Financial settlement of long-term contracts.

Review of the key parameters

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At the heart of medium and long-term contracts, the financial settlement mechanism is a risk allocation tool

The idea that Energy Only Market need to be completed with a LT module is now widespread in Europe.

EC consultation raises the question of the form of the contracts : PPAs, CfDs, standard products…

The debate focuses on the type of the counterparty : public or private ? Which one to favor ? How to make them coexist.

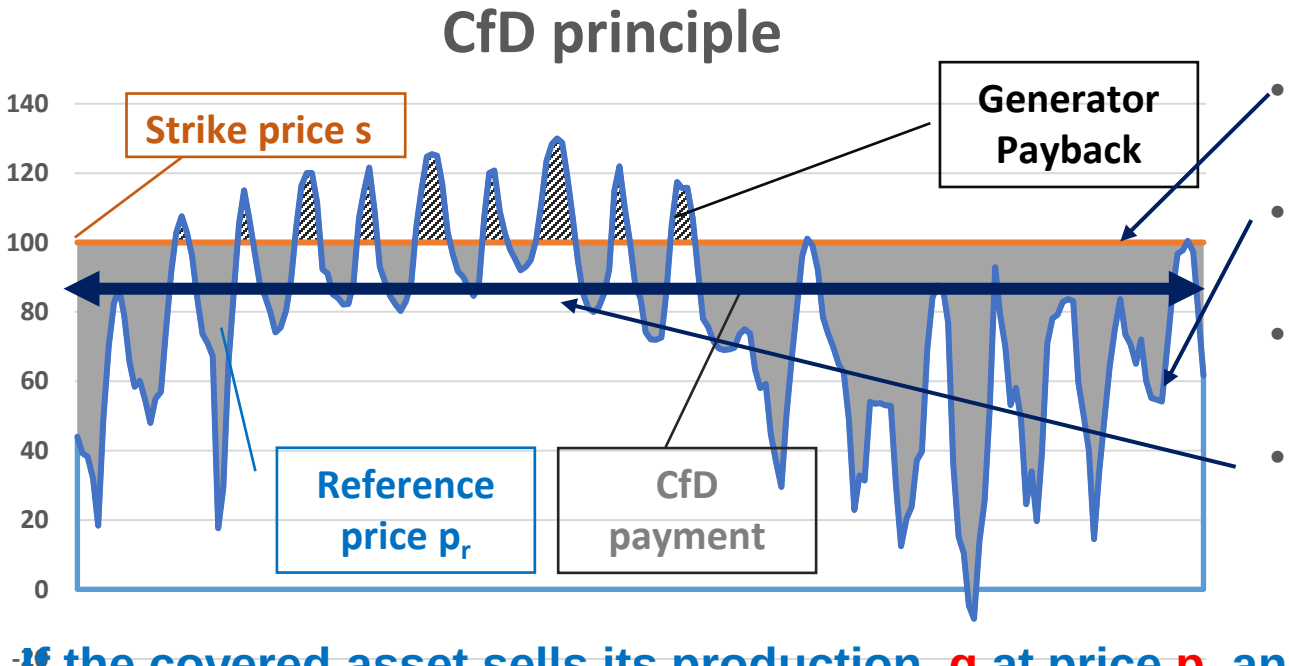
In this work, we will explore the heart of all these contracts : the financial settlement mechanism that is very often a contract for difference as well in PPAs as in CfDs and even in standard futures contracts.

Some authors (Newbery 2023, Fabra 2022, Schlecht Maurer and Hirth 2023) have made concrete proposals on the form these contracts should take. Some of them are even recommended for nuclear power plants. I wanted to empirically assess the consequences of one choice or another on incentives and risk sharing.

The 4 parameters of a contract for difference

A contract for difference is a financial mechanism that generates pay-offs whose variations hedge the variations of the market incomes of the covered asset.

