ITINERA INSTITUTE ANALYSIS
Paving new ways

Blackout risks in the coming years ?

2014/8
09 | 10 | 2014

PEOPLE
WELFARE
PROTECTION

Estimations of the reserve margin and investment needs during the nuclear phase-out in Belgium

Abstract

The outlook of the Belgian electricity system is increasingly unpredictable and challenging. Belgium is confronted with a nuclear phase out in a liberalized European electricity market which is strongly impacted by climate and renewable energy policies. The investment climate for controllable, non-intermittent assets is very problematic. We present the evolution of the estimated reserve margin between 2014 and 2030 in Belgium based on the existing nuclear phase-out plan and with the inclusion of the recent safety issues in two nuclear reactors. Between 2014 and 2017, we expect the reserve margin to vary from -2% to -34% (-4973 MW). In case a new investment wave does not take off in the next decade, we find very negative and unsustainable reserve margins (approx. -60%) for the period between 2025 and 2030. Filling this capacity gap with biomass and gas assets between 2013 and 2030 would result in a cumulative investment costs of at least € 11-13 billion. We estimate that about 24 new CCGT's (300 MW) and 7 new biomass plants (300 MW) are needed in a "low peak demand" scenario while 28 CCGT's (300 MW) and 9 biomass (300 MW) plants keep the reserve margin at the 5% level in a "high peak demand" scenario. We can conclude that the winter of 2014/2015 poses significant risks for a blackout. However, the next winters risk to become even more challenging.

JOHAN ALBRECHT, Senior Fellow Itinera
RUBEN LALEMAN, UGent

Keywords

Reserve margin, Nuclear Phase Out, Belgium, Electricity Markets, Shortage

Abbreviations

RM	Reserve Margin
RAC	Reliably Available Capacity
PD	Peak Demand
TSO	Transmission System Operator
BM	Biomass
FIT	Feed-In-Tariff
CREG	Commission for the Regulation of the Electricity and Gas markets

1. Introduction

1.1. Nuclear energy in Belgium

In 2012, more than half of the electricity produced in Belgium originated from nuclear reactors. With a 32% share of nuclear capacity in total installed capacity, Belgium ranks second in the world behind France with a share of 51% [1]. In total there are 7 nuclear reactors in Belgium, with a combined total capacity of 5927 MW (Table 1). The 7 reactors are located in 2 power plants, one in Doel (near Antwerp) and one in Tihange (in Wallonia). All nuclear reactors were built in the 1970s and 1980s and are therefore reaching their "end of life" in the next decades.

Table 1: Nuclear Assets in Belgium [2]

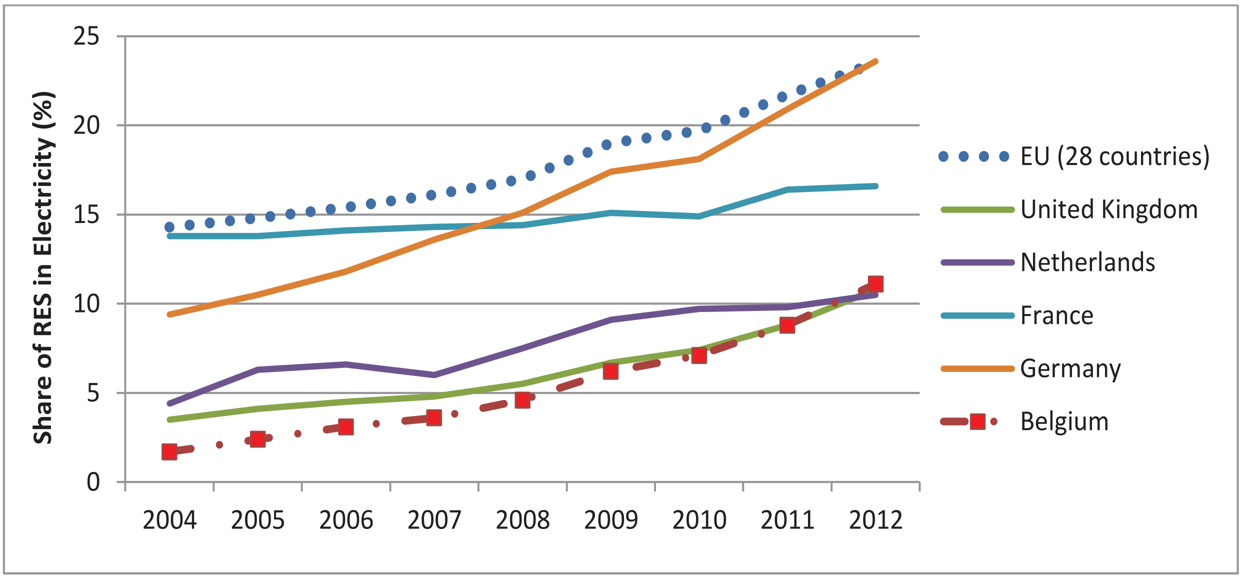
Power plant	Reactor	Reactor size (MW)	Start up year	Lifetime in 2015
Doel	Doel 1	433	1975	40
	Doel 2	433	1975	40
	Doel 3	1006	1982	33
	Doel 4	1039	1985	30
Tihange	Tihange 1	962	1975	40
	Tihange 2	1008	1983	32
	Tihange 3	1046	1985	30
TOTAL	**7 Reactors**	**5927**		

A detailed review on the political decision to phase-out nuclear capacity in Belgium is provided by Aviel Verbruggen [3]. One of his conclusions is that " *...little work and resources were spent on conceiving, developing and implementing a full alternative for the nuclear plants. A country heavily tied to the nuclear path cannot be expected to change course overnight.*" [3]. This lack of a back-up plan is somehow surprising in the uncertain context of the ongoing liberalization and integration of electricity markets. As nobody can or could predict the new electricity landscape after the liberalization (probably by 2020) a close observation of market dynamics and investment patterns is no luxury for a country with ambitious phase-out plans. Most of the policy interventions in Belgium in the recent years were directed to the costly promotion of (mainly variable) renewable energy sources.

