Portfolio management fundamentals by time horizon and utilities decisions

1- Production portfolio management

2 - Production management with uncertainties

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Disclaimer

Tout avis et toute opinion donnés dans cette presentation sont ceux de l'auteur, et ne sont pas nécessairement ceux du groupe EDF.

The crucial balance

Electricity is barely storable

- In a given zone, at each time, required equilibrium between load consumption/production in this zone and physical exchanges with neighbouring zones.
- Limited storages: some batteries and hydro storages.

Consequences

- The equilibrium needs to be prepared well in advance and operations are required until real time.
- Forecast equilibrium depends on the precisions of forecasts and uncertainty realisations.
- In real time, flexibilities are required to solve any unbalance.

A utility is a Balance Responsible Party

- A Balance Responsible Party is financially engaged to pay for its imbalance measured at posteriori on its perimeter.
- Perimeter = injection + withdrawal (physical and market based)
- This mechanism incentives operators to actively participate to the global equilibrium of the system.
- Balance Responsible Party can be of different natures: utilities, large consumers, financial counterparts…
- A Balance Responsible Party can exchange with other Balance Responsible Parties in order to balance its position → the block of energy is declared to the TSO/ISO

- A2A S.p.A
- Acciona Green Energy Developments S.L.U
- ACTILITY SA
- AGREGIO
- AIR LIQUIDE France Industrie (ALFI)
- ALPIQ AG
- ALTERNA
- ArcelorMittal Energy SCA
- ARKEMA France
- Axpo Trading AG
- Axpo Trading AG
- Azienda Elettrica Ticinese
- BCM ENERGY
- BHC ENERGY
- BHC ENERGY
- BKW Energie AG
- BLUE ELEC
- BNP Paribas Commodities Futures
- BP Gas Marketing Ltd
- Burgo Energia S.r.l.
- Castleton Commodities Merchant Europe Sarl
- Centrica Energy Ltd
- CEZ a.s.
- CITADEL ENERGY INVESTMENTS LTD
- Citigroup Global Markets Ltd
- CKW - Centralschweizerische Kraftwerke AG
- COMAX France SAS
- Compagnie Nationale du Rhône
- CONVEX ENERGY GmbH
- CVA Trading S.r.l. a S.u.
- DALKIA France
- Danske Commodities A/S
- DOLOMITI ENERGIA Trading S.p.A.
- Duferco Energia SpA
- DXT COMMODITIES
- E6 SA
- EBM Energie SA
- Edelweiss Energia Spa
- EDF Luminus
- EDF Obligations d'Achat
- EDF Trading Ltd
- EDISON SPA

Example: lists of balancing responsibles in France by the regulation commission CRE

Production portfolio management objective

In EU open markets, a producer is a Balance Responsible Party: the producer is in charge of the balance load/production on its perimeter.

The objective of production portfolio management is to maximize the financial gains, i.e. to produce with the least expensive production assets.

Tools

- Production dispatch,
- Buy/sell volumes,
- Customers portfolio.

Constraints

- Ancillary services obligations,
- Power plant and specific hydro power plants constraints,
- Financial risks,
- Emissions…

Examples of production power plants (1/2)

Nuclear generation

- Not expensive
- But low flexibilities

Fossil Fuel generation

- More expensive (coal), or even more expensive (gas, oil)
- Less constrained
- CO_2 emission and other pollutants (SO_2, NOX)

Examples of production power plants (2/2)

Hydro power

- Free
- … but partly non-manageable …
- And with lots of constraints

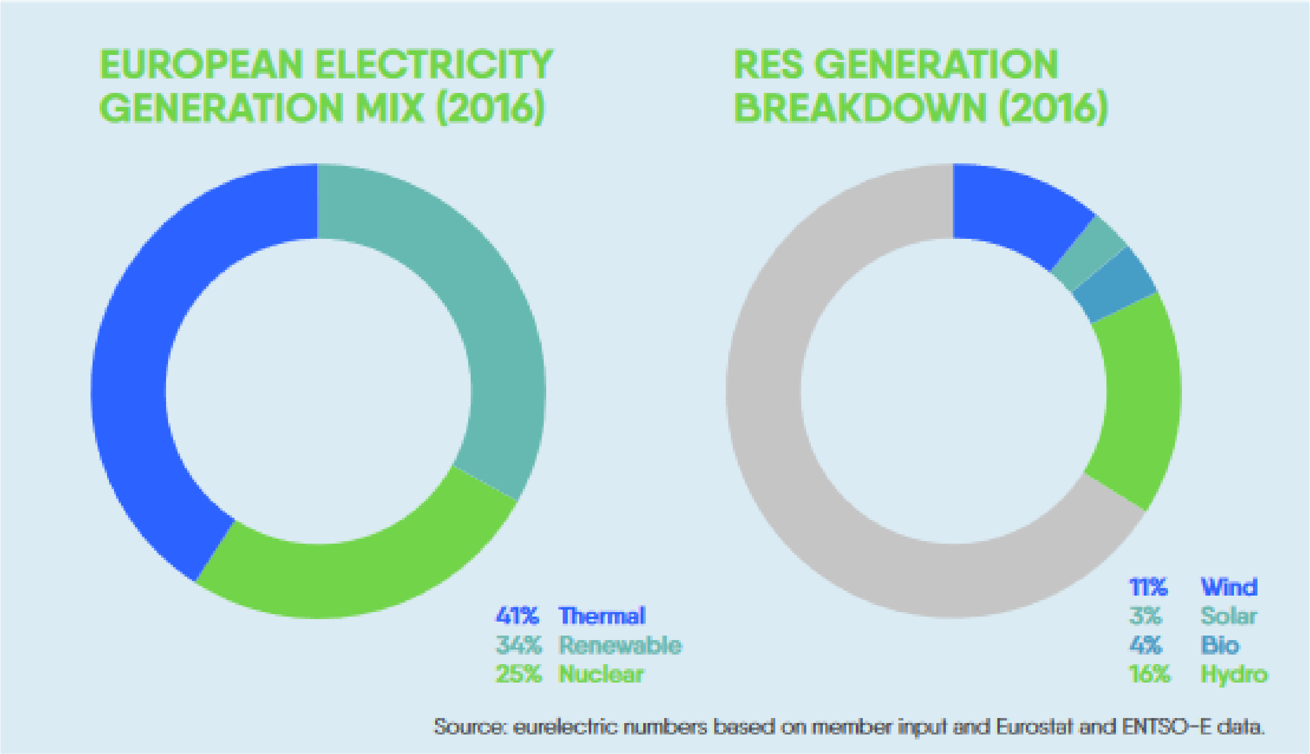
Others

- Renewables production: free but non mainly non-manageable
- Consumer flexibility: limited and partly manageable

Focus on wind and solar production

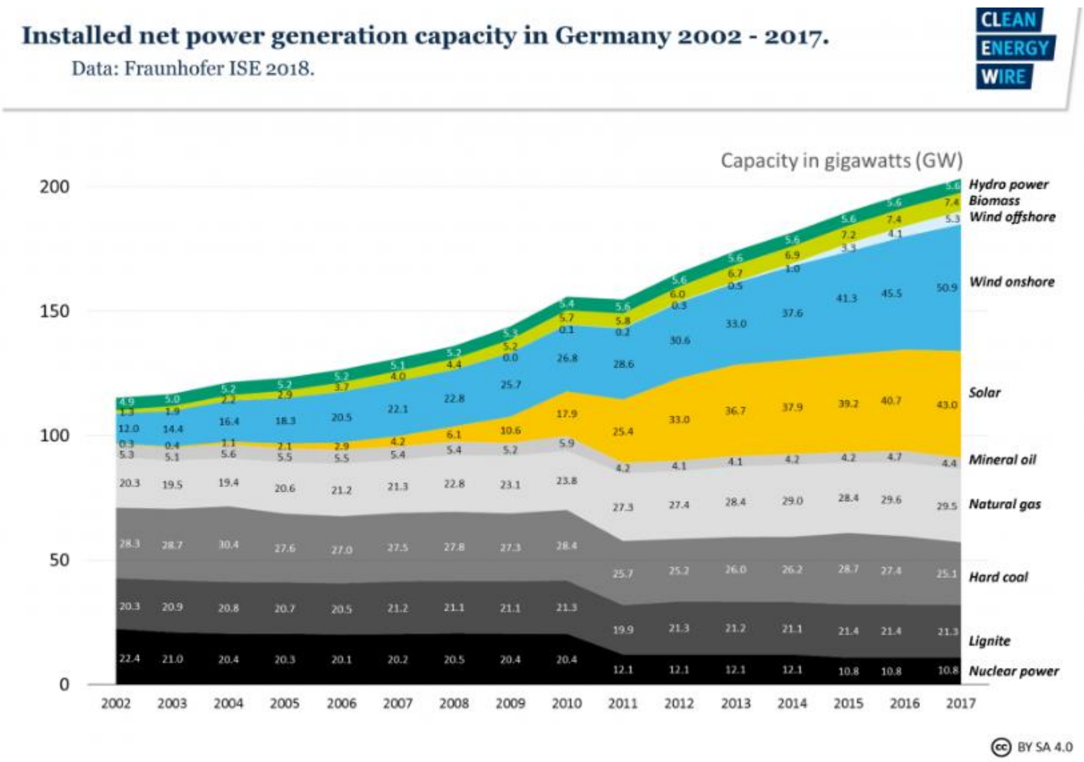
- Difficult to forecast
- … and then difficult to manage…
- Production is fatal: it must be used
- Need to have flexible production and / or storages

