The future of energy in Belgium : an overview

Louis Regout

November 30, 2019

This paper proposes an accessible overview of different plans for Belgium energy transition.
It's intended to be readable by any audience.
It has NOT been reviewed, and probably contains mistakes. If so, please contact me.

In brief

We have 2 main options :

1. We cover 33% of the territory with solar farms, and buy 10 billion Tesla's power wall.
2. We build 50 Tihanges like nuclear centrals. With this plan, chances of civil evacuation implying accident are less than 16%[1] (*this value is a large upper bound*). If such an event occurs, the consequences are on the order of : 0 death, 100 000 citizen displaced and 1% of the territory gets unusable.

Contents

[1]In 30 years of operation. The full plan supposes that fusion power will be available by 2050, and replace nuclear reactors.

1 At stake

Current climate models predicts an increase of 3 degrees for 2100. If this is the case, an estimated 300 Million peoples will have to leave flooded areas.

2 The goal

We want an energy plan that

1. Is able to meet our energy demand.

2. Nullify the CO2 production by 2050.

As the graph below show, our yearly energy consumption has been quite stable the last 2 decades.

I didn't found any prediction about the future energy needs of the country, but, by looking at the graph, it feels safe to say that, by 2050, our energy consumption will be *at least* 400 TWh, and more likely around current level.

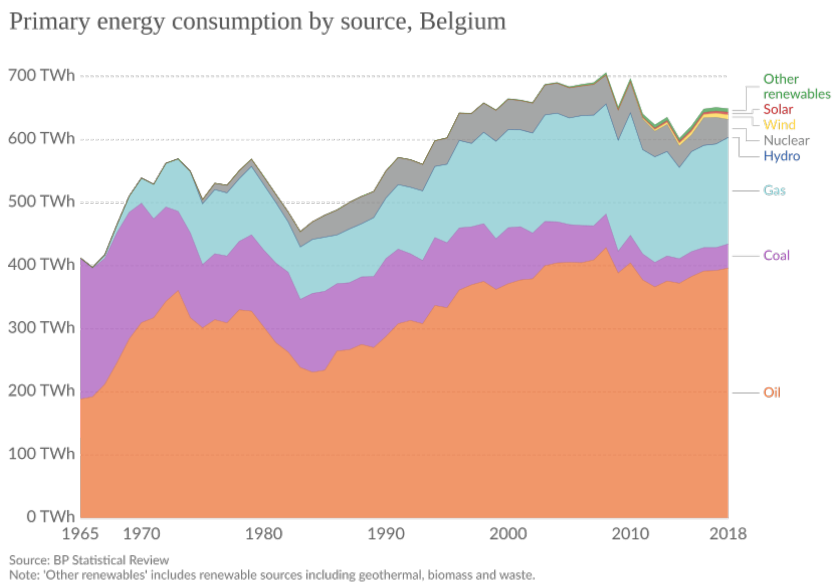

Figure 1: Belgium yearly energy consumption.

3 The tools

Lets list our options:

Technology	gCO2eq/kWh	Yearly potential		LCOE	
Fusion	likely low [2]	∞		likely low[3]	
Onshore wind	11	5	TWh	60	\$/MWh
Offshore wind	12	10	TWh	130	\$/MWh
Nuclear	12	∞		100	\$/MWh
Hydro	24	0.5	TWh	50	\$/MWh
Solar PV	41	0.1	TWh/km^2	90	\$/MWh
Compared to					
Gas (CCGT)	490	∞		50	\$/MWh

Figure 2: Means of producing electricity. Geothermal was omitted, as it isn't really an option in Belgium

Grid of lecture :

- The second column is like 'how much does this pollutes', taking every step of the central life cycle into account per energy produced. (construction, maintenance, fuel, dismantle)
- The yearly potential specifies how much this energy can produce on the Belgian territory. Those values are approximates (orders of magnitude).
- LCOE is like 'how much cost the electricity', taking into account every cost of the central (construction, maintenance, fuel, dismantle). Those values are approximates.

3.1 About intermittence

Wind and solar are intermittent : On a good day, PV will produce 550 MWh/km^2. On a bad day, PV will produce 10 MWh/km^2. Wind produces around 19% of the time. This leaves the following solutions :

1. Store the energy. However, this is hard. For example, even the 'Centrale de Coo-trois-ponts' can only store 5 GWh, which would last 4 minutes[4].
2. Only run non essentials items (factories, etc) when those energies are producing. Which has obvious economical drawbacks.
3. Buy from our neighboring countries. Which doesn't work if everybody attempt the same strategy
4. Have a fallback production method. This fallback is (almost always) fossils fuels.