When the asset is a power plant, the general form of the contract contains 4 parameters:



- **The strike price s** which defines the level of profitability sought
- The **reference price p_r** which represents the price at which the production is expected to be valued
- The **reference quantity q_r** which represent the basis on which payment are calculated
- The **contract duration T**

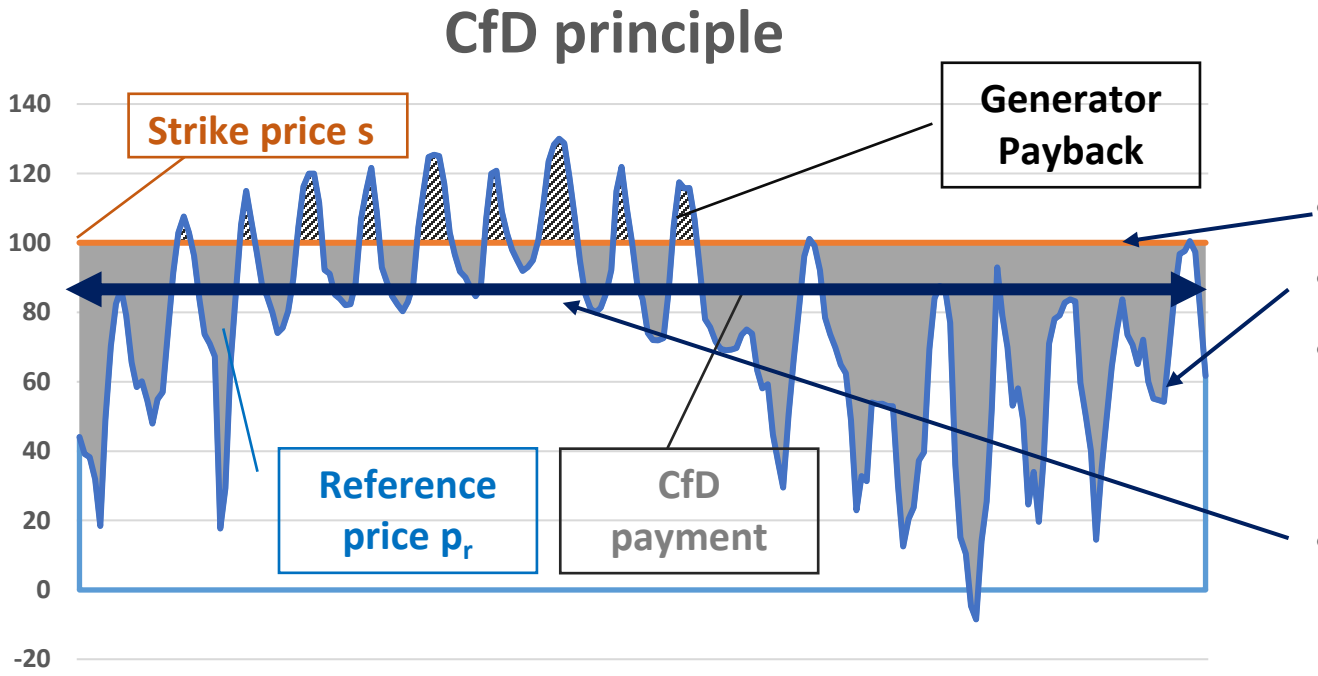
If the covered asset sells its production q at price p, and if c represents its variable costs (or opportunity costs), the generated cash flow is :

$$CF = CF_{market\ sales} + CF_{CFD} = (p-c).q + (s-p_r).q_r$$

Parameters s, p_r, q_r et T can be fixed or variables, according to different formulas opening up multiple contractual possibilities.

Example 1 : The « Conventional CfD »

This is the type of contract introduced in 2014 in the UK for renewables.



- **The strike price s** is fixed
- The **reference price p_r** is the Day Ahead price **(p_r=p)**
- The **reference quantity q_r** is the actual power produced (*pay as produced* ou *injection- based)* **(q_r=q)**
- The contract duration **T is fixed**