1.2. Renewable electricity production in Belgium

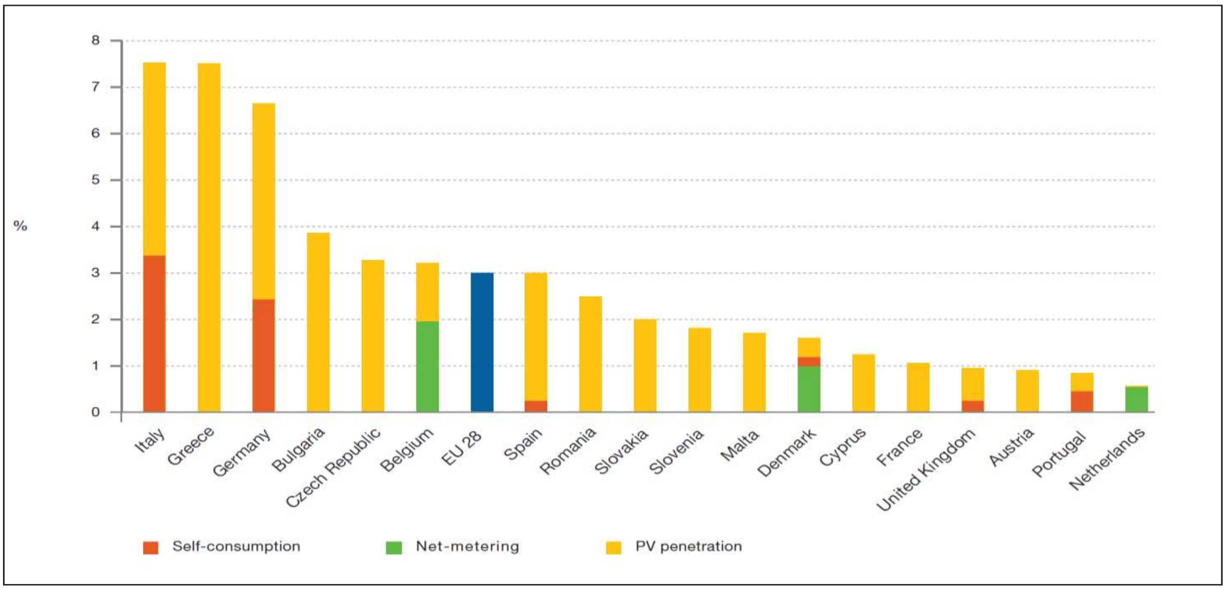
In 1997, the share of renewable electricity in Belgium was among the lowest in the European Union [4]. Since the introduction of ambitious renewable policies in Belgium in 2005-2006 – first in Flanders, later on in Wallonia – the share of renewable electricity production increased rapidly. The share of RES (Renewable Energy Sources) in the electricity mix has increased from only 1,7% in 2004 to a remarkable 11,1% in 2012. Belgium has thus reached the same share of renewables as the Netherlands or the United Kingdom. Only Germany's share of RES has grown at a faster pace than that of Belgium in the past 8 years (Figure 1).

Figure 1: Evolution of the share of RES in the electricity mix 2004-2012 (data from [5])



The biggest contributors to the rapid pace of renewables' growth are wind, biomass and PV-systems. Especially the latter had grown markedly in the years 2008-2010 in the region of Flanders, due to a subsidy scheme that was similar to the FIT-system in Germany. According to EPIA [6] the share of PV electricity in Belgium reached about 3,3% in 2013 (Figure 2). This is slightly above the EU average of 3%, but still much lower than the shares of PV electricity in Italy, Greece (> 6%) and Germany (> 5%). However, we should not forget that the output of a solar panel in Belgium is much lower compared to Italy or Greece [7].

Figure 2: Share of PV in EU member states in 2013 [6]

