- *Supply* side (revenues):
  - G_1 receives $120 \times 0 = 0$ €, $(R_1^{DA,G} = 0)$
  - G_2 receives $50 \times 0 = 0$ €, $(R_2^{DA,G} = 0)$, etc.
  - G_8 receives $55 \times 37.5 = 2062.5$ €, $(R_8^{DA,G} = 2062.5)$

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- Do you foresee the potential consequences of pay-as-bid pricing, e.g., in terms of fixed cost recovery for energy producers and strategic behaviour of market participants?

Settlement with uniform pricing

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Payment and revenues for our example market clearing

- *Consumption* side (payments):
  - D_1 pays $250 \times 37.5 = 9375$ €, $(R_9^{DA,D} = -9375)$
  - D_2 pays $300 \times 37.5 = 11250$ €, $(R_9^{DA,D} = -11250)$, etc.
  - D_9 pays $30 \times 37.5 = 1125$ €, $(R_9^{DA,D} = -1125)$
- *Supply* side (revenues):
  - G_1 receives $120 \times 37.5 = 4500$ €, $(R_8^{DA,G} = 4500)$
  - G_2 receives $50 \times 37.5 = 1875$ €, $(R_2^{DA,G} = 1875)$, etc.
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- It is expected to attenuate some of the potential negative consequences observed with pay-as-bid pricing

Properties induced by these two settlement approaches

- Day-ahead markets with the two settlement approaches guarantee **individual rationality**

  In both cases, consumers will pay at most what they were ready to pay, and producers will receive at least what they wanted to be paid for, i.e.,

$$R_i^{DA,D} \leq \lambda_i^D y_i^D, \quad \forall i, \qquad R_j^{DA,G} \geq \lambda_j^G y_j^G, \quad \forall j$$

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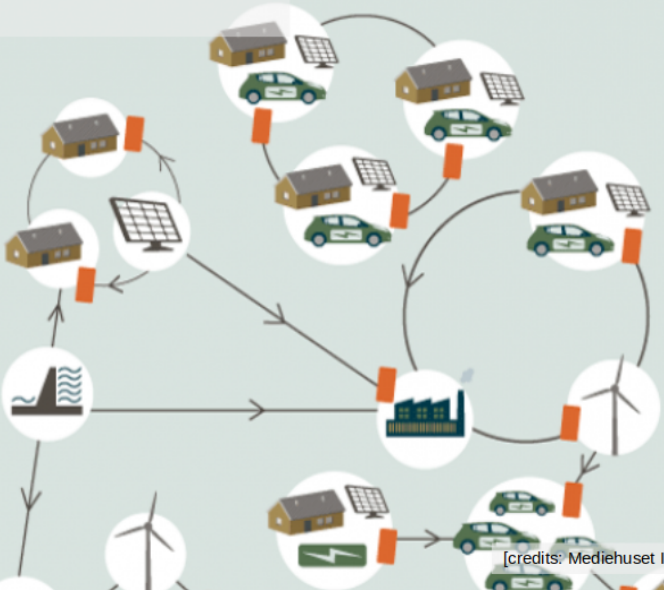
- Uniform pricing yields **budget balance**. Pay-as-bid pricing does not

  Only for uniform pricing, the sum of revenues is by definition equal to the sum of payments

Use the self-assessment quizz to check your understanding!



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