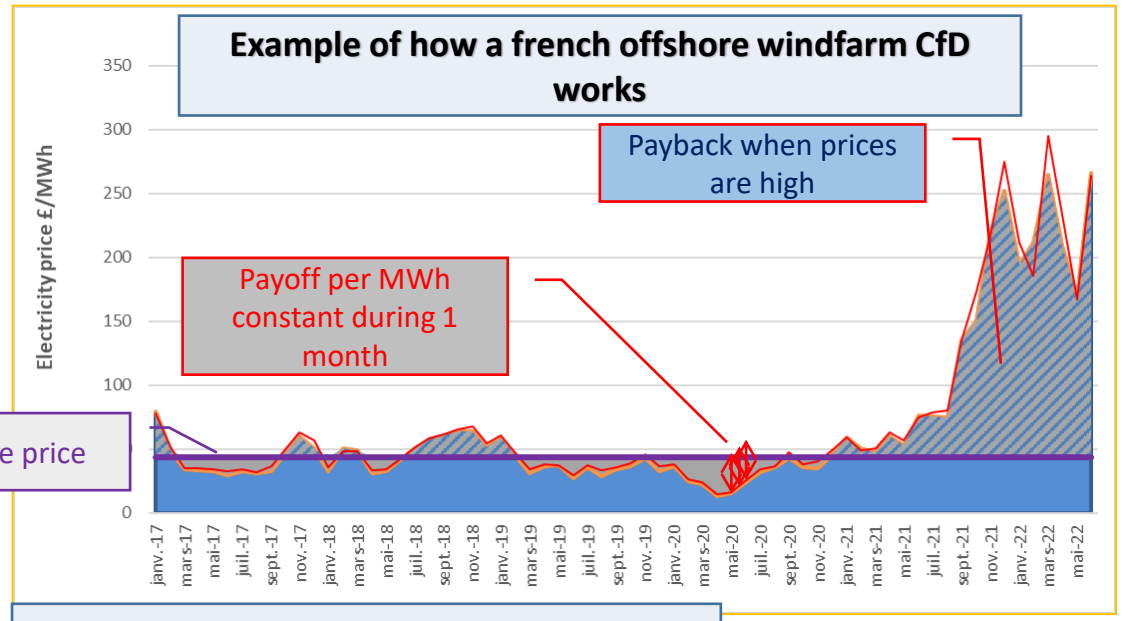
If the energy produced is sold on the spot market, the financial flow generated by the covered asset is :

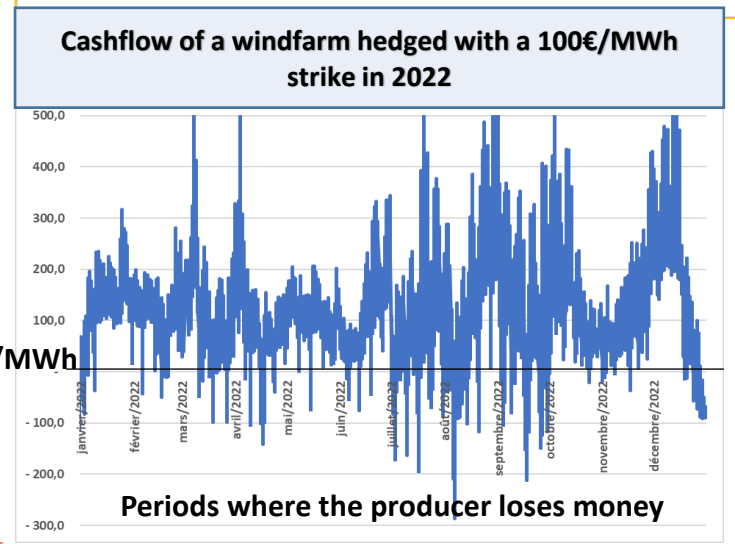
$$CF = (p-c).q + (s-p_r).q_r = (s-c).q$$

- **Independent of market price and proportional to production.**
- **Price risk hedging is perfectly achieved but the volume risk and therefore the income risk are not covered.**
- **Encourages production when it is not economically optimal (when p<c)**
- **Deletes incentives to optimise maintenance shutdown**

Example 2 : Playing on reference price

The French « complément de rémunération » contract for offshore windfarm





This contract is also *Pay as produced.* ($q_r=q$).

To restore incentives this contract plays on 2 fields :

- **A dedicated clause obliges the plant to stop when prices are negatives.**
- **The reference price is defined as the monthly average spot price weighted by the volumes of wind production in France** ($p_r=p_m$), it is on average lower than the unweighted average price.

  CF = $(p-c).q + (s-p_r).q_r = (p-c).q + (s-p_m).q =$ **$(s-c).q + (p-p_m)\,q$**

  This add an incentive **$(p-p_m)\,q$** to produce when the price is the highest and to place unavailability when prices are low.

  The producer is only hedged if he produces according to the average wind profile in France. But it is rather exposed positively if the wind regime is shifted because prices drop when there is a lot of wind.

There remains a distortion: if p_m is large at the beginning of the period and the spot price falls, it may be relevant to stop a competitive power plant because the producer has to payback more than he will earn on the market.

With a strike price of 100€/MWh, the cash flow of such a contract was negative almost 900h in 2021 and 2022. The producer had interest to stop when the power system didn't.