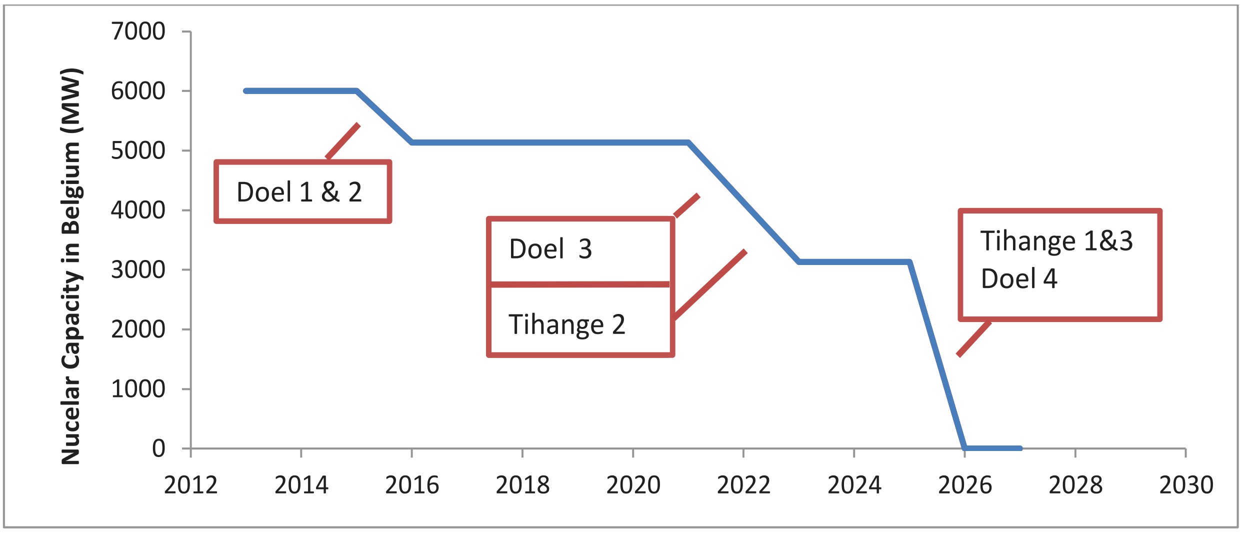


> *With a 32% share of nuclear capacity in total installed capacity, Belgium ranks second in the world*

1.3. The nuclear Phase-out plan

In the summer of 2012, the federal government approved a nuclear phase-out plan to clarify its vision on the energy mix for the next years [8]. This 'Plan Wathelet' contains next to the sequence of phasing-out nuclear assets also some measures to cope with the resulting lack in controllable capacity, namely a tender for 800 MW of gas-fired capacity [9]. In the plan the lifetime of the nuclear plant Tihange 1 will be extended for 10 years, while Doel 1 and Doel 2 will be phased out in 2015. In addition, 70% of the operational profits resulting from the extension of the reactor "Tihange 1" will be allocated to a fund for offshore wind energy subsidies [10]. Figure 3 shows the phase-out plan as set in the 'Plan Wathelet'.

Figure 3: Nuclear Phase out Plan [9]



However, the phase-out plan can be altered when security of supply is not guaranteed. This concern motivated the 10 year extension permit for Tihange 1. Recently, some technical issues concerning the reactors of Tihange 2 and Doel 3 (combined capacity of 2014 MW) resulted in the decision to stop using these reactors until "the structural integrity of the reactor pressure vessel" is fully demonstrated [11]. The Belgian TSO (Elia) has already indicated that "the situation could potentially become serious" in the winter of 2014-2015. The problems that result from the sudden closure of Tihange 2 and Doel 3 could, in theory, give rise to a reform of the above mentioned "plan Wathelet".

1.4. The lack of market incentives

The plan to phase-out nuclear capacity in Belgium is not new and is central to the debates on energy policy and the generation mix for some 10 years. The debate on the generation mix often neglects critical market developments such as the low wholesale prices since 2009. The low electricity price level is due to a combination of factors; a sluggish demand because of the economic crisis and energy-efficiency measures, the very low price of CO2 permits in the ETS, the low price of coal and the strong increase of renewable capacity (mainly intermittent) in markets with some overcapacity. The electricity landscape is further complicated by the vague post-2020 climate ambitions of the European Union – there still is no agreement on post-2020 targets – and the changing patchwork of national RES-support and capacity remuneration regimes. This unstable environment increases the risk premium connected to all investment projects. Apparently, high levels of uncertainty and current price expectations do not trigger investments in new assets, even in countries with very ambitious phase-out intentions…

Figure 4 shows that prices are in decline since the economic crisis of 2008. Average wholesale prices in the CWE-region have remained below 50€/MWh since the peak of about 70 €/MWh in 2008.

Figure 4: Average wholesale electricity prices (2003-2012) in the CWE-region [12] [13] [14] [15]

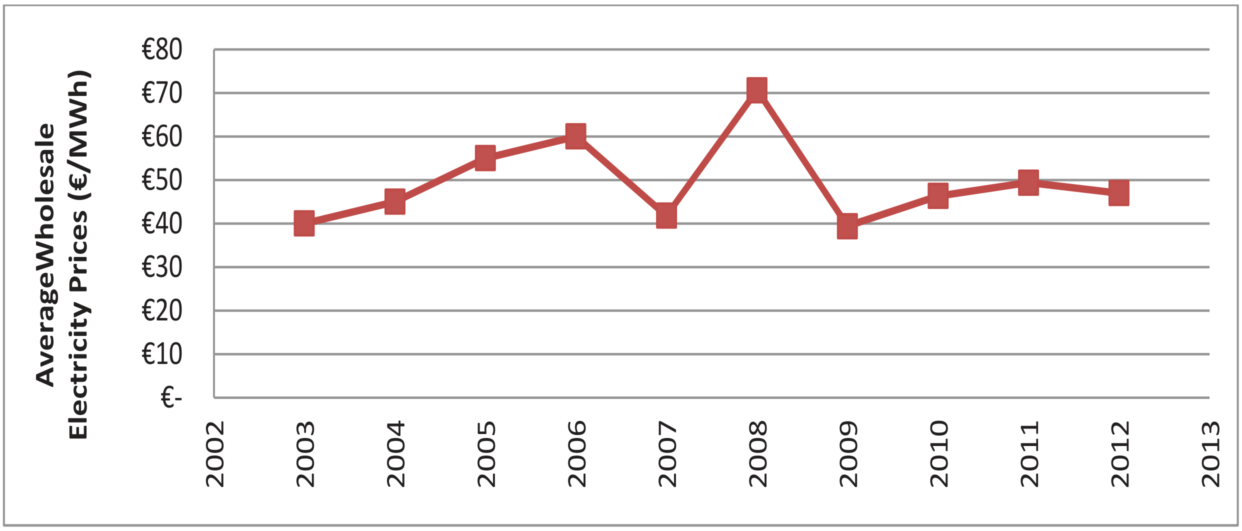


Figure 5 shows the most recent trends, indicating a sharp fall in the CWE peakload and baseload prices in 2013. The Quarterly Report on European Electricity Markets by the EU commission mentions that "high levels of renewables generation contributed to the lowest wholesale power prices observed in the last few years". In addition, hydro levels were also higher than expected and Europe enjoyed a mild spring [15]. As prices below marginal generation costs remove any incentive to invest in new (controllable) capacity and to use existing capacity with high marginal costs, utilities are closing or 'mothballing' several of their gas-fired power stations [16]. The Quarterly Report mentions that "Gas-fired generation remained unprofitable in Germany in Q2 2013, with the average of the clean spark spread falling as low as -19.5 €/MWh".