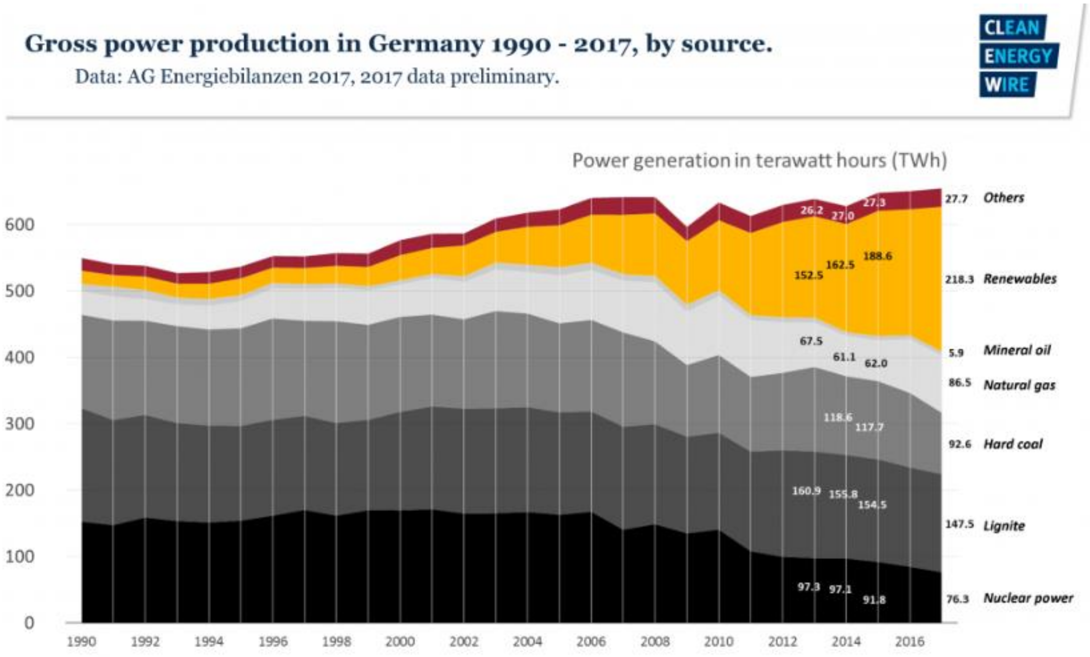
Example of production in Europe



Source: eurelectric

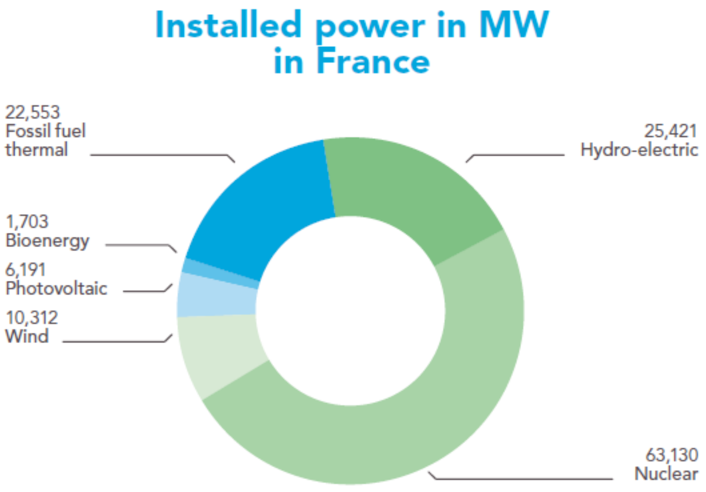
Examples of production in Germany

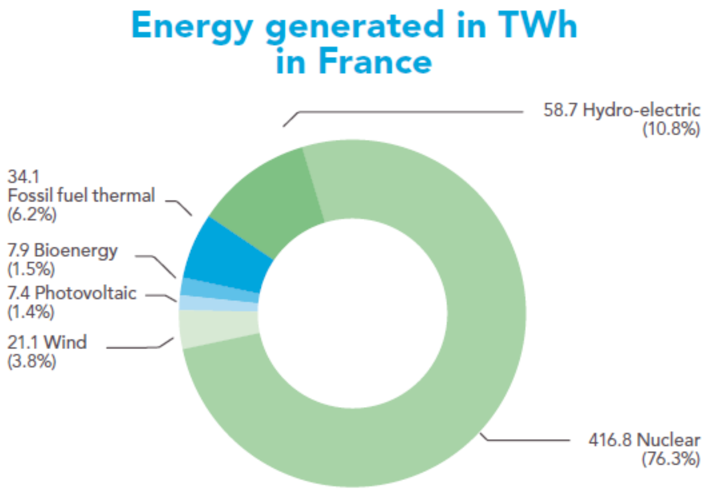




Source: Clean Energy Wire

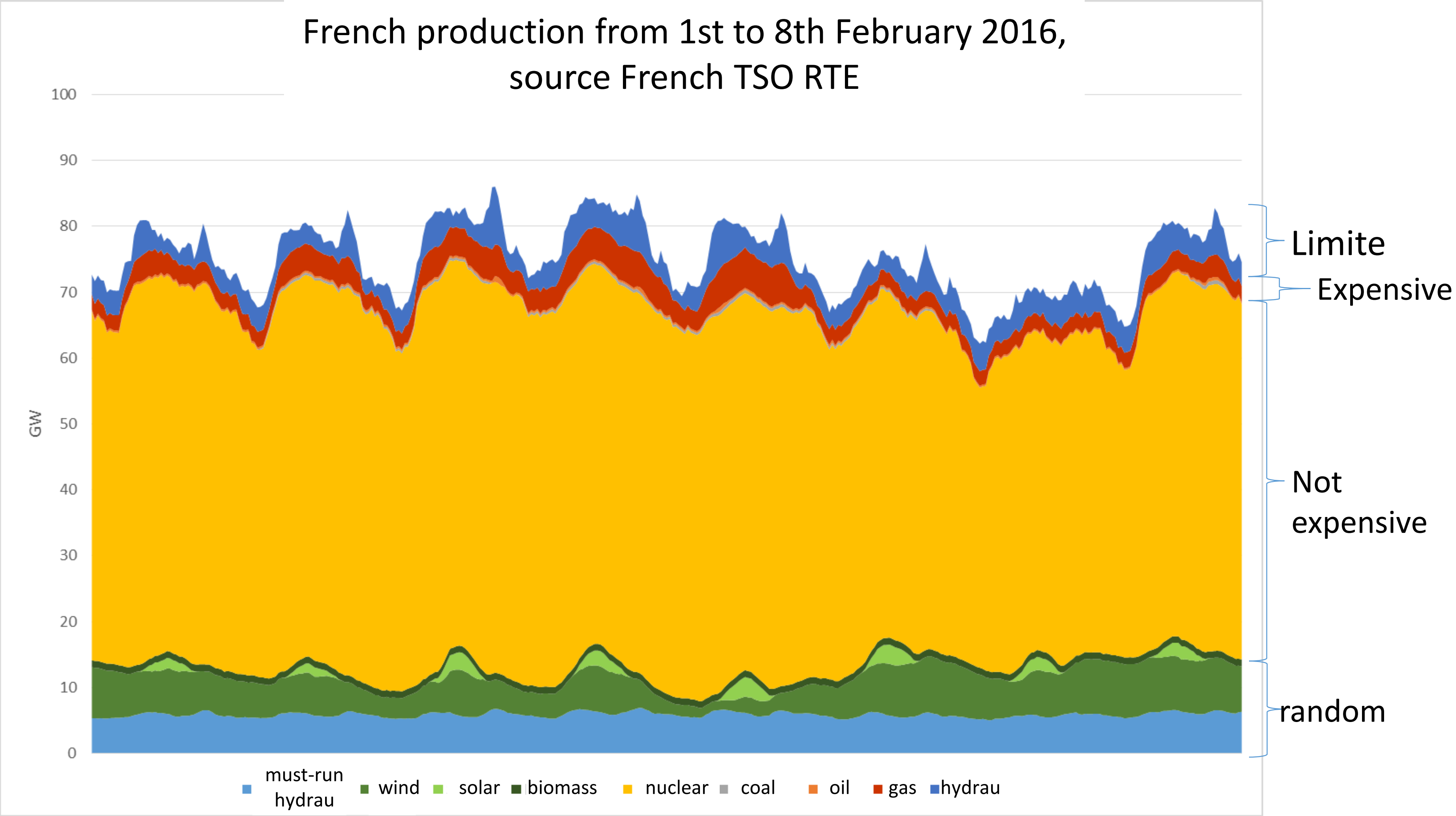
Examples of production in France





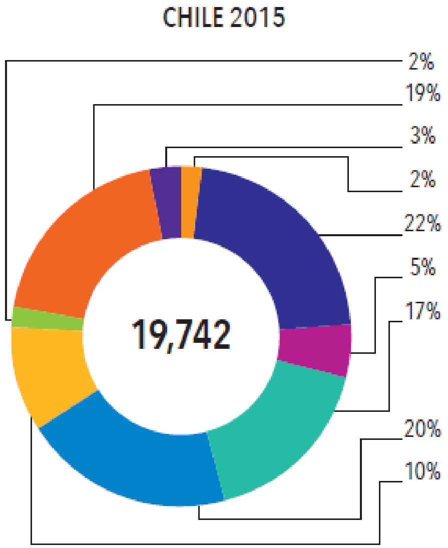
Source: French TSO RTE, figures 2016

Example of stack production over a week in france

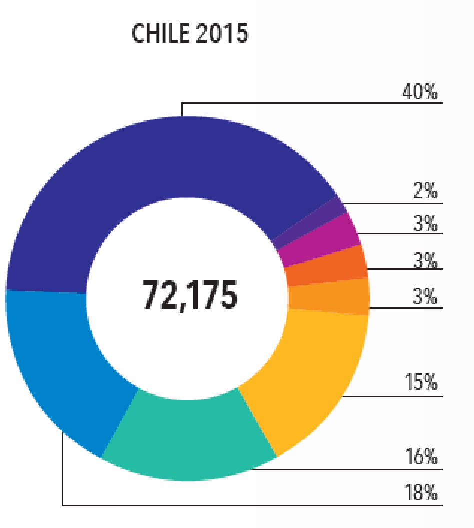


Example of production in Chile

Installed Power Generation capacity

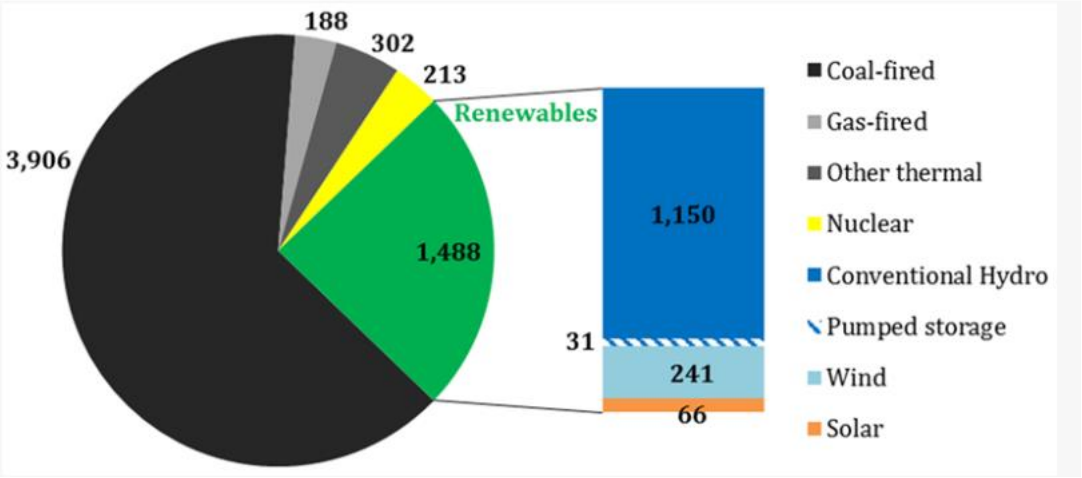


Power Generation

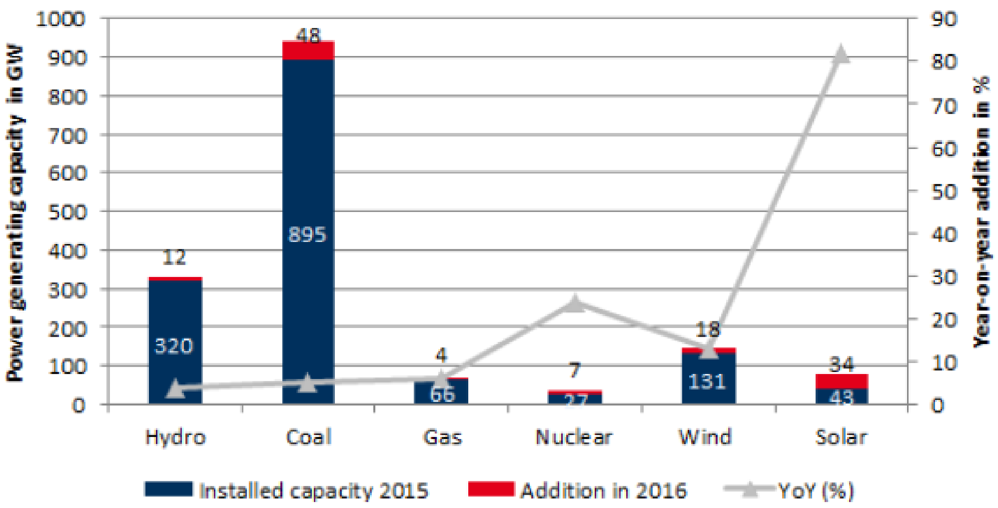


Source: www.cne.cl

Example of production in China



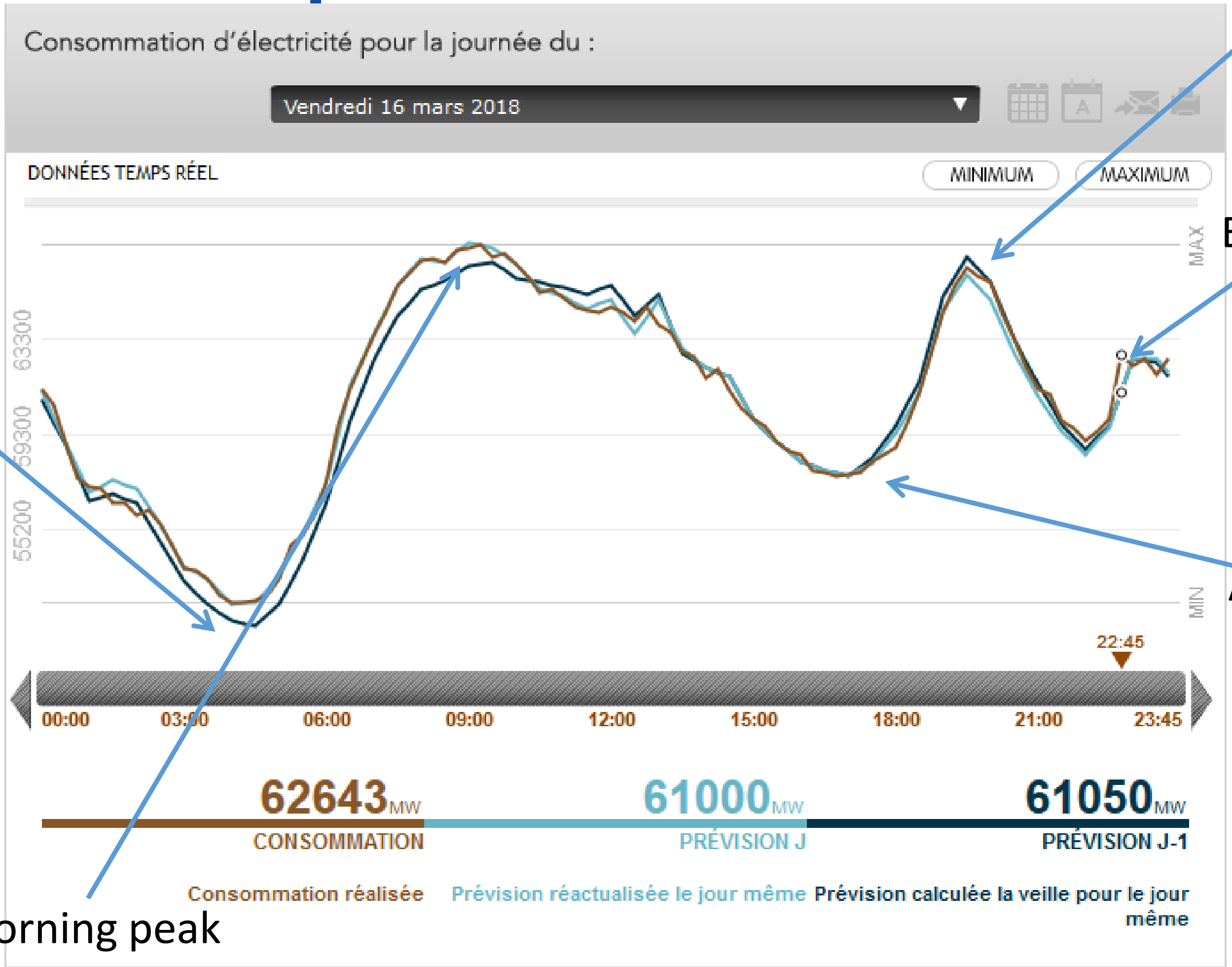
China’s electricity mix in 2016 in TWh



Power generating capacity in GW (left axis) and the year-on-year growth in percent (right axis)

Source: https://blog.energybrainpool.com/en/power-statistics-china-2016-huge-growth-of-renewables-amidst-thermal-based-generation/

Example of consumption in France



Evening peak

Electrical water heating peak

Night offpeak

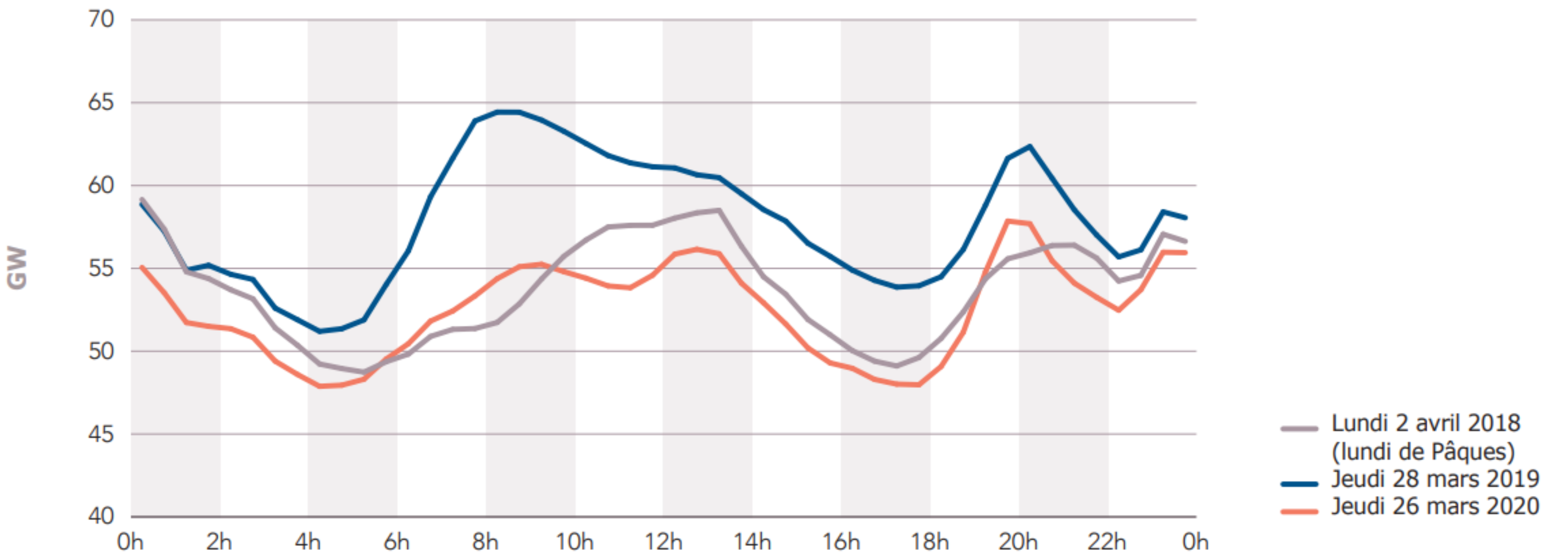
Afternoon offpeak

Morning peak

Source: French TSO RTE

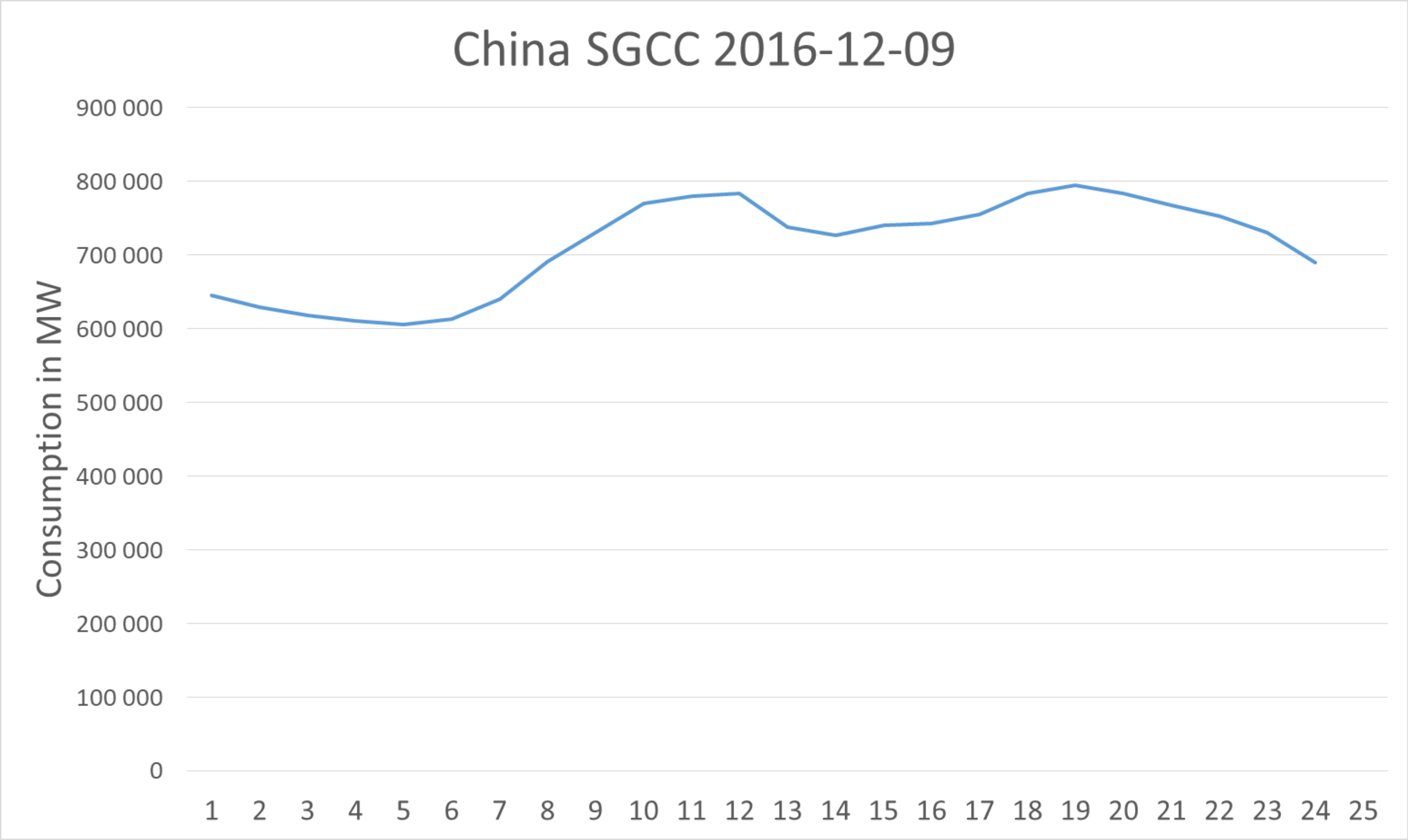
Consumption profile during COVID in France

Figure 6. Comparaison du profil de puissance du jeudi 26 mars 2020 avec des journées comparables sur les années précédentes