Example 2b : Playing on reference price

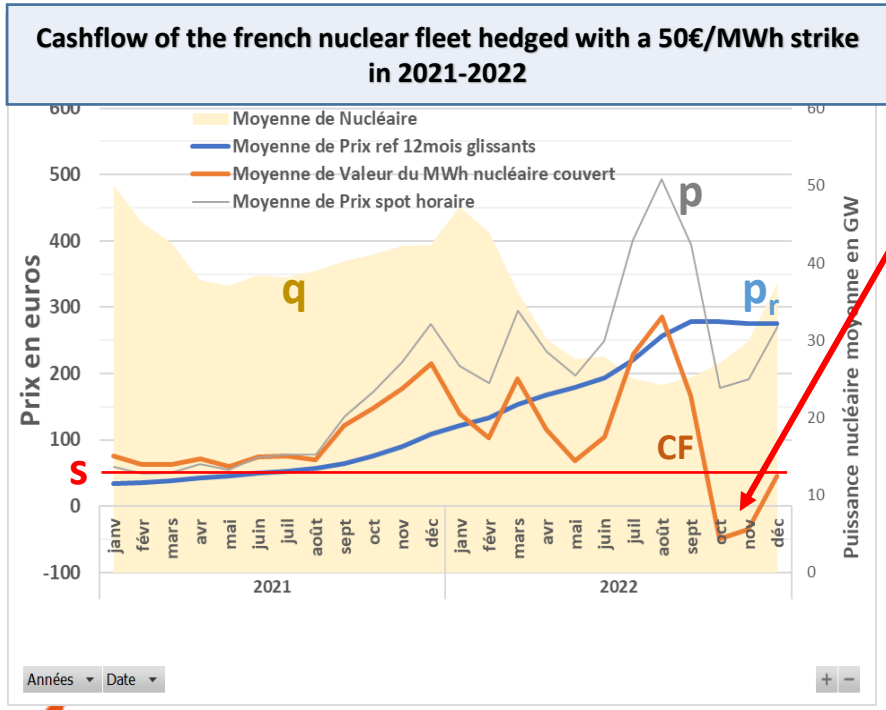
N. Fabra « Flexibility Contracts »proposal

In its proposal to reform European Electricity Markets, N. Fabra (2022) has proposed the same kind of contract for hydroelectric and nuclear power plants. The idea is to correct the lack of incentives by playing on the reference price.

- The contract is also *Pay as produced :* ($q_r=q$)
- The reference price p_r is taken equal to the 12 rolling months average price : p_m

$$CF = (p-c).q + (s-p_r).q_r = (s-c).q + (p-p_m)\,q$$

- The term $+(p-p_m)\,q$ is presented as a flexibility bonus which induces to place shutdown for maintenance when p is the lowest



The main problem is that this reinforces the distortion on short-term optimization:

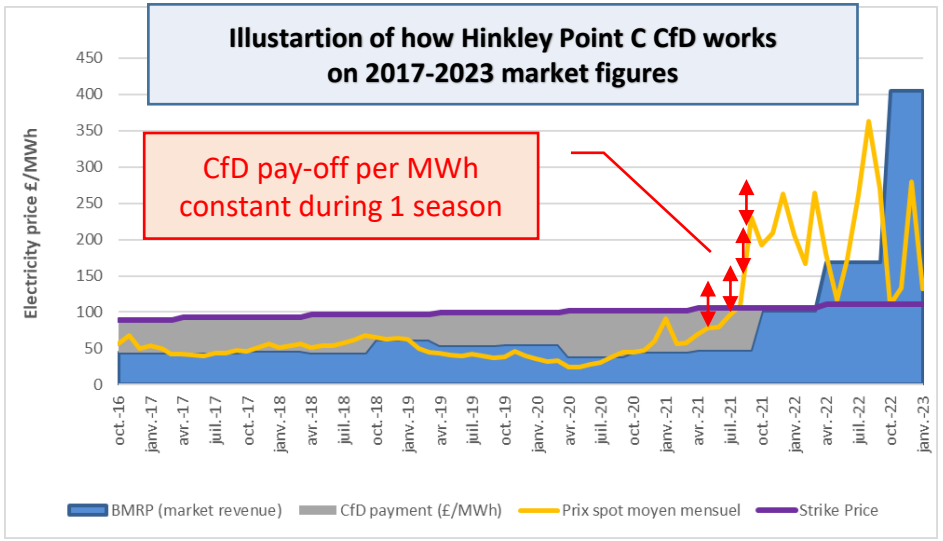
- In October and November 2022, the monthly spot price fell to its lowest value of the year: the flexibility term +(p-pm) became very negative (~-100€/MWh) greater than the guaranteed gain (s-c), **the short-term optimization would therefore have led to the shutdown of the plants at a time when the system was very tense.**