Most countries solve this problem with a mix of 1, 3 and (mostly) 4.

[4]Coo-trois-ponts is one out of the 2 STEP central in Belgium. And no, we cannot just build 237 more of those (what we would need for a 16 hour night), as this requires peculiar relief.

4 So, what's the plan ?

4.1 The end game plan

What we ultimately want, is fusion power : it's the cleanest, the most scalable, quite safe (both from an accident perspective and from an armament race perspective), and with abundant fuel.

To my knowledge, nobody contest this objective, and politics invest a lot for the research in that area (see the ITER project if your are interested).

The hiccup is that the technology isn't ready yet (optimistic estimates puts its grid insertion starting in 2050), and that we need a solution quickly. Enters the temporary plan.

4.2 The temporary plan

4.2.1 With nuclear

We install 50 Tihanges[5] like nuclear centrals. And install all the hydro capacity.

The reason we don't install any renewable in this plan, is that, because of the intermittence, this would not reduce the number of nuclear centrals (we would still need the centrals as a backup). This would just end up costing more, for the same risk.

As soon as fusion power is available, all nuclear centrals should be decommissioned, and replaced by the fusion.

4.2.2 Without nuclear

We implement all wind and hydro possible. However those energies can at best produce 2.5% of our needs.

The solar must then take over. Because of some days are very bad for solar arrays, one need to store the energy. There exist an infinite variety of plans, depending on the battery size (see figure 3).

Plans implying to cover more than the whole country are not included in this plot. And quite logically, there is also a minimum area of solar panels in order to cover our needs.

Obviously, one other solution is to declare that we shut down our entire economy in winter. In this case, we would indeed need way less storage. This option is not presented either, as

1. it is hard to quantify this assumption
2. it is associated with huge economical drawbacks.

When fusion is available, we simply stop replacing old PV, and put fusion reactors in place.

[5] Assuming our power consumption ranges from 52 GW to 96 GW.

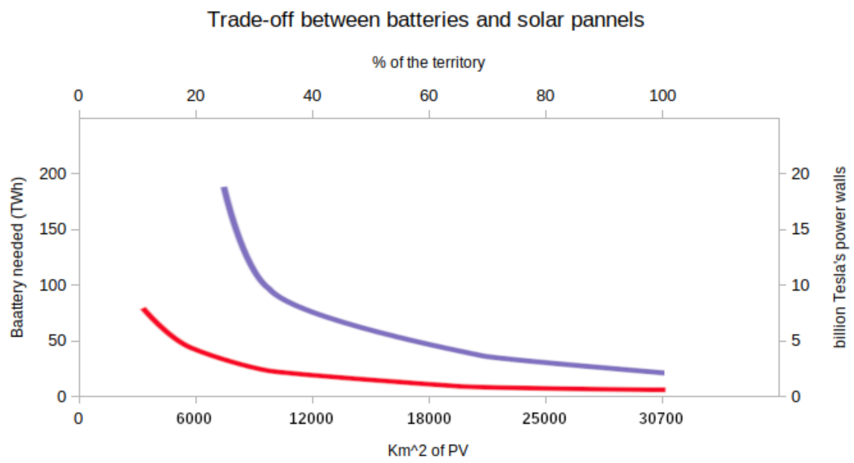

Figure 3: Blue line represent present technology : PV efficiency of 20%, battery round trip 0.9, battery self discharge of 2% per month, and present consumption (75 GW).
Red line is an hypothetical future : PV are 30% efficient, battery round trip 0.95 and battery self discharge 1% monthly, and only 66% of current consumption (50 GW)

4.2.3 With or without ?

Lets see a comparison table

With	**Without**
+ Less CO2 emitted	+ Favorable public opinion
− Centrals tends to blow	− More land used
− Waste is a poisoned gift for future gen	− Slower fusion adoption
+ More energy available	+ Cheaper electricity
+ Smaller investment	

CO2 emissions : 120 gCO2eq/kWh of solar, 400kWh/1kWh of battery (en france : 80*400 g/1kWh)

12 gCO2/kWh,

In 30 years, at current rate, we will consume 19500 TWh.

Produced by the nuclear, this would translate to 0.25 billion tons of CO2 equivalent.

By burning gaz, we release 9.75 billion tons of CO2.