Figure 5: Drop in CWE wholesale prices in the summer of 2013 [15]

High levels of uncertainty and current price expectations do not trigger investments in new assets, even in countries with very ambitious phase-out intentions...

1.5. Security of supply

The recent developments in the Belgian and Central West European electricity market have resulted in concerns about the availability of sufficient firm capacity in the (near) future. A number of studies have already highlighted some of these issues.

An interesting study by the FOD Economy has been published 3 years ago. Based on the announced closure of old fossil and nuclear plants, the FOD Economy concluded that already in 2015-2016 there could be a shortage in the range of 2300 - 3700 MW [17]. It is clear that an extra loss of 2000 MW would increase the shortage risk even more, potentially up to 5000 MW.

The Commission for the Regulation of the Electricity and Gas markets (CREG) in Belgium argued that the study by the FOD Economy lacks some important aspects, such as the CWE-perspective and the strong correlation between electricity demand in France and cold winter spells. However, the CREG agrees with the general conclusion that there is a high risk of a shortage in the Belgian electricity system in the near future [18].

Black outs of over 8 hours will result in exponentially more economic damage since back-up generators can only handle short blackouts

Recently, the Bureau Federal du Plan (BFP) published two working papers on the Belgian electricity market, one that estimates the production adequacy until 2030, and another that estimates the cost of a black out in Belgium. The former working paper states that a sharp increase in capacity will be needed in the short term (to cope with the phase-out in 2015) and especially in the years 2024-2025 to cope with the phase-out of three nuclear reactors [19]. The latter paper concludes that a black out in Belgium of 1 hour during a normal working day would result in economic losses of about € 120 million. The cost of a black out is however not linearly related to the amount of time that a blackout lasts, black outs of over 8 hours will result in exponentially more economic damage since back-up generators can only handle short blackouts. With long blackouts, the temperatures of refrigerators risk to reach levels that threaten food safety [20].

A recent fact sheet by the University of Leuven (KUL) considers the safety concerns of reactors Doel 3 and Tihange 2. The fact sheet estimates peak demand and total (firm and non-firm) capacity for 2012-2017 and concludes that Belgium will have to use all of its import capacity in order to meet the peak demand in 2017. Capacity markets could solve some issues, but the authors are concerned that this could be yet another subsidy on top of the existing subsidy schemes for renewables [21].

This papers aims to contribute to this literature by focusing on short term as well as long term shortage issues. We want to be very transparent on the reserve margin estimates and the key assumptions (peak demand, phase out of nuclear, closure of fossil assets) that drive the results. Given the recent issues regarding the reactors of Tihange 2 and Doel 3, we estimate how the (possibly permanent) shutdown of these reactors - on top of the existing phase out plan - will impact the Belgian reserve margin. The contribution of intermittent renewables to the reserve margin is also discussed. First, we will estimate the current reserve margin in Belgium (in 2013) and compare this with the reserve margin in the neighboring countries. Then we will look at the short and long term issues regarding the peak capacity. Finally, we will estimate the needed investments and provide some policy recommendations.

2. Estimating the capacity shortage

2.1. Methodology

Estimating the Reserve Margin (RM) in the short term is relatively easy, since there is a high level of certainty regarding the phase-out of nuclear and fossil assets. However, there are still doubts about whether the reactors of Tihange 2 and Doel 3 will be restarted or not.

First, we will present two short term capacity scenarios, one with the restart of Tihange 2 and Doel 3 (Restart Scenario), and one without Tihange 2 and Doel 3 (NO Restart scenario). Then we will estimate peak demand and the resulting reserve margin. We will also estimate the longer term evolutions of the reserve margin, focusing on the big drop in the firm capacity due to the phase-out of nuclear assets in 2025.

In order to calculate the reserve margin, we need to estimate the total peak demand and the reliably available capacity (RAC). The latter is defined by ENTSO-E as "part of national generation capacity that is actually available to cover the load at a reference point". For this we need to subtract from the total installed capacity the total non-usable capacity at peak load: intermittent capacity (wind, PV), outages, system service reserve, capacity in maintenance and overhauls, and generation constraints due to severe conditions.

We can then use the RAC to estimate the reserve margin as defined by the Energy Information Administration:

"Reserve margin is (capacity minus demand)/demand, where "capacity" is the expected maximum available supply and "demand" is expected peak demand" [22]

Thus, when we apply the RAC-definition from ENTSO-E to the RM definition of the EIA we obtain the following formula:

RM = (RAC-PD)/PD [%]