There are other problems we won't detail :

- The rolling average introduce a delay on the price signal that reduces its efficiency
- The spot price is not the good signal to optimize nuclear power plants because maintenance shutdown are planned several years in advance

Example 3 : Playing on the reference market

Hinkley Point C Contract for Difference



- The contract is also *Pay as produced :* ($q_r=q$)
- The reference price is the BMRP (Baseload Market Reference Price), used for all CfD in the UK for baseload power plants:
  It is a forward index calculated as an average of the quotations of seasonal products (6 months between April and October) on the previous 6 months weighted by the volumes traded.
  It is of course different from the spot price found ex-post. $p_r = p_{bmrp}$

$$CF = (p-c).q + (s-p_{bmrp}).q = (s-c).q + (p-p_{bmrp})\,q$$

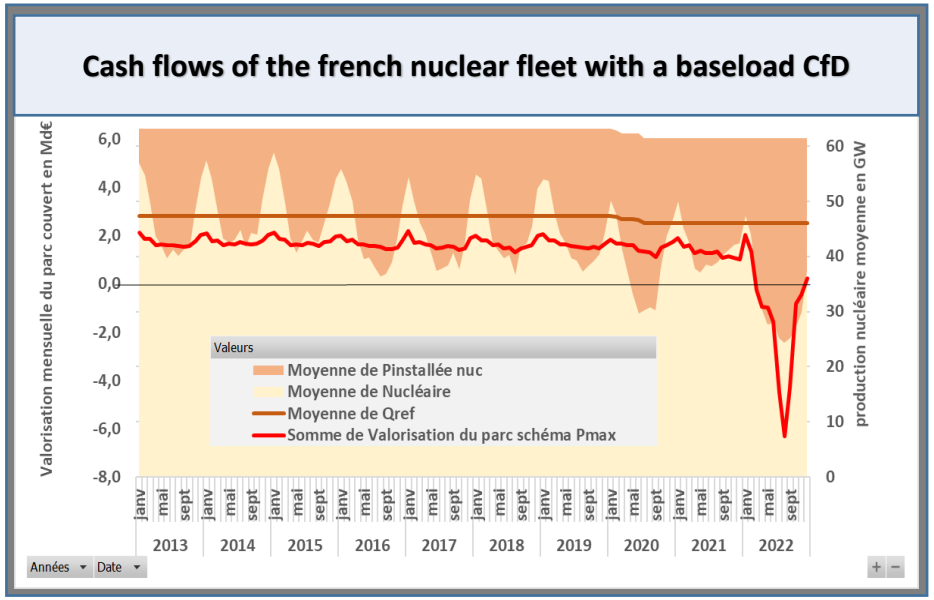
- **The premium per MWh produced is constant during the 6-month season** and does not depend on when this energy is produced within that season.
- **To be covered, and effectively receive the agreed price (the strike), HPC must sell its forward production, during the 6 months preceding delivery, at the market pace and produce exactly as expected: baseload electricity for 6 months... The reference price indicates on which market and at what pace to sell the production to be hedged.**
- If the plant does not produce in baseload, it becomes exposed to the form of prices (difference between the spot price and the average spot price)
- Like any Pay as Produced contract, this contract may induce distortions in optimization. Nevertheless, we have not observed situations over the period 2012-2022 where this distorsion would have been effective.

Example 4 : Playing on reference quantity

Schlecht & al.proposals for nuclear power plants

As Pay as produced contracts distort incentives to produce, several authors say it is preferable to have a reference quantity q_r independent of the actual production. That has 2 main advantages :

- **It leads to internalize the short term optimization criterion**
- **It allows optimization between energy markets and capacity markets for ancillary services**



One of (Schlecht, Maurer and Hirth, 2023) proposal is to use a baseload profile to hedge nuclear power plants.