Produced by PV + batteries, it really depends on the option PV/battery ratio we choose, and the manufacturing place.

As shown in figure 2, the Nuclear produces 3 times less equivalent of CO2 per watt than the PV. Real world data are even more in favor of nuclear : The French electricity (nuclear heavy) produces 80g/kWh, compared to the German one (renewable heavy) produces 450g/kWh.

Public opinion : money supporting the second plan will come in more easily. And it is quite useless to have a plan if you don't execute it. The 'no nuclear' plan is almost guaranteed to (at least) happen.

Centrals safety versus land use : the fact that centrals tends to explode is their main drawback. I will not tell you that a new generation central, in a country where there is no earthquakes of magnitude 6 in recorded history, has very little chances to fail.

Instead, lets look at what happens when there is a nuclear failure in a developed country, by examining the data from Fukushima :

- Nobody died nor will die (because of the reactor failure)
- The land loss (neglecting the temporary ≈20 km security perimeter) is a ≈10 km radius zone, for at least 40 years.

Because there is no health issues related to nuclear disasters, one could conclude that this is a matter of 'losing inhabitable lands'[6]. And this we can compare to the PV farms :

So, if we wish to replace, lets say Thiange (yearly production : 17 TWh), by solar panels, we have to install 170 km^2 of solar farm.

The amount of land lost is 0.5% of the territory, with certainty.

However, if we keep it, there is a **small**[7] probability p of nuclear disaster within the next 30 years. In this case, we would roughly lose $300km^2$, due to the 10 km evacuation zone.

The expected land lost is thus only $p\% \leq 0.006\%$ of the territory.

Nuclear wastes : With the same logic as before, one could argue that the nuclear wastes are simply a waste of space again.

However, there is an even better answer to that : Our current so called nuclear 'waste' is mainly fuel waiting to be processed in newer generation reactors.[8]

And then again, even if there is the 'Ok, in 10 000 years we will have to be careful in this area', I think we should first focus on ensuring that the human specie reach that epoch[9]

Fusion adoption rates : Nuclear centrals and fusions centrals are suited for the same task : base loads. This will ease the transition between them, as this is the same logical component of the network. Moreover, people will look forward to get rid of the nuclear, for the safety reasons mentioned above.

On the other side, trying to replace a highly intermittent energy by this much more static one is going to cause a lot of challenges, and slow the adoption down.

[6] Well, losing lands in a hurry, which can make a difference. However, one could argue that we could just declare the area around every central a natural reserve, and already remove permanent habitations, removing the problem altogether.

[7] Go on, choose p as you want, according to your beliefs. If you are pessimistic, you can consider that reactors don't improve from generation to generation, and set $p_a = \frac{\texttt{Nb of nuclear events with civilian evacuation}}{\texttt{Nb of nuclear plants years}} = \frac{3}{15{,}080} = 0.02\%$. The probability of an accident in 30 years of operation is then $p = 0.6\% = 6.10^{-3}$

[8] With existing technologies btw. Just lacking political will.

[9] It's like saying 'don't put tape on the hole of the sinking boat, because this is not the best solution, we will have to fix it again later'. The point is that the fix is fast, and works for a time, not that this is the final solution (Did I already mentioned that we are in a hurry ?).

And this is annoying, because, lets remind it, the fusion is much more ecological than the PV, especially because PV are combined with the fallback productions methods.

Energy abundance : The nuclear scenario scales very well. Building a nuclear plant, if it was not against public opinion, is mainly about finding a spot next to a river. For an equivalent production with PV, one has to acquire $170km^2$ (i.e. 0.5% of the territory).

Electricity prices : The nuclear option, because of its safety requirements, is likely to lead to a higher electricity price than the PV option. However, one could note that the money of the PV goes into China's pocket, and on the other case stays a lot more in the country.

Real world data (France vs Germany comparison) show that the price is roughly the same.

5 Conclusion

Our energy should come from fusion. In the meantime, a mix of wind, nuclear, hydro and solar is necessary.

A plan without nuclear will not be able to meet our CO2 objectives.

My point is that all our solutions requires land; For 75 TWh (i.e. 2018 need) we have the choice to give up 2.5% of the territory for the PV farms, or to *maybe* give up 1% of the territory in case of nuclear event.

5.1 What could change this perspective

A dramatic improvement in PV efficiency combined with either the development of efficient, large, energy storage means or the discovery of an efficient way to remove CO2 from the atmosphere would allow for a 'full PV' solution.