With: RM: Reserve Margin

RAC: Reliably Available Capacity

PD: Peak Demand

2.2. Belgium in the CWE-region

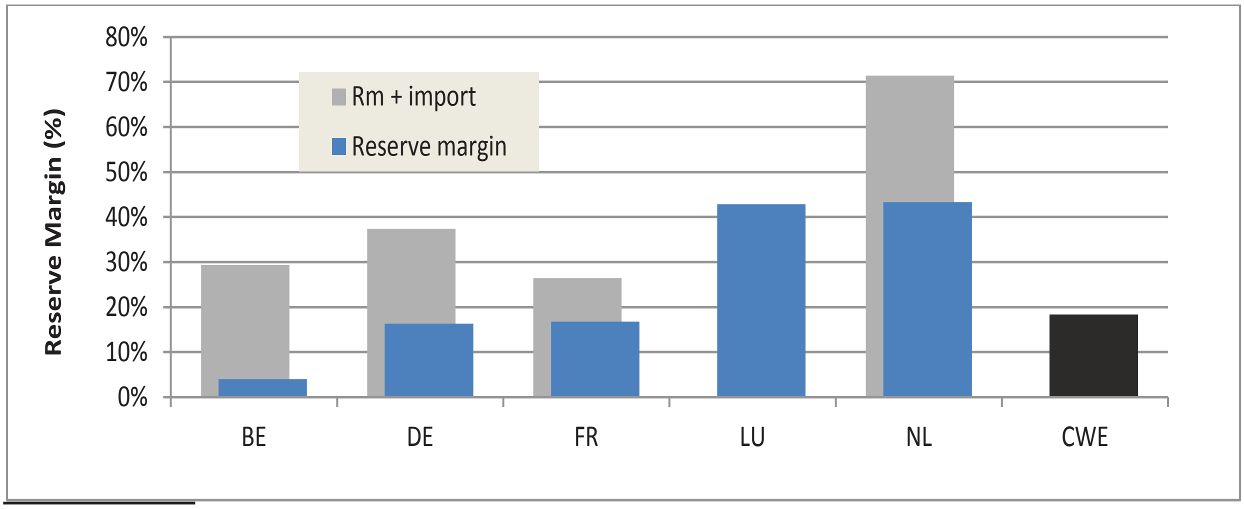
The ENTSO-E (European network of TSO's) provides very interesting information about the risk of a shortage in the European Member States. The "Winter Energy Outlook" is an annual publication that seeks to estimate security of supply in EU for the next winter. In 2012, the ENTSO-E gave Belgium a "Code Red" to cope with the winter peak demand. This means that in a cold winter night/morning Belgium would need to make full use of its import lines, primarily from the interconnection with the Netherlands.

The import/export capacity in Belgium is relatively high, due to the fact that it is a small nation; however, it appears not to be sufficient. Belgium can import/export about 1700 MW to The Netherlands. From France, Belgium can import 2300 MW, while it can export 3400 MW. The difference is due to the limited capacity of the French national grid [21].

The reserve margin for the CWE-region as a whole is about 20% (Figure 6). Only the Netherlands and Luxemburg have a RM above 25 percent. The graph clearly shows

the very low RM in Belgium, and the opportunity of importing from the Netherlands. However, as mentioned above, this import is (currently) limited to only 1700 MW.

Figure 6[1]: Reserve margins in CWE (based on data from [23] [24] [25])



1 On the peak demand in Germany, very diverging data can be found; appendix III in the Commission report mentions a peak load of 92 GW, while DENA mentions data in the range of 78-83 MW. A graph by IHS indicates a reserve margin of about 20% for Germany [27]. We have opted for a peak demand of 83 MW in this study, since this seems to fit most of the literature estimates.

2.3. Short term shortage

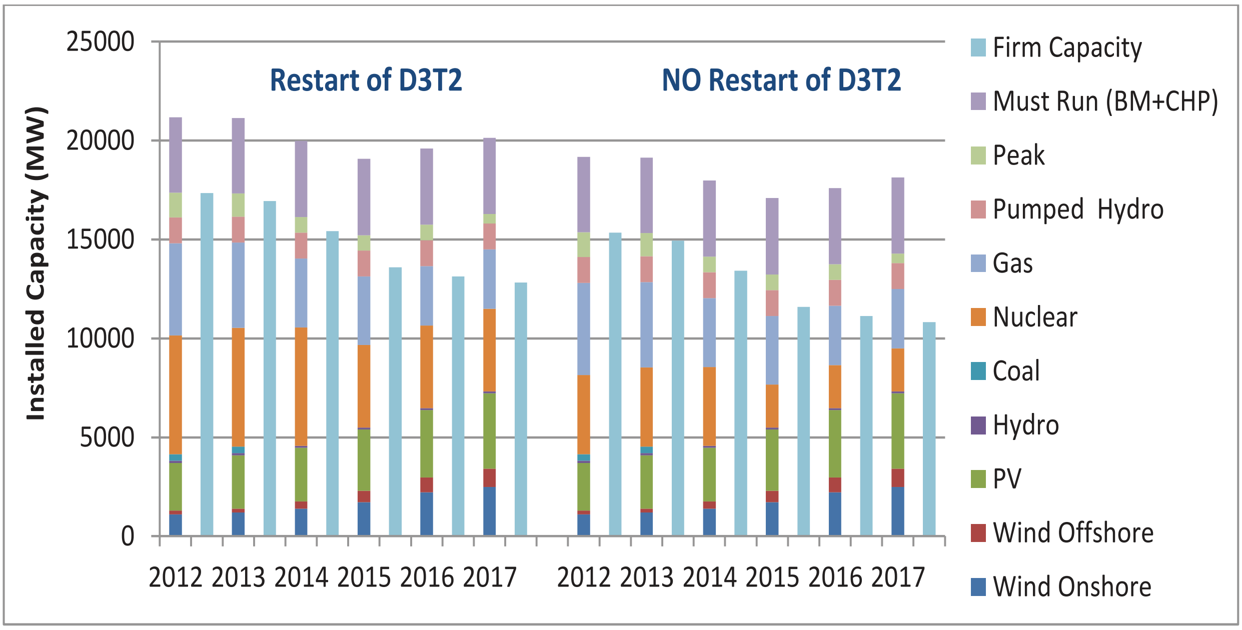
2.3.1. Estimating available capacity

In Figure 7 we see the evolution of the installed capacity in Belgium in a Restart scenario and a NO Restart scenario; the blue bars indicate the Firm Capacity. Figure 7 is based on data in the literature [17], from the PV industry [6], information from Belgian utilities and data from the European electricity association [26].