Source: French TSO RTE

Example of consumption in China



Notion of marginal cost

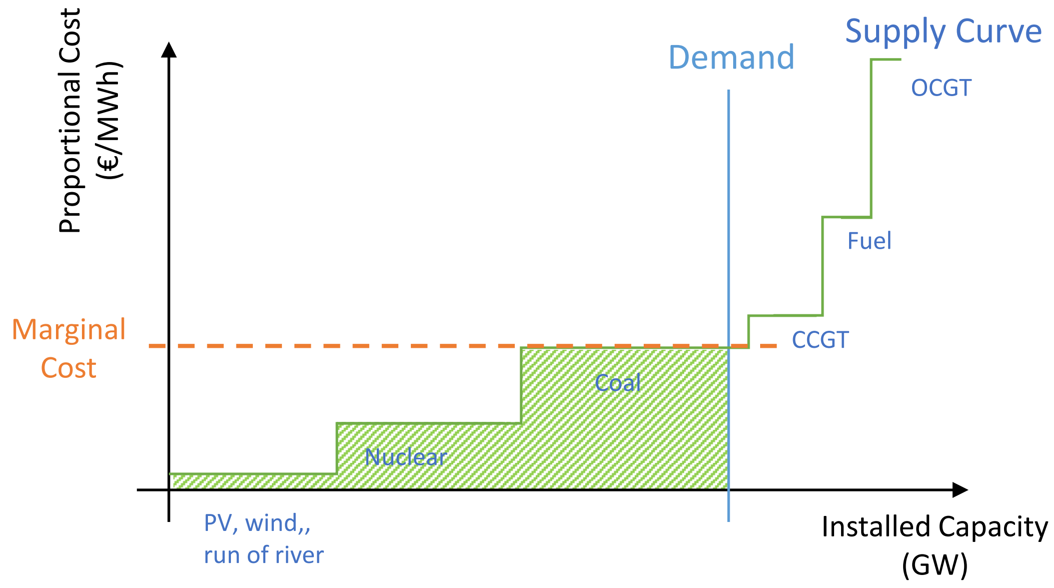
Definitions for a simple vision of production fleet

- Proportion cost of the most expensive running production unity
- Cost to produce one additional MW over one hour

But what about starting costs, dynamic constraints, the fact that the load is never exactly satisfied, etc. ?

If the market runs well, marginal costs of the different participants are equal.

The marginal cost is an indicator of the market tension.



Balance between supply and demand

Simplified example of production dispatch

Fleet	Pmin MW	Pmax MW	Cost €/MWh
Nuclear	600	1300	6
Coal1	500	1000	35
Coal2	200	500	40
Oil	100	400	80

Marginal Cost ?

	0h – 4h	4h – 8h	8h – 12h	12h – 16h	16h – 20h	20h – 24h
Demand MW	1800	2300	3200	2700	3200	2100
Nuc1						
Coal1	35 €	35 €				35 €
Coal2				40 €		
Oil			80 €		80 €	

In practice, the optimisation has contraints

Example of dynamic constraints of thermal plants:

- Ramping up and down constraints and maximum rate of output variation
- Minimum on-time
- Minimum off-time
- Maximum number of ramping per day
- Maximum number of start-ups per day

Some of these constraints are real technical constraints whereas others correspond to implementation of policies in order to limit the aging of plants.