We have simulated such a contract with :

- q_r =75% q_{nom}
- **s** = 50€/MWh
- p_r **= p** (Day ahead spot price)

$$CF = (p-c).q + (s-p_r).q_r = (s-c).q_r + (q-q_r).(p-c)$$

- The term $(q-q_r).(p-c)$ creates an exposure if you deviate from the reference trajectory, positive if above, negative if below: q_r **gives a trajectory to beat when prices are high**.
- While income appears to be fairly stable until the end of 2021, the combination of very poor availability and very high prices shows penalties that are difficult to bear of €16.5 billion in 2022
- A more subtle choice for q_r nevertheless reduces this risk: -€12.7 billion for a trajectory formed according to the load curve; +€3.5 to 4.8 billion if the commitment relates to availability in December N-1.

Example 5 : Playing on reference quantity

The « Deemed CfD » Newbery proposal for windfarms

(Newbery 2023) made several interesting proposals for wind contracts. We will only present the one concerning the reference quantity.

- He proposes to base the reference quantity $\mathbf{q_r}$ on a local wind forecast and a contractual wind to power transfer function (chosen by the supplier)
- The reference price is the DA price : $\mathbf{p_r = p}$

$$\mathbf{MBE =} (p-c).q + (s-p_r).q_r = \mathbf{(s-c).q_r + (q-q_r).(p-c)}$$

- $\mathbf{q_r}$ being independent from **q**, there is no distortion of short term optimization (start only if prices are above variable costs, possible arbitrages between short-term markets and ancillary services)
- If the wind turbine produces $\mathbf{q_r}$, its income is independent of the market price. It is encouraged to optimize its availability as if it were facing the market.

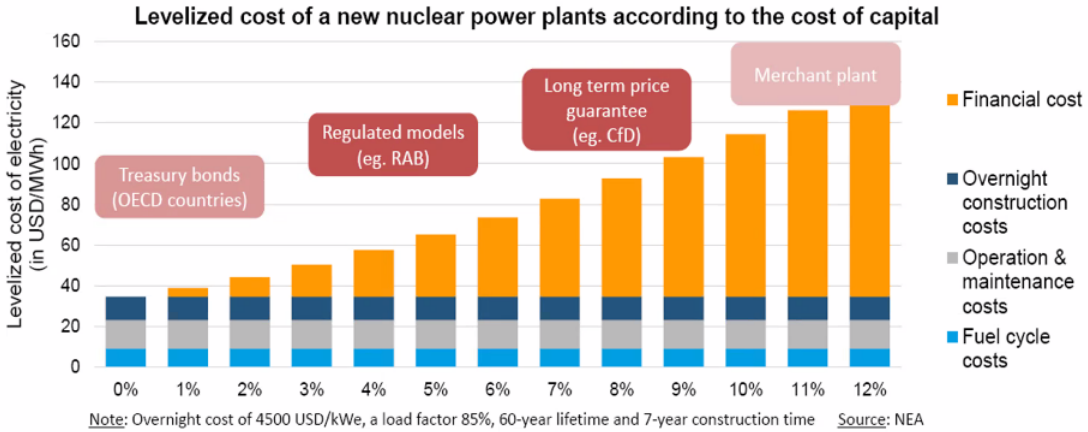
- **The challenge for this mechanism is its practical implementation**
- However, **degraded implementations of this mechanism that are easier to deploy can be imagined**. A national “wind” signal for example would lead to a price risk hedge identical to that provided by the French CfD (“complements de remuneration”) without the distortions linked to the Pay as produced clause.