As a matter of reference, the factsheet of KUL arrives at similar but somewhat lower estimates for 2015-2017 [21]. In Figure 7 we explicitly make the distinction between firm capacity and reliably available capacity as not all firm capacity is reliably available. In our estimates we use an availability factor of 88%. This means that at any given time, some 12% of all the firm assets are unavailable due to outages, maintenance or other reasons.

> *In a cold winter night/morning Belgium would need to make full use of its import lines, primarily from the interconnection with the Netherlands*

Figure 7: Drop in Firm Capacity in two phase-out scenarios (data from [6] [17] [26] [21])

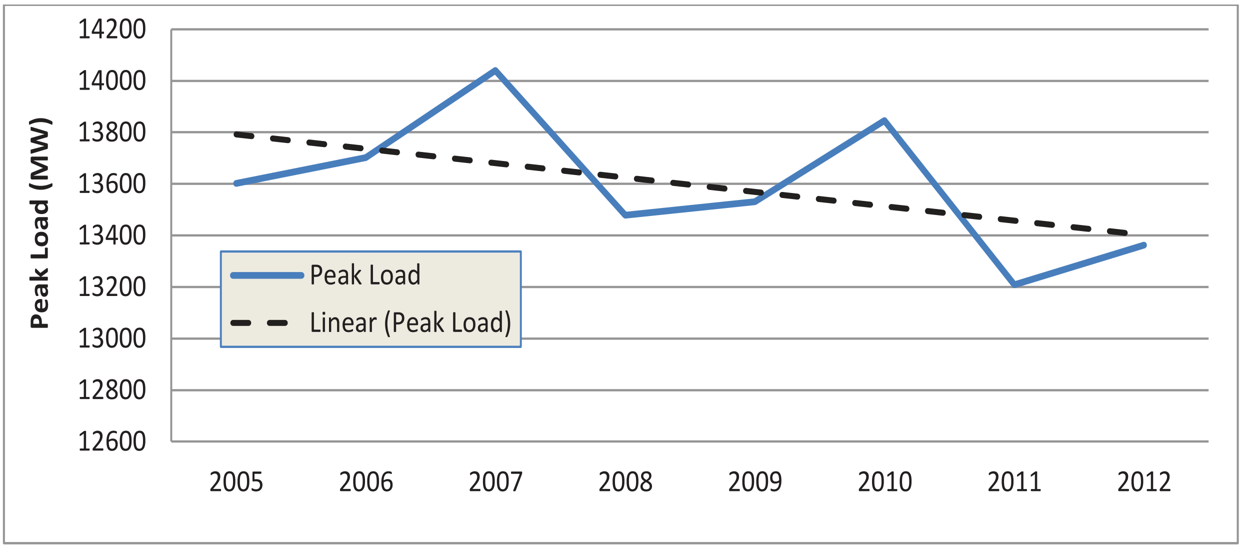


2.3.2. Estimating Peak demand

Unfortunately, data for overall peak demand are hard to obtain because of the increasing auto-production (mainly PV). Peak load is measurable and precise figures are available. Peak demand (including auto-production) is higher than peak load (= electricity taken from the grid). Assessments based on peak load always underestimate peak demand. But as Belgium is a country with peak demand mostly during winter evenings without sun, peak load at those moments is rather close to peak demand.

Nevertheless, we observe that peak load has decreased in the recent past. Peak load reached a maximum of about 14.000 MW in 2007, to drop to around 13.400 MW in 2012 (Figure 8). It is very unclear whether this decrease in peak load is a structural trend or whether the decline is due to the economic crisis. Another explanation relates to the widening of the gap between peak load and peak demand. Overall, there is no certainty that the peak load (or peak demand) will continue its slowly decreasing trend in the next years.

Figure 8: Peak Load (LOAD; source: (Elia, 2013) - remark: auto-production not included)



It is difficult to foresee how peak load and peak demand will evolve in the next 5 years. The KUL assumes a peak demand of 14.191 MW for 2012-2017 [21]. The FOD-Economy report mentions three scenarios, one with constant peak demand, one with a decreasing peak demand, and one with an increasing peak demand (Table 2). The reference scenario of the FOD economy mentions a peak demand of 14391 MW [17]. In this paper we will use two scenarios for 2017, one with a higher peak demand (14.500 MW) and one with a lower peak demand (13.800 MW). The latter can be regarded as a scenario with little economic growth and/or a surge in efficiency investments; the former can be regarded as a scenario with increased economic development, and thus increased electricity (peak) demand.

Table 2: Estimates of Peak demand in 2017 in Belgium [21] [17]

Peak Demand in 2017	FOD economy (MW)	KUL (MW)	This paper (MW)
Low	13.413		13.800
Medium	14.391	14.191	
High	15.429		14.500

2.3.3. Results and discussion of short term shortage issue

We combine the 2 capacity scenarios - Restart or NO Restart of reactors Doel 3 and Tihange 2 - and the two peak demand scenarios (High or Low peak demand, see Table 2) to obtain 4 estimates of the reserve margin in Belgium in 2017 (Table 3).

The results confirm the concerns mentioned in all of the papers on the Belgian electricity supply. Already in 2014 we find very low reserve margins. The situation will become very problematic in 2015 with the closure of Doel 1 and Doel 2, and the shutdown of some other fossil assets. The situation will become dramatic when the two other reactors (Doel 3 and Tihange 2) remain closed, as they provide a combined capacity of about 2 GW. By 2017, the reserve margin varies from -18% (2 513 MW) to -34% (4 973 MW).