→ **These constraints create coupling between time-steps!**

Production cost of thermal plants

Production cost of thermal plant =

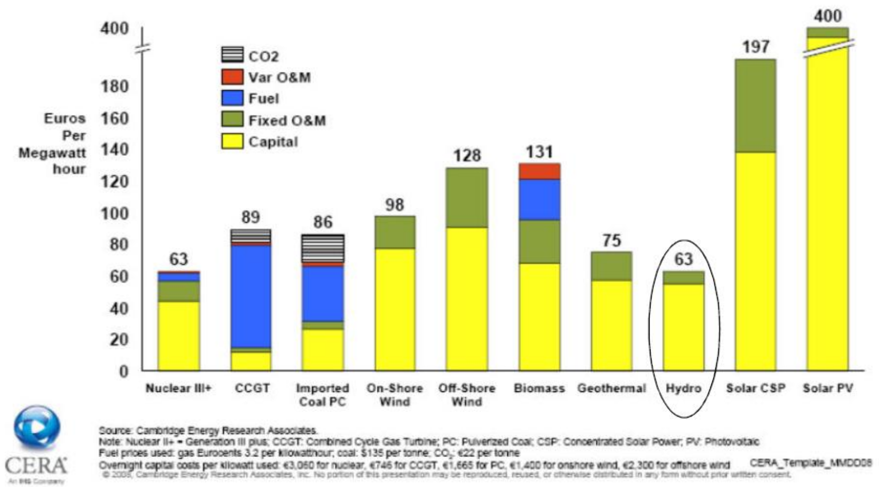
Start-up cost + fixed cost + proportion cost x P

This cost is added at each startup. It depends on the duration of the previous off-time

This cost is independent of the generated power as soon as it is not null.

This cost is proportional to the generated power.

This cost only depends on the production and does not include amortization, maintenance, labor costs…



Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		
Investment		
Salary		
Maintenance		
CO2 emission		
Decommissionning		

Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		x
Investment		
Salary		
Maintenance		
CO2 emission		
Decommissionning		

Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		x
Investment	x	
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Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		x
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Salary	x	
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Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		x
Investment	x	
Salary	x	
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Decommissionning		

Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		x
Investment	x	
Salary	x	
Maintenance	x	
CO2 emission		x
Decommissionning		

Distinction between fixed and variable production costs

	Fixed costs	Variable costs
Fuel		x
Investment	x	
Salary	x	
Maintenance	x	
CO2 emission		x
Decommissionning	x	

Practical exercise: determined variable and fixed costs

€/MWh	Fuel	Investment	Salary	Fixed maintenance	Variable maintenance	CO2 emission	Decommissionning	Fixed costs	Variables costs	Total costs
Nuclear 7000h/year	10	20	2	4	2	0	2			
Coal 7000h/year	46	16	1	3	2	22	1			
CCGT 7000h/year	49	12								
OCGT 200h/year	130	380								

Cautions: this is an exercice and calculated costs are not relevant anymore !!

Fuel costs: Month-Ahead pro ... gu
CO2 emission cost: forward ...ice for D ... r 2008 ... in Août 08 A... ust 2008
Other figures: Ministère de l'industrie D ... IP 2003

Practical exercise: determined variable and fixed costs

€/MWh	Fuel	Investment	Salary	Fixed maintenance	Variable maintenance	CO2 emission	Decommissionning	Fixed costs	Variables costs	Total costs
Nuclear 7000h/year	10	20	2	4	2	0	2			
Coal 7000h/year	46	16	1	3	2	22	1			
CCGT 7000h/year	49	12	1	2	1	10	1			
OCGT 200h/year	130	380	10	5	5	15	5			

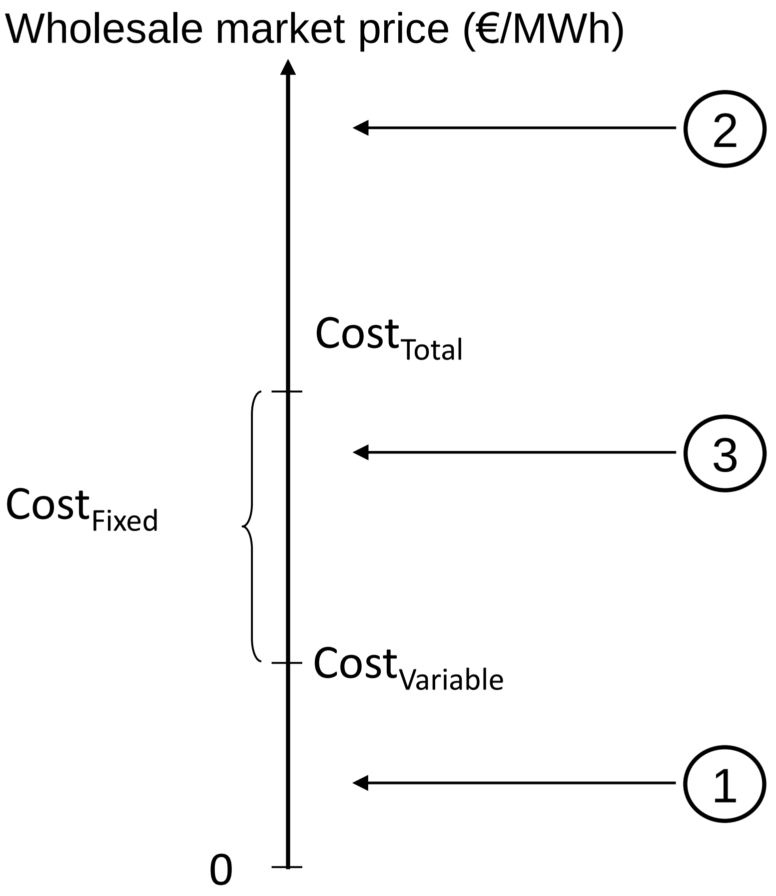
Fuel costs: Month-Ahead product quoted in August 2008
CO2 emission cost: forward price for December 2008 quoted in Août 08 August 2008
Other figures: Ministère de l’industrie DGEMP 2003

Practical exercise: determined variable and fixed costs

€/MWh	Fuel	Investment	Salary	Fixed maintenance	Variable maintenance	CO2 emission	Decommissionning	Fixed costs	Variables costs	Total costs
Nuclear 7000h/year	10	20	2	4	2	0	2	**12**	**28**	**40**
Coal 7000h/year	46	16	1	3	2	22	1	**70**	**21**	**91**
CCGT 7000h/year	49	12	1	2	1	10	1	**60**	**16**	**76**
OCGT 200h/year	130	380	10	5	5	15	5	**150**	**400**	**550**

Fuel costs: Month-Ahead product quoted in August 2008
CO2 emission cost: forward price for December 2008 quoted in Août 08 August 2008
Other figures: Ministère de l'industrie DGEMP 2003

Training: costs of a powerplant and the market



Do we propose the production to the market? yes

If the production is activated by the market, total costs (variables and fixed) are covered
→ Long-term profitability is guarantied

Do we propose the production to the market? yes

If the production is activated by the market, variables and part of fixed costs are covered
→ Short-term profitability is guarantied

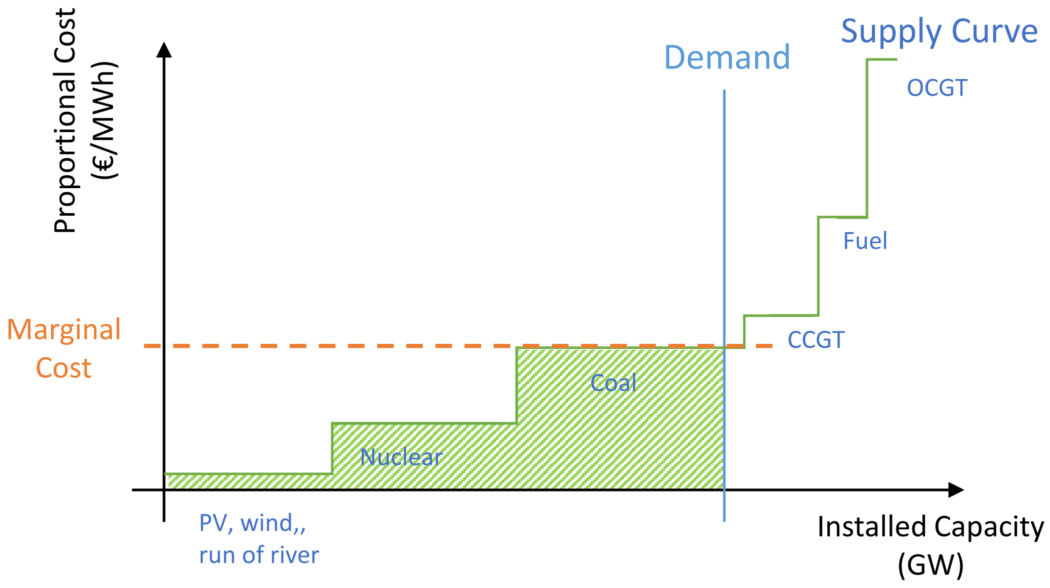
Do we propose the production to the market? no

If the production is activated by the market, variables costs are partly covered but no fixed costs
→ It is uneconomical to produce

How does the marginal cost evolve with wind and solar production ?

- Production with cost equal to 0
- Translate the offer curve to the right
- Then diminishes the price
- Can even induce negative prices

Question : what about the most expensive production unities ?



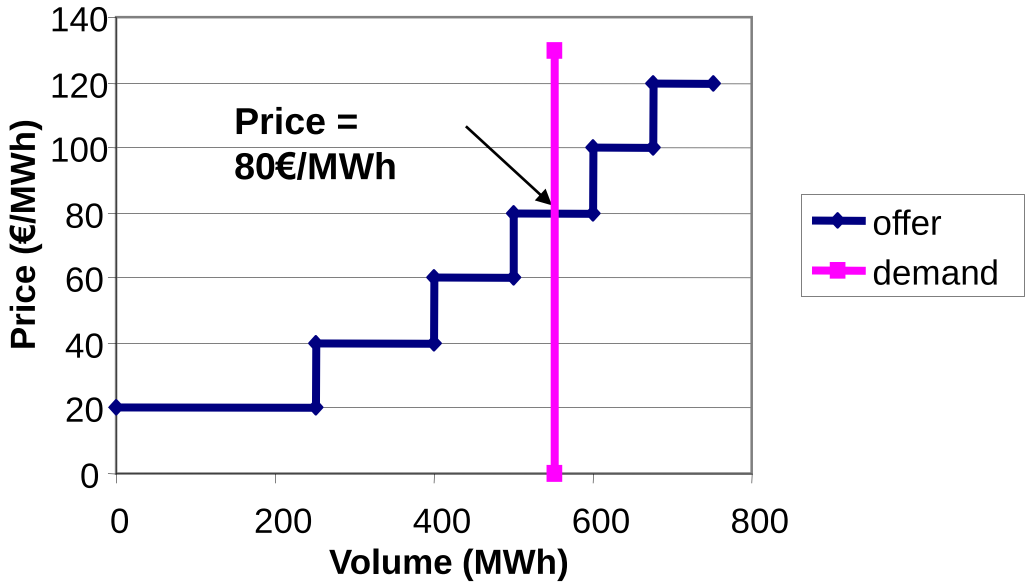
Balance between supply and demand

Training:
Market equilibrium

offer	Q (MWh)	P (€/MWh)
A	250	20
B	150	40
C	100	60
D	100	80
E	100	100
F	75	120

demand: 550 MW

Classic fixing rule on power market: all accepted transaction are priced at the price of the last accepted transaction.