Example 6 : Playing on contract duration

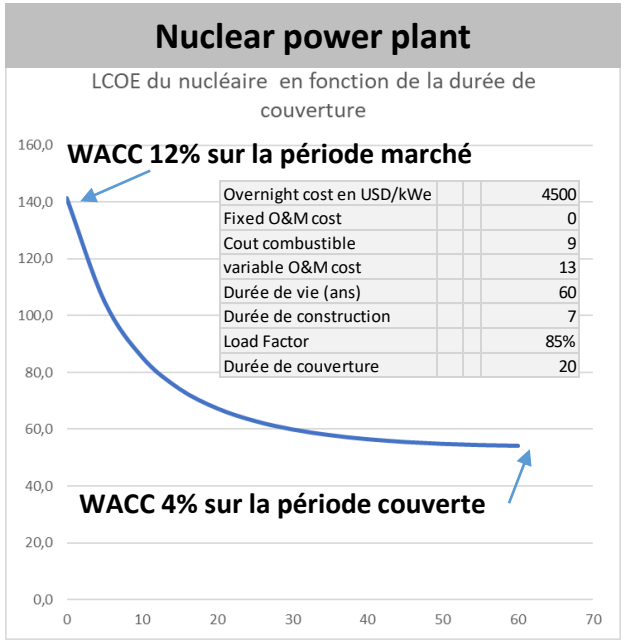
Impact on LCOE

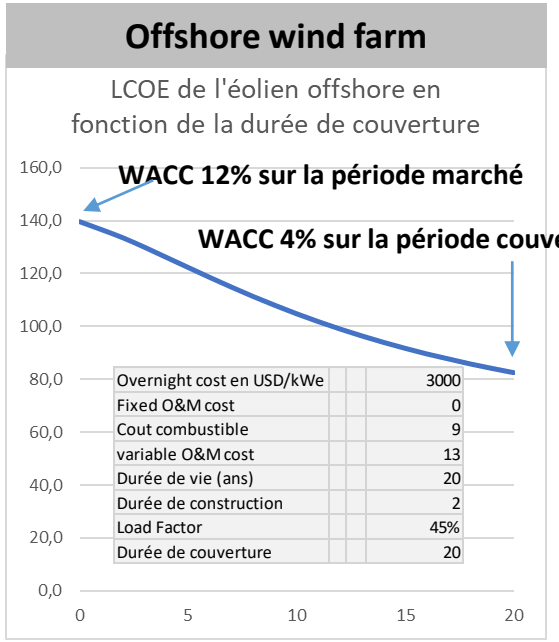
- **Hedging level affect the financing cost and ultimately the LCOE of the MWh produced**
- RAB hedging can lead to WACC reduced at 4-5% when merchant plant will require 10-12%

- **If the hedging level changes during the asset live you have to use a small WACC for the hedged part and a higher WACC for the merchant part. LCOE is a decreasing curve of the cover period.**
- **For nuclear power plant, a hedging period of less than 30 years significantly increases the full cost of the MWh produced, for wind power, of shorter life duration the decrease in the price as a function of the cover period is almost linear.**



Source : Percebois 2022 + NEA 2020





Source : IEA et NEA 2020, calculs EDF-R&D

Playing on strike price formula

It is possible to use the strike price to transfer other risks not managed by the contract for difference formula in particular risks related to construction or operating costs.

- This can be done in a simple way by indexing these costs to indices.
  - This is what is used for example in French offshore wind contracts with an indexation formula during the construction phase and another during the operation phase.

- This can also be done in a more complete (and complex) way by a Regulated Asset Base type mechanism that will adjust the level of remuneration according to the costs actually incurred.
  - This additional risk transfer has the advantage of reducing the producer's income requirement to cover its risk aversion (D. Newbery et al. 2019)

To sum up, for each parameter, several choices exist or have been proposed in academic literature …

Reference quantity : q_r	Reference price: p_r	Strike s	Contract duration T
As produced: $q_r = q$	Spot price	**Fixed**	**Fixed between 7 et 60 years**
Deemed production • From wind measurement • From availability	Average of forward quotations		
Model • Building a counterfactual	Rolling average of spot prices	**Indexed on public indices**	
Predetermined production • Baseload, Peakload, Guide curves	An average price captured by a set of assets	**Indexed on costs**	**Variable, linked to production**
	Price from a model		

Takeaways

1. **Pay as Produced contracts, which are widespread and sometimes still advocated, should be cautiously implemented because they could result in short-term inefficiencies**

2. **The yardstick CfD, which uses a reference quantity independent of actual production, does not have these disadvantages and is therefore preferable. However, the choice of this reference quantity must be made carefully so that the penalty for not achieving the objective is reasonable. It is also necessary that the development of this reference quantity is not too complex to be transparent and of a moderate implementation cost.**

3. **The choice of the reference market will induce liquidity in that market. Therefore, LT contracts do not necessarily dry up futures markets but can give them depth.**

4. **During the first 30 years of the asset's life, extending the duration of the contract significantly lowers the cost of capital and therefore the LCOE of the asset covered. After 30 years, the gain is less.**

5. **It is possible to transfer risks other than market risks through the strike-price formula, including risks on construction costs and operating costs. This transfer of risk also reduces the cost of capital and LCOE of the assets covered.**

6. **More generally, LT contracts are objects where the trade-offs between income security, income levels and incentives for efficient exploitation are fixed. Therefore, it is important to fully understand how the financial settlement mechanisms works to find the right compromises.**