Table 3: Estimates of short term reserve margin in Belgium in 4 scenarios (own estimates)

Peak demand (MW)	2013	2014	2015	2016	2017
low PD	13800	13800	13800	13800	13800
high PD	13800	13975	14150	14325	14500
RAC (MW)					
Restart	14904	13571	11966	11550	11287
NO Restart	13144	11811	10206	9790	9527
RM					
Low PD - Restart	8%	-2%	-13%	-16%	-18%
Low PD - NO Restart	-5%	-14%	-26%	-29%	-31%
High PD - Restart	8%	-3%	-15%	-19%	-22%
High PD - NO Restart	-5%	-15%	-28%	-32%	-34%

We did not include the contribution of wind to the reserve margin in the calculations, since this is normally not part of the RAC as defined by ENTSO-E. However, including the availability of wind does not result in any significant change in the overall conclusion. Based on our estimates, wind has a minimal output of about 7% of the total installed capacity in Belgium. The reserve margin would increase by about 1% in all scenarios if a 7% availability of wind is taken into account.

2.4. Long term Shortage

In the longer term, it is harder to predict the evolution of peak demand, since new technologies can change things in a way we cannot foresee today. For example, the peak load could be reduced by investments in demand side management and in energy efficiency. European energy-intensive companies can leave Europe in response to the increasing energy cost gap with the US, leading to a strong reduction of electricity demand in industrial regions - in some regions, the share of industry in total demand exceeds 50%. On the other hand, peak load can also drastically increase if the uptake of electric vehicles is not regulated properly, resulting in demand peaks when homeowners plug-in as they come home from work.

As mentioned above, the current electricity price levels do not trigger investments in new assets. Unless countries like the Netherlands and Germany commit to the gradual phase-out old coal plants, a significant overcapacity in CWE risks to persist up to 2018 leading to too low prices to launch an investment wave. But even higher prices will not be sufficient to trigger massive investments. European climate and energy policies are vague and need to be radically adjusted. But more fundamentally, once market participants start to believe that total demand will structurally decline, the prospects for investments without any form of government guarantee will be poor.

In our approach, we assume that between now and 2030 old assets will be phased-out while no capacity remuneration mechanism (CRM) or other incentive scheme will trigger investments in new assets. Our approach can be considered as a 'no policy' scenario in which no private investments are triggered, as a consequence of low price expectations. Calculations of the reserve margin under such a no policy scenario reveal the total investment need between now and 2030[2] .

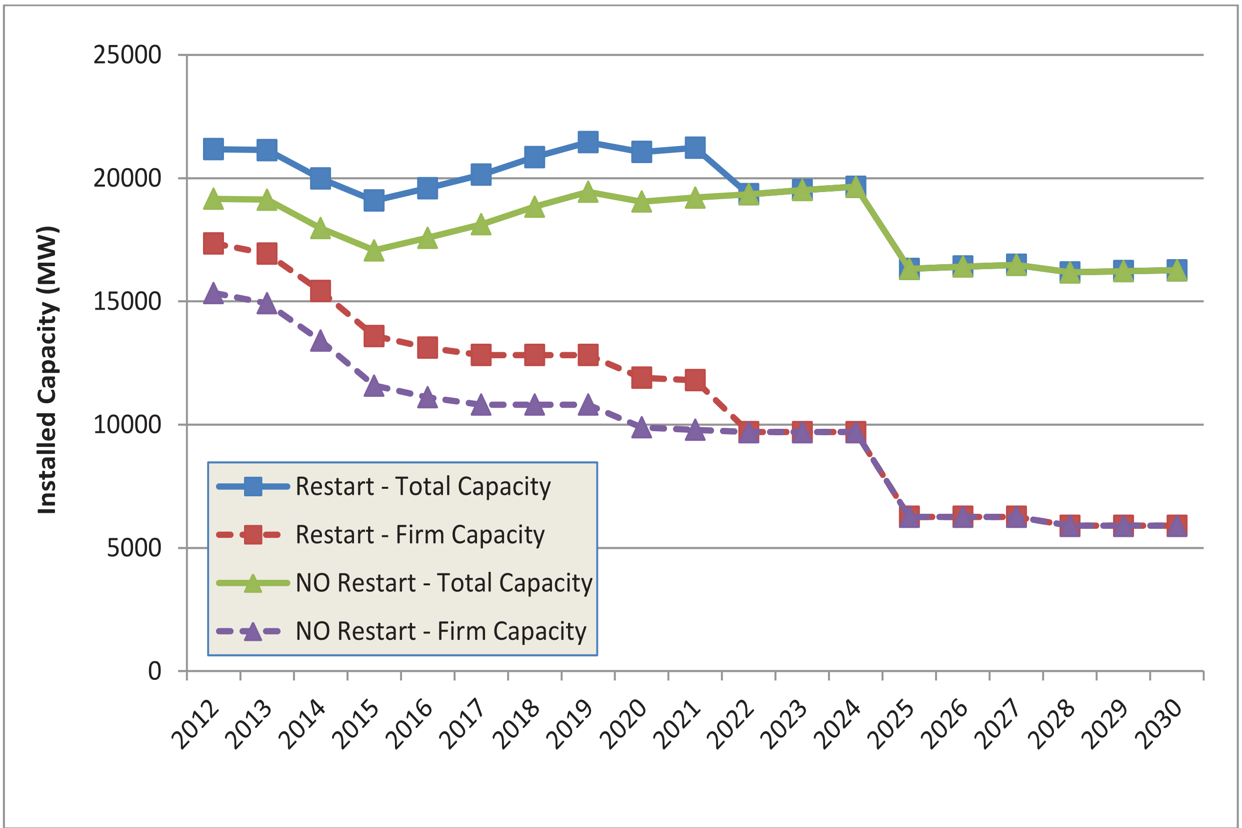
"Unless countries like the Netherlands and Germany commit to the gradual phase-out old coal plants, a significant overcapacity in CWE risks to persist up to 2018 leading to too low prices to launch an investment wave"