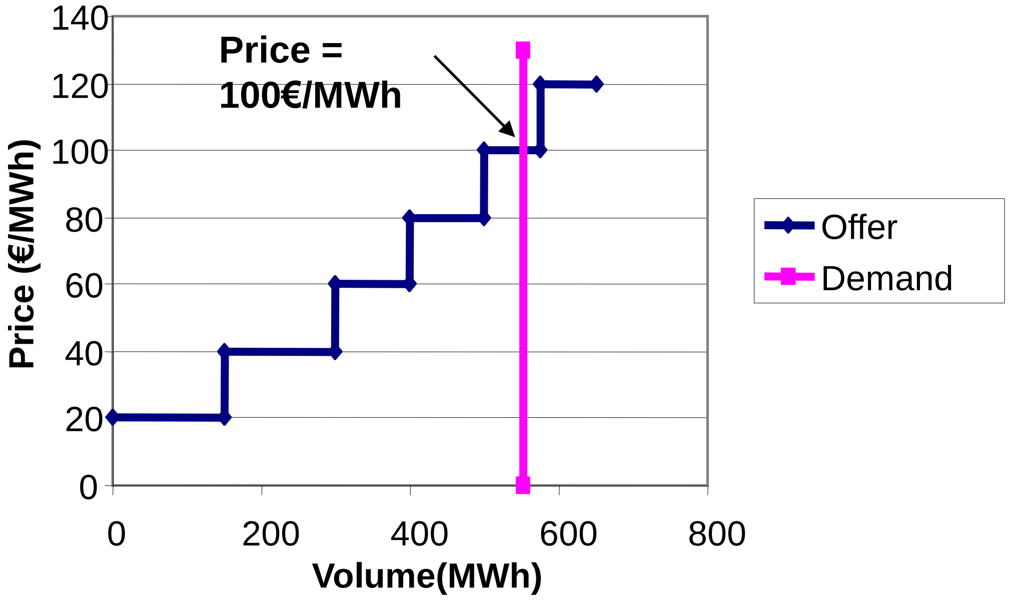


Training:
Market equilibrium

Impact of unavailability of one offer

Offer	Q (MWh)	P (€/MWh)
A	150	20
B	150	40
C	100	60
D	100	80
E	100	100
F	75	120

demand: 550 MW

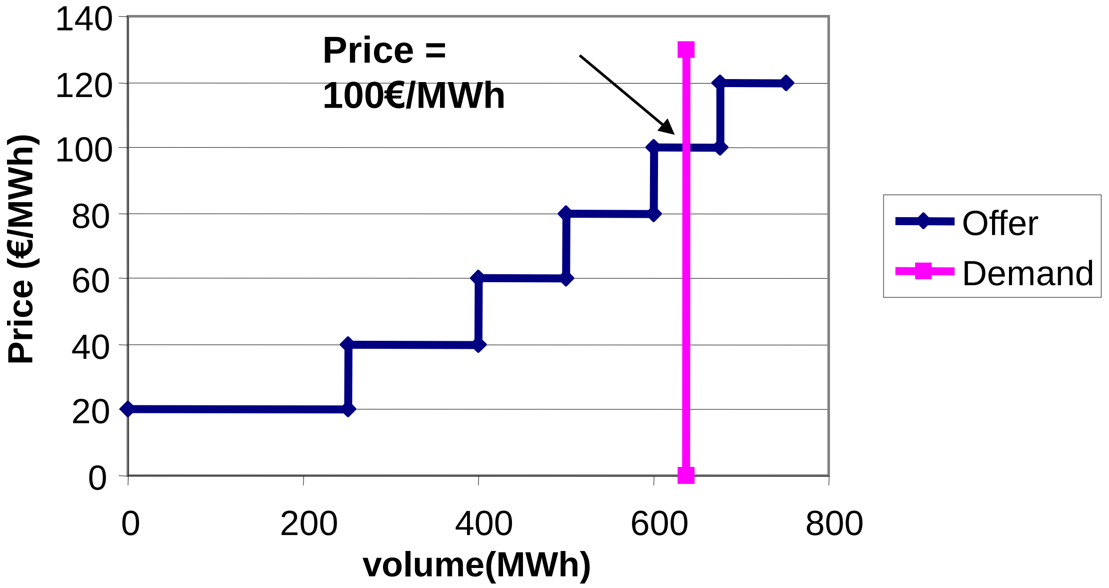


Training:
Market equilibrium

Impact of increase of load

Offer	Q (MWh)	P (€/MWh)
A	250	20
B	150	40
C	100	60
D	100	80
E	100	100
F	75	120

Demand: 650 MW



Terms of the training

Each team represents a utility in competition. Each utility is in charge of a **production** and **consumption** portfolio. Utilities are short or long (short = local load demand > local production, long = local load demand < local production)

An **exchange** (like Powernext) enables to make **bid and sell offers**.

Terms of the game:

All the local demand must be satisfied, either by using local production either by buying on the exchange.

All the demand which is not satisfied locally is automatically bought on the exchange.

Each plant which is not used locally is automatically proposed on the exchange at its variable cost.

Terms of the training

We will play several rounds:

- First round = peak hour (typical day of autumn in France)
- Second round = off-peak hour
- Third round = extra peak hour (corresponding to very cold winter day in France)

Objective: **maximizing your profit both on the supply of the local demand and on the selling of your production on the exchange.**

One round consists in gathering volumes used locally and sold to the market for each utility.

At the end of the round, we observe the market equilibrium (i.e. the price) and we will look if profits have been maximized for each team.

Terms of the training

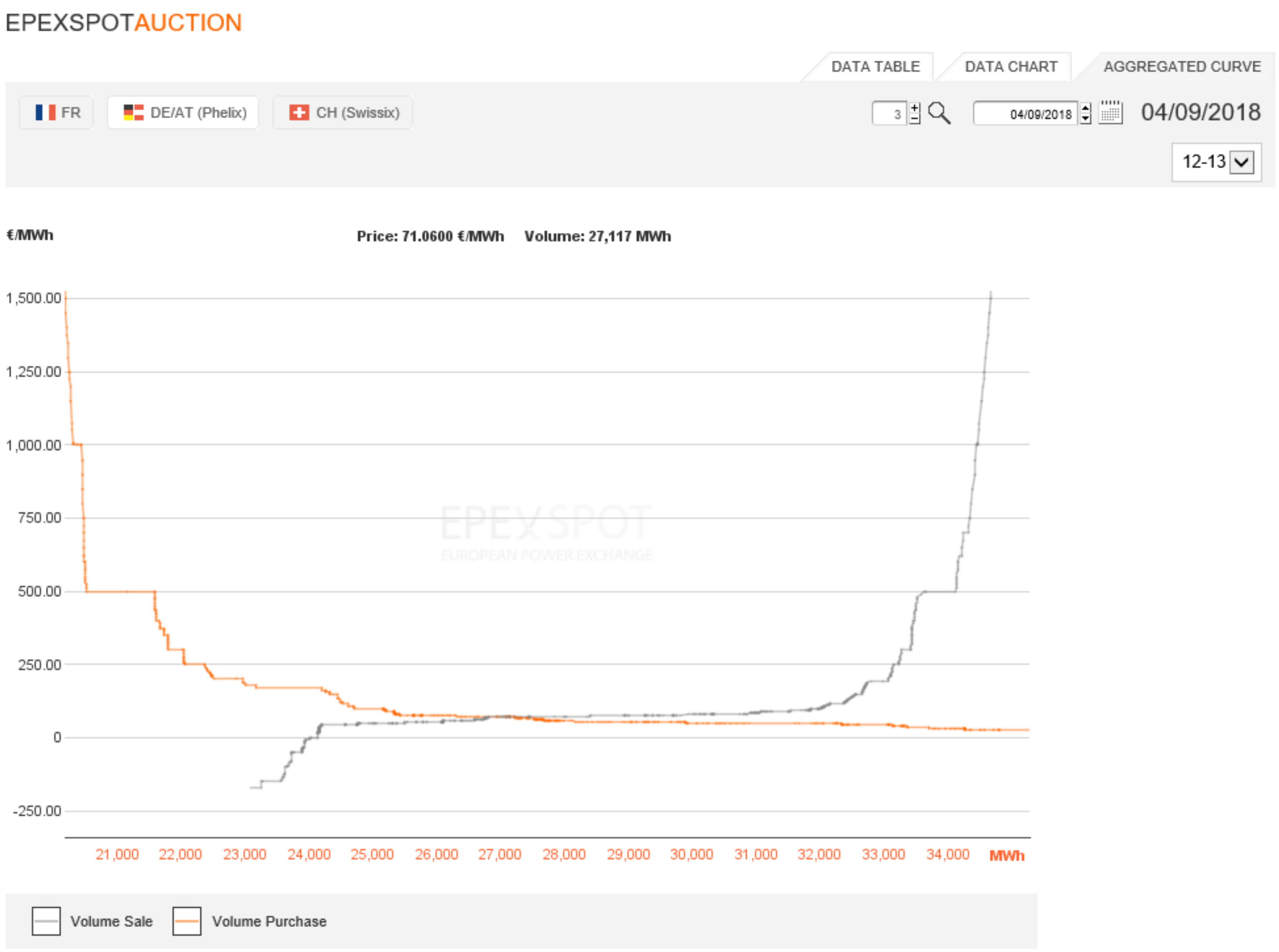
Concretely, for each power plant (capacity **Q**):

- Chose the volume you want to use for your local demand = **V**
- Propose the remaining capacity at the exchange: **Q-V**, the sum of the two volumes must be equal to the maximum power of the power plant.

Try for yourself!

A real example of merit order

Source: epex spot



Training: debrief in mathematical formulation

Power plant: capacity Q in MW, variable costs VC in \$/MWh

Market price: p_{market} in \$/MWh

Local demand: D in MW

V chosen volume of local production to cover local demand

Volume proposed to the market **Q-V** in MW at the variable costs VC in \$/MWh

Objective function: $\max_{V} \underbrace{(Q - V).(p_{market} - VC)^{+}}_{\text{Revenue on the market (=0 if } p_{market} < VC)} - \underbrace{(D - V)\, p_{market}}_{\text{Cost for buying local demand not satisfied locally}} - \underbrace{V \,.\, VC}_{\text{Cost for producing locally}}$

Training: debrief in mathematical formulation

Power plant: capacity Q in MW, variable costs VC in $/MWh

Market price: p_{market} in $/MWh

Local demand: D in MW

V chosen volume of local production to cover local demand

Volume proposed to the market **Q-V** in MW at the variable costs VC in $/MWh

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→ Solution of this problem is V = 0!

Training: debrief

If I decide to use my production to cover local demand:

→ I may loose profits if the market could provide me the volume at a lower cost (meaning that there exists on the market a power plant which is available at a lower cost)

If I offer all my production to the exchange (at its variable cost):

→ The exchange will notify your offer only if the price is higher than my variable cost, the variable costs are automatically covered.

→ If my offer is not notified (the equilibrium price is inferior to my variable cost), my local consumption will be covered by another power plant.

In the training, the safer strategy is therefore to propose all power plants to the market.

Training : limits

In the training, the safer strategy is therefore to propose all power plants to the market.

In practice, other parameters need to be consider such as

- Transaction costs: with price forecast, utilities can offer only close-to marginal power plants.
- Volume risk: available volume on the exchange might be limited, volume of production and load are uncertain
- Forward agreements might have be contracted

Impact of startup cost

Startup cost : coal = 30 k€ oil = 17 k€

Fleet	Pmin MW	Pmax MW	Cost €/MWh
Nuclear	600	1300	6
Coal1	500	1000	35
Coal2	200	500	40
Oil	100	400	80

Startup costs: 30 + 2*17 = 64 k€

By replacing 100 MW of coal by oil:

- Additional costs of 100*4* (80-40) = 16k€
- But saving of 17 k€ from startup costs

	0h – 4h	4h – 8h	8h – 12h	12h – 16h	16h – 20h	20h – 24h
Demand MW	**1800**	**2300**	**3200**	**2700**	**3200**	**2100**
Nuc1	1300	1300	1300	1300	1300	1300
Coal1	500	1000	1000	1000	1000	800
Coal2			500	300	500	
Oil			400	100	400	

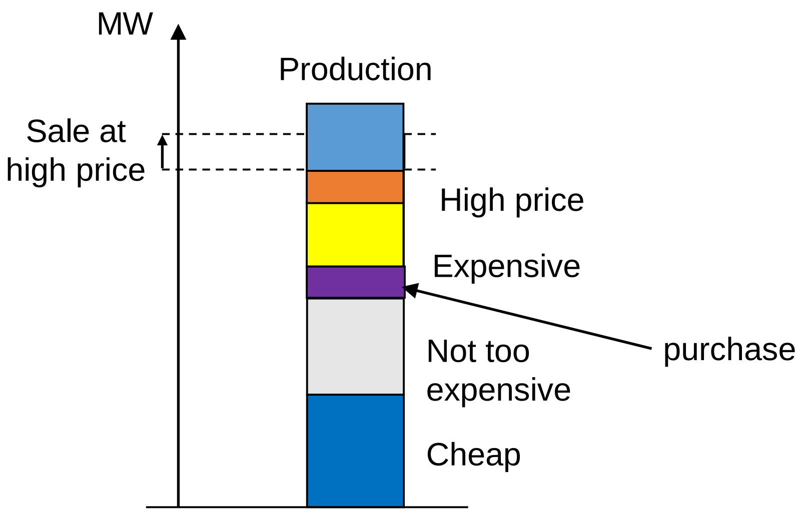
To add constraints disoptimizes the dispatch

And the market in the story?

With a market, purchases and sales need to be integrated.

- A utility buys to the market if the volume bought can be substituted at a lower cost to a volume of its own production.

- A utility sells to the market if the volume sold covers the production cost of the most expensive plants in operation.



Electricity markets

Forward markets

- Sell/purchase of energy blocks for future horizons (up to several years)
- Product periods ➔ week, month, quarter, year
- Base or off-peak
- Organized markets or OTC = Over The Counter

Day-ahead markets (spot)

- Sell/purchase of energy blocks for the day of the day after
- Mainly hourly energy blocks
- Organized markets or OTC = Over The Counter

Intraday

- Sell/purchase of energy blocks for coming hours
- Hourly or quater energy blocks
- Organized markets or OTC = Over The Counter

Presence of the market in our example

Fleet	Pmin MW	Pmax MW	Cost €/MWh
Nuclear	600	1300	6
Coal1	500	1000	35
Coal2	200	500	40
Oil	100	400	80

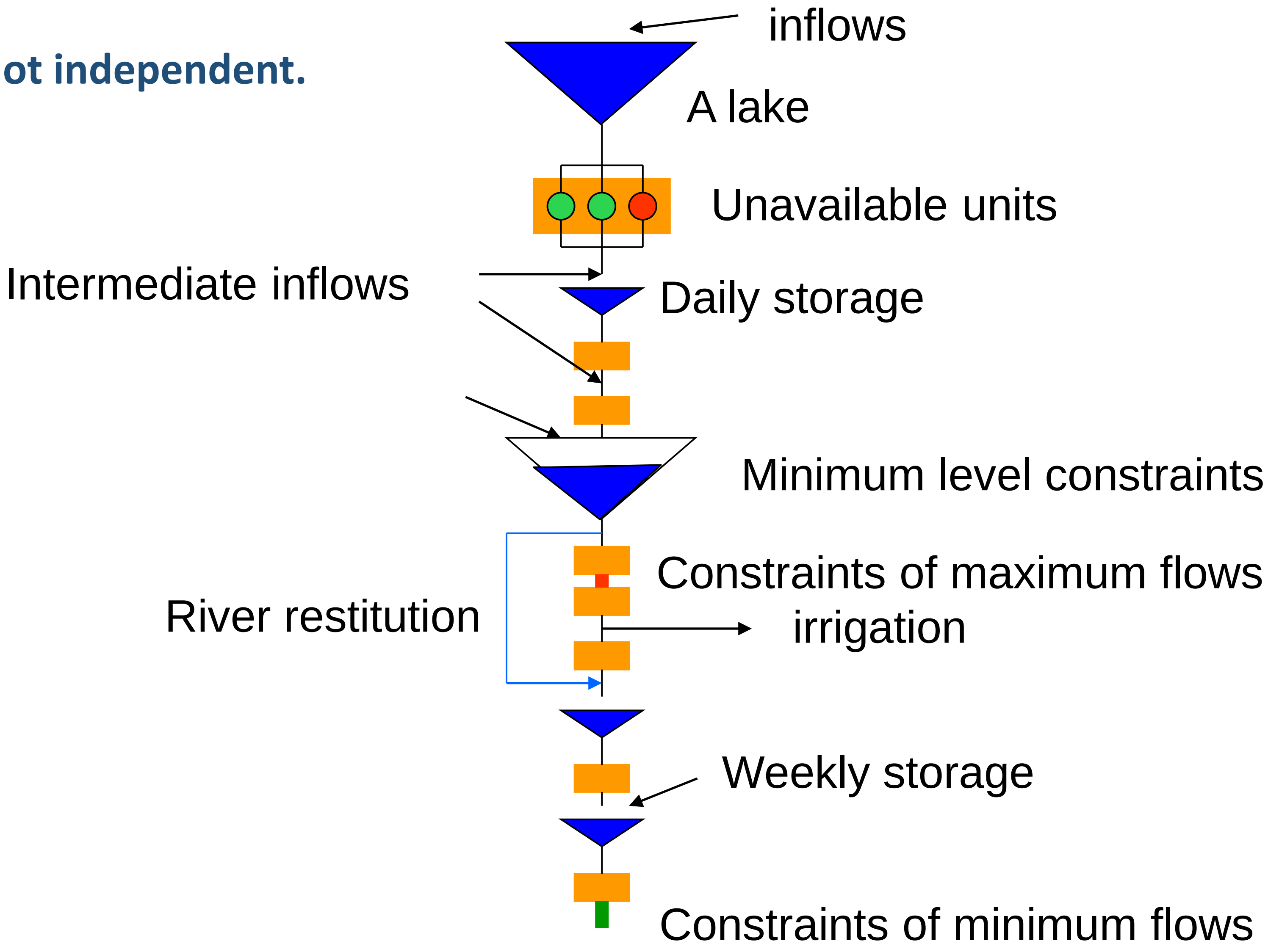
To simplify calculation, we suppress the startup costs.

	0h – 4h	4h – 8h	8h – 12h	12h – 16h	16h – 20h	20h – 24h
Demand (MW)	**1800**	**2300**	**3200**	**2700**	**3200**	**2100**
Spot price (€ / MWh)	37	39	79	75	85	37
Sale depth (MW)	-200	-300	-200	-250	-700	-400
Purchase depth (MW)	2000	500	300	400	200	300
Nuclear	1300	1300	1300	1300	1300	1300
Coal1	700	1000	1000	1000	1000	1000
Coal2			500	500	500	
Oil			100		400	
Purchases (+) / Sells (-)	-200	0	300	-100	0	-200

Hydraulic production

Lots of constraints!

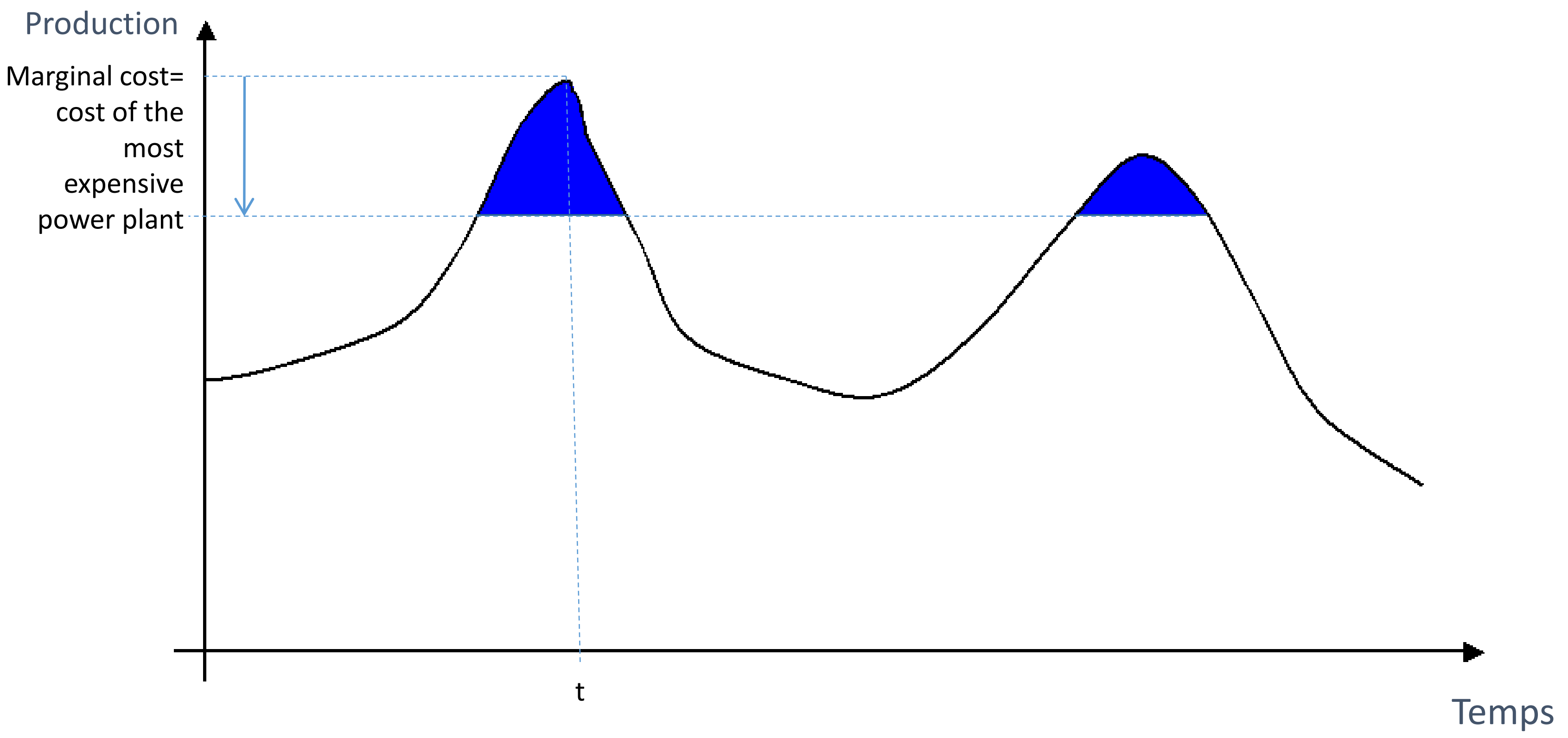
Power plant are not independent.



Hydraulic production management

Water costs nothing but is limited in quantity → stored water is used in replacement of most expensive production plants…

Often very flexible → enables to release some dynamic constraints on the production fleet.



Presence of an water storage in our example

Fleet	Pmin MW	Pmax MW	Cost €/MWh
Nuclear	600	1300	6
Coal1	500	1000	35
Coal2	200	500	40
Oil	100	400	80

Hydraulic power plant : Pmax = 200 MW

Reserve = 1600 MWh (100 MW x 4 time step) to be used within the day

	0h – 4h	4h – 8h	8h – 12h	12h – 16h	16h – 20h	20h – 24h
Demand (MW)	**1800**	**2300**	**3200**	**2700**	**3200**	**2100**
Spot price (€ /MWh)	37	39	79	75	85	37
Sale depth (MW)	-200	-300	-200	-250	-700	-400
Purchase depth (MW)	2000	500	300	400	200	300
Nuclear	1300	1300	1300	1300	1300	1300
Coal1	700	1000	1000	1000	1000	1000
Coal2			500	500	500	
Oil			0		200	
Water storage			200		200	
Purchases (+) / Sells (-)	-200		200	-100		-200

And with a pumping station?

Fleet	Pmin MW	Pmax MW	Cost €/MWh
Nuclear	600	1300	6
Coal1	500	1000	35
Coal2	200	500	40
Oil	100	400	80

Hydraulic power plant : Pmax = 200 MW

Reserve = 1600 MWh (100 MW x 4 time step) to be used within the day, pumping station: Pmax = -200 MW Rendement : 1/2

	0h – 4h	4h – 8h	8h – 12h	12h – 16h	16h – 20h	20h – 24h
Demand (MW)	**1800**	**2300**	**3200**	**2700**	**3200**	**2100**
Spot price (€ /MWh)	37	39	79	75	85	37
Sale depth (MW)	-200	-300	-200	-250	-700	-400
Purchase depth (MW)	2000	500	300	400	200	300
Nuclear	1300	1300	1300	1300	1300	1300
Coal1	900	1000	1000	1000	1000	1000
Coal2			500	500	500	
Oil			0		200	
Water storage	-200		200	100	200	
Purchases (+) / Sells (-)	-200		200	-200		-200

We pump 200 at 37€/MWh

But we can sale 100 à 75€/MWh

Management of hydraulic asset at mid-term

Three Gorges Dam

Fuel = water is free of cost but in limited quantity

→ necessity to optimize when it is used.

Cost and Value are different!

At any time, need to optimize between:

1 - To use the storage immediately

- save another fuel
- benefit from water storage flexibility
- diminish the level of storage

2 – To delay the use of water

- used another fuel potentially more expensive of less flexible
- keep the level of storage unchanged

Optimization tools are designed to estimate the value of the dam:

→ evaluation of the expectation of the earnings with and without the dam

Expected value = average gain in probability with a vision of uncertainties at mid-term horizon

Management of hydraulic asset at mid-term

In France: 45 dams in 50 valleys

In practice, the expected values depends on the time of the year: more expensive when the water is scarce or when the load level is high and less expensive when the water is abundant and/or the load level is low.

Typically, before winter, expected value of water are high

water must be kept for cold winter days → high expected value

Before the snowmelt, expected value of water are low

water must be realized to be able to store the new inputs without discharging→ low expected value

Dam of Roselend

Some remarks on wind and solar production

Let us remind that wind and solar production are fatal.