2.4.1. Estimating available capacity in the long term

To assess the risks for a black-out in Belgium beyond 2017, we will again present a "Restart" and a "NO Restart" scenario (Figure 9). We see that in both scenarios the total installed capacity remains somewhat constant, at around 20 GW until 2024. However, from 2012 onwards there is a gradual decline in the firm capacity, from 15-17 GW in 2012 to only 10 GW in 2022 and even to 6 GW in 2025. Also, notice that in the "NO Restart" scenario, the installed firm capacity remains almost constant, at a very low level, between 2016 and 2025 (around 10 GW).

2 In practice, this investment need can partly be met by private investment without any policy incentive complemented by investments that are triggered by instruments such as CRM. The relative contribution of policy instruments such as CRM to the total investment needs is not the scope of this paper.

Figure 9: Estimated evolution of the installed capacity (2012-2030)



2.4.2 Estimating Peak demand in the long term

Again, we evaluate a low and a high Peak Demand scenario, in the "low" scenario we assume that peak demand remains constant at the level mentioned in the "short term analysis", namely 13 800 MW. In the "high" scenario we will assume a gradual increase in peak demand, assuming that electrification of transport, heating… will become a policy target in the future, possibly combined with a growth in demand from industry after the recession. Table 4 shows that the gap between the two scenarios becomes very large in the last years. In 2030, the difference between a low and a high peak scenario has reached about 1500 MW. Notice that our 'high' scenario is not that high, as the 'high' peak demand in 2030 corresponds with the peak demand mentioned in the FOD-economy paper for 2017. We can therefore assume that our scenarios are relatively conservative.

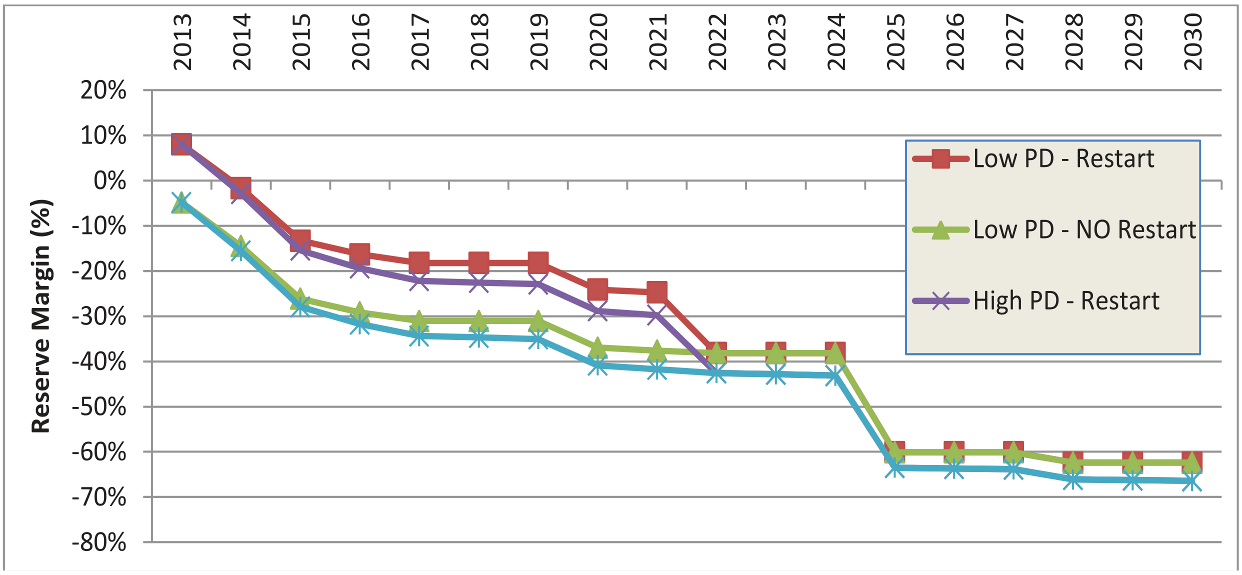
Table 4: Long term estimates of peak demand (2013-2030)

Peak demand (MW)	2013	2014	2015	2016	2017	...	2020	...	2025	...	2030
low PD	13800	13800	13800	13800	13800		13800		13800		13800
high PD	13800	13975	14150	14325	14500		14719		15090		15471

2.4.3. Results and discussion of long term shortage issue

Figure 10 shows the evolution of the reserve margin from 2013 to 2030 in Belgium, according to our estimates on installed capacity and peak demand. Keep in mind that the reliably available capacity (RAC) is 12% lower than the total installed firm capacity.

Figure 10: Estimated evolution of the Reserve Margin (2013-2030)



As mentioned before, already in the short term we see problems with the security of supply as reserve margins for the winter of 2014-2015 are negative (even if the reactors of Doel 3 and Tihange 2 can be restarted). It is however rather unlikely that this will happen. In the "High PD-NO Restart" scenario - the worst case scenario from a security perspective - the reserve margin will drop from -5% in 2013 to -40% in 2020. This would a very extreme evolution. The import capacity of about 3500 MW would be far from sufficient to fill this gap