- Not optimized, it can be for instance removed for the demand (residual demand)

Green certificates :

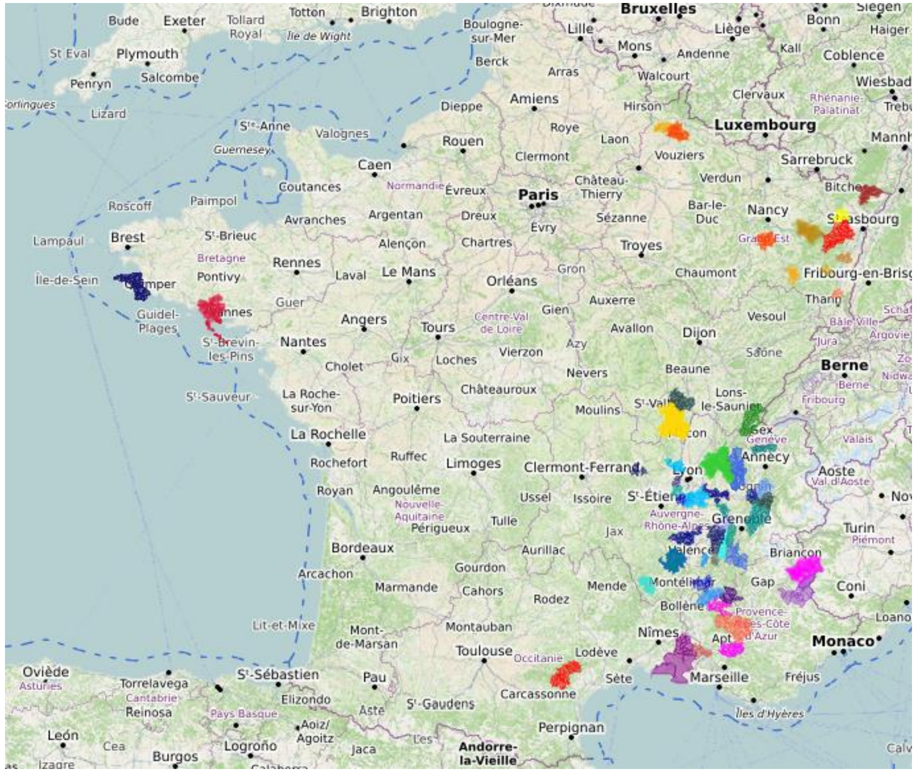
- Attest that electricity was produced from a renewable source (hydro, wind, solar, biomass)
- Electricity supplier needs to prove that for 1kWh consumed by its client, 1kWh of renewable energy is injected into the electricity grid
- Difficult to set up a specifig grid for renewable production
- Green certificates can be bought to other producers in Europe
- Allow to increase renewable producer’s incomes

What about self-consumption?

Use of renewable plants

Local supply demand equilbrium and optimization can be done

Connected to the grid : can increase incomes of a local community



https://www.centralesvillageoises.fr

Portfolio management fundamentals by time horizon and utilities decisions

1- Production portfolio management

2 - Production management with uncertainties

Uncertainties

In the first section, we consider everything as being deterministic.

But real life is **stochastic**: different uncertainties impact the forecasted vision of the system equilibrium.

Uncertainties coming from the **exchange market**

- Prices and volumes

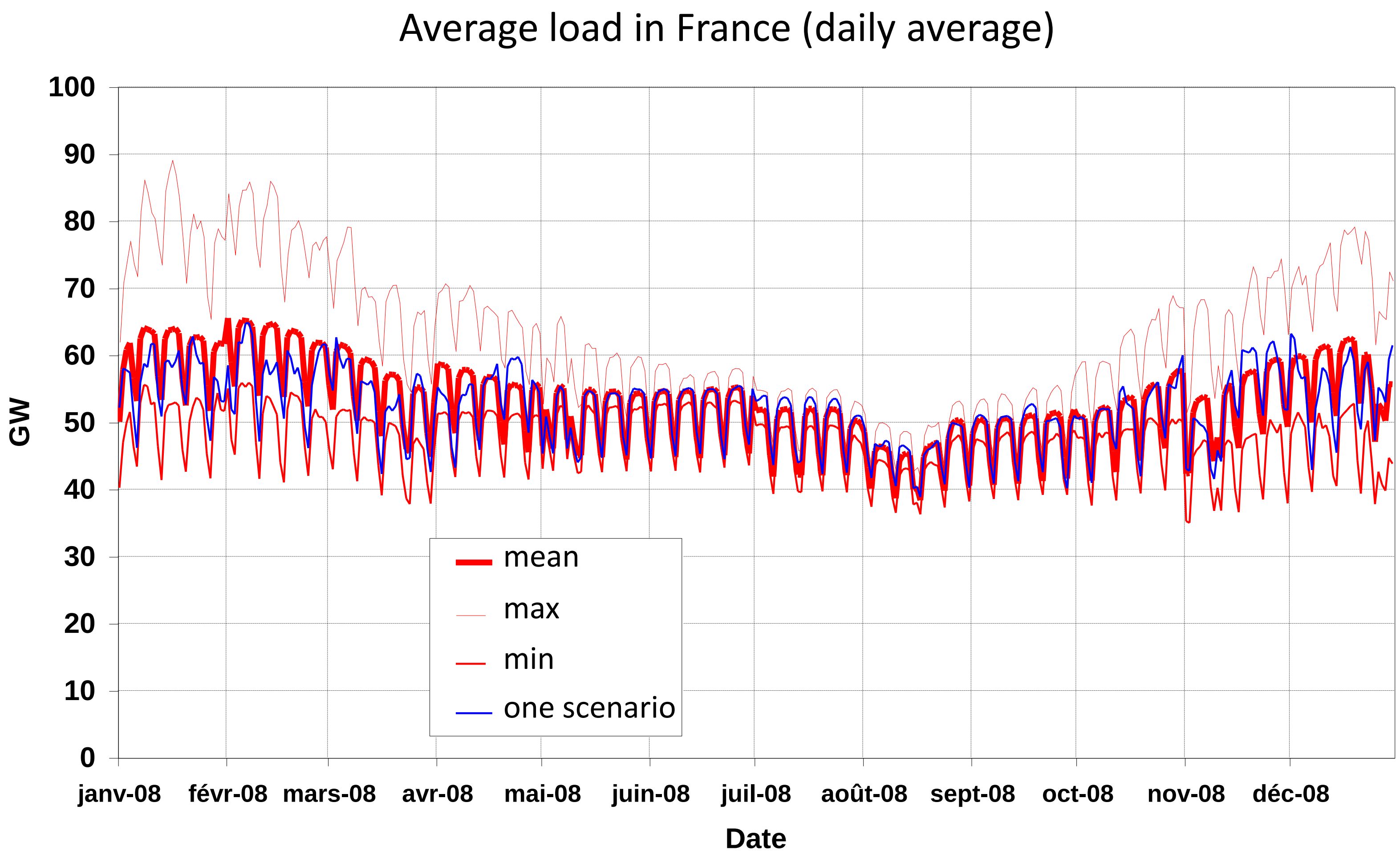
Uncertainties coming from the **load consumption**

- Forecasted error

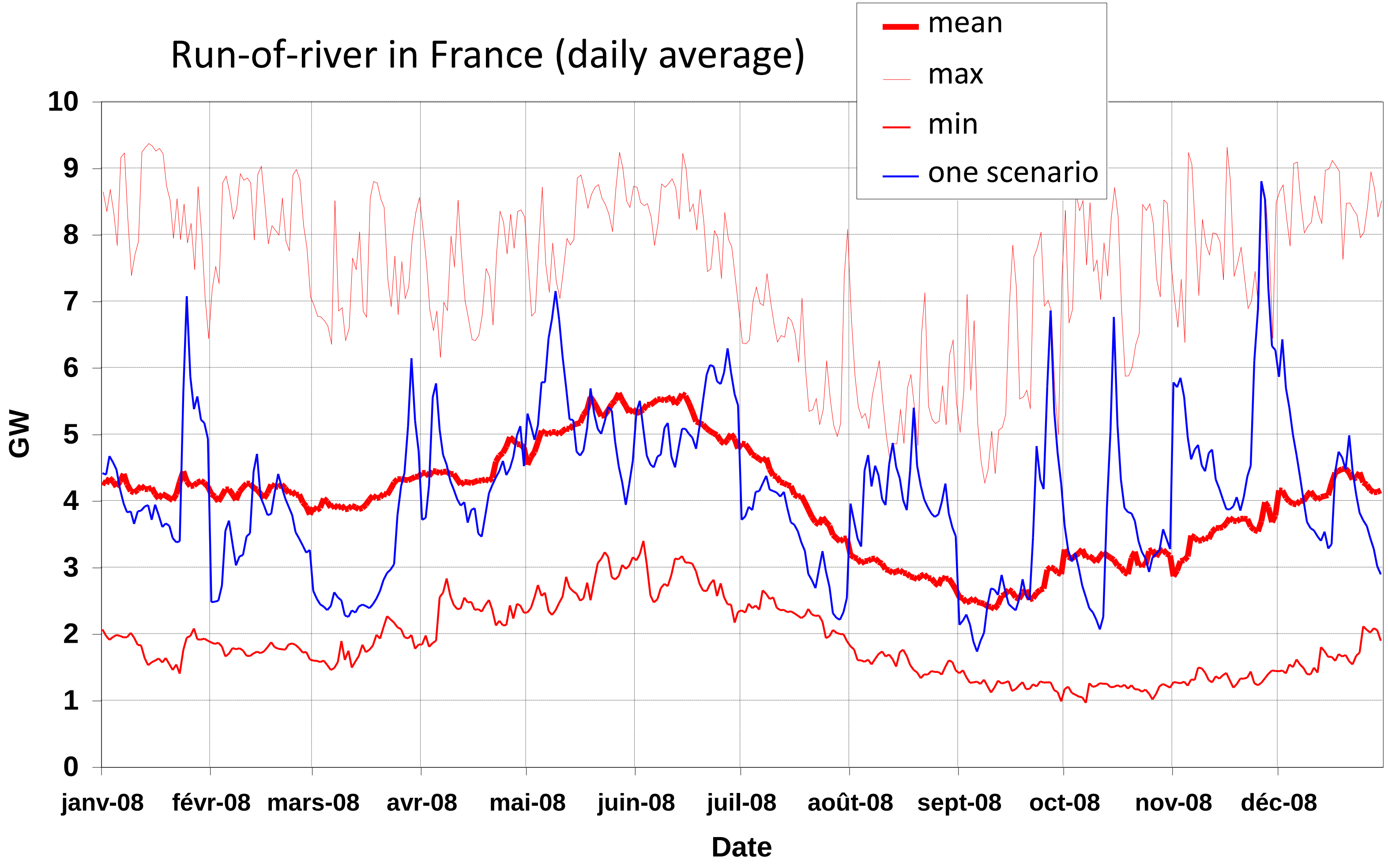
Uncertainties coming from the **production**

- Forecasted error for renewables (wind, photovoltaic, run-of-river production…)
- Forecasted error hydraulic inputs which can change the expected planning of dam dispatch
- Shutdowns which can lead to partial or total unavailability of the asset
- Delayed coupling

Example of uncertainty on the load



Example of uncertainty on the run-of-river



Real Time Management

When imbalance between power injected and withdraw from the network (which happens nearly all the time!)

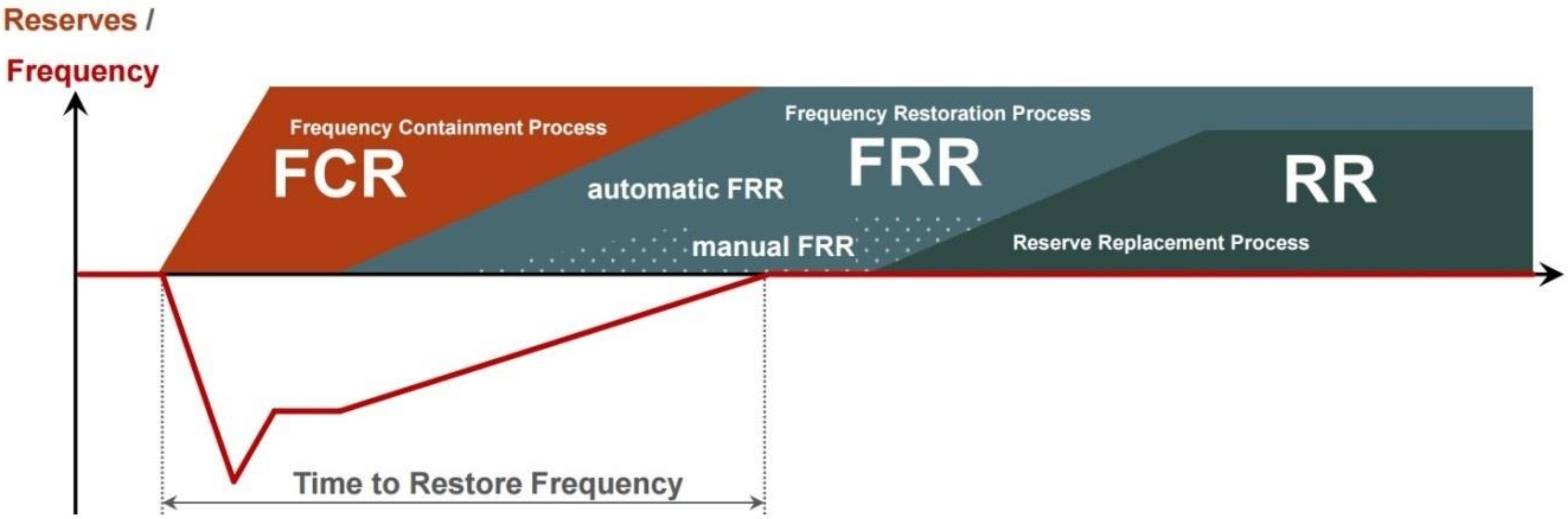
- The difference of energy is compensated by the *kinetic energy* of the synchronous rotating generating

- Frequency is modified from its guidelines
  → increases when injections>withdrawals
  → decreases when injections<withdrawals

- If nothing is done
  → variation of the frequency increases
  → domino effect which can lead to isolation of a large number of consumers or even to the failure of the entire grid

- Equilibrium recovery: automatic systems and reserve contracts

Reserves



Some reserves are compulsory, for other auctions/markets

→ the utility needs to organize its dispatch to fulfill its commitments

→ The utility needs to price its offers on reserve market

Thermal plant: FCR and FRR

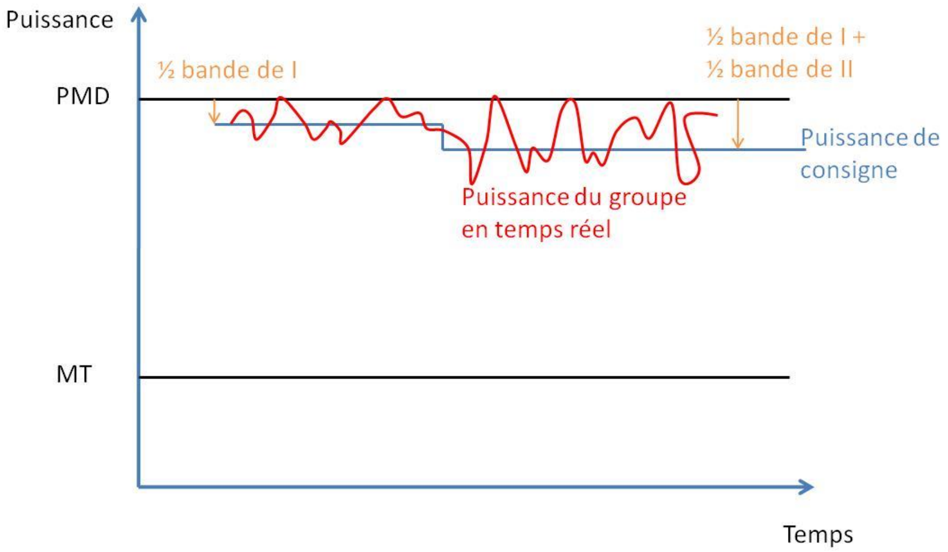
The effective power of a thermal power plant is between its technical minimum and its maximum power.

For FCR and FRR,

→ when the power plant runs at its maximum, its power generation needs to be diminished

→ when the power plant runs at its technical minimum, its power generation needs to be increased

Most expensive service systems corresponds to least expensive power-plants



Reserves in our example

In case the demand is already satisfied

Fleet	Pmin MW	Pmax MW	Cost €/MWh
Nuclear	600	1300	6
Coal1	500	1000	35
Coal2	200	500	40
Oil	100	400	80

A unique level of reserve,

Respect of the reserve disoptimizes the optimal stack

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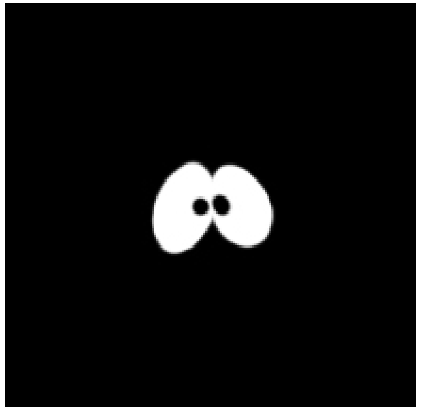
Purchase depth (MW)	2000	500	300	400	200	300
Nuclear	1300	1300	1300	1300	1300	1300
Coal1	700	1000	1000	1000	1000	1000
Coal2		200	500	300	500	200
Oil			100		200	
Purchases (+) / Sells (-)	-200	-200	300	100	200	-400

Physical risk

Evaluation of the probability of uncertainty realization → sizing required margin of the system to keep the risk level at an acceptable level at future date T

- The further away, the larger the uncertainties
- But the more possibilities to be activated to face the risk



Physical risk is not the responsibility of utilities, but some utilities still monitor it and take some actions to contain it.

- Some utilities are predominant on some geographical perimeter
- The reputation risk might be severely degraded in case of physical issue on the rid.

Purchase of security contracts

The capacity of production fleet might be not able to face the load at the equilibrium perimeter or the required margin might be too low.

Potential failures can be anticipated or very high level of load.

Some security forward contracts can be made to hedge against this risk.

Financial risk

A balance responsible is not responsible for the physical risk, only for the **financial risk**.

Many uncertainties influence the revenues:

- Uncertainties on volumes (production/load)
- Uncertainties on prices (electricity and commodities)
- → Results in uncertainties on EBITDA (Earnings before interest, taxes, depreciation, and amortization)

Risk evaluation: **risk indicators** which measures financial results in the worst case, e.g.

- EaR (Earning at Risk) = difference between average and 5% percentile of EBITDA
- EEaR (Extreme Earning at Risk) = difference between average and average of 5% worst case of EBITDA

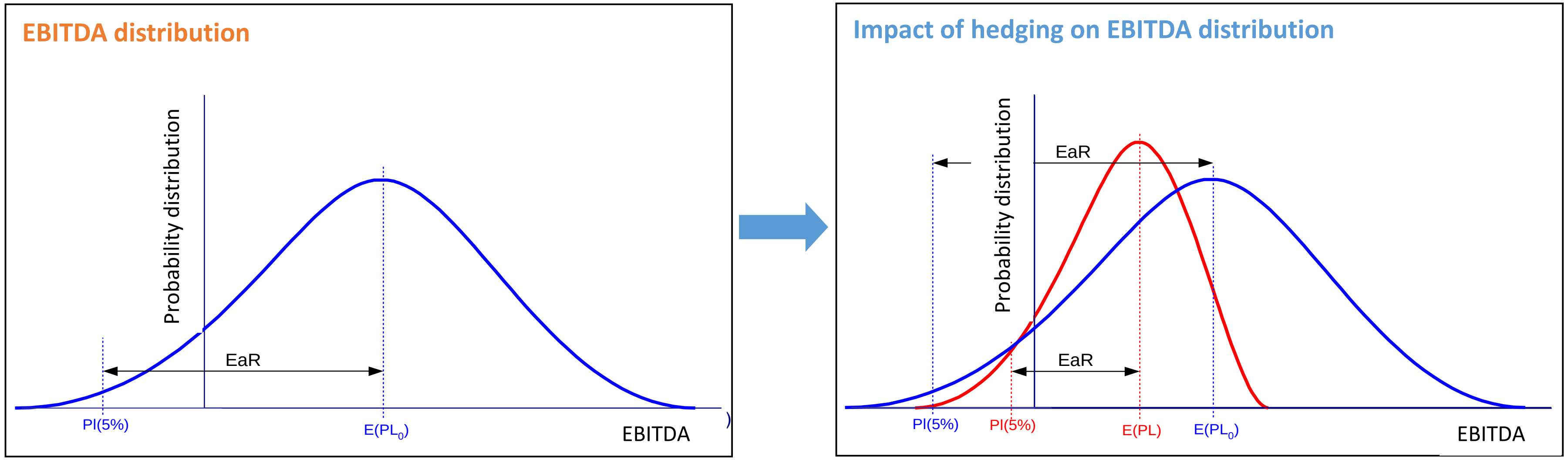
Risk management → actions to keep these indicators under some threshold thanks to **hedging** on the market

Hedging principle

Hedging = price risk reduction at the expense of a diminution of the average results (transaction costs, market premium…)

Forward markets enables to hedge price risk. In addition, prices are less volatile at mid-term

Financial options are also available



Portfolio design

Utilities can decide to mitigate its risks by hedging on the markets BUT also by modifying the structure of its portfolio:

- Vertical integration

  - short/long positions matching

  - choice of certain type of customers with opposite risks

- Risk transfer through structured contracts with customers

  - fixed tariff

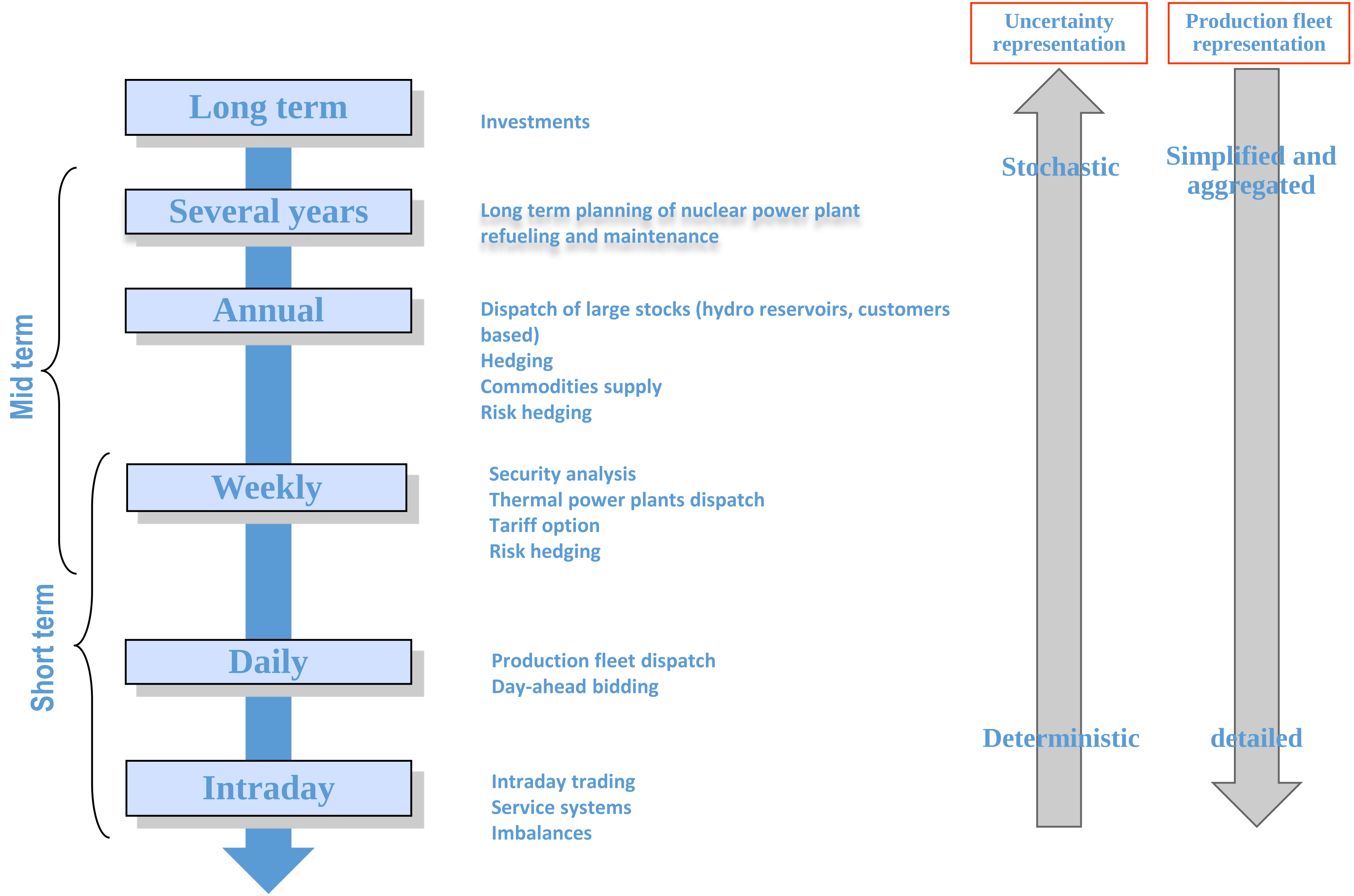
  - demand side management

  - electricity demand reductions

- Change the structure of its physical assets portfolio

  - investments, mothballing, dismantling…

Production management: decisions and actions



To perform all these operations, many quantities need to be forecasted

Prices

Load

Production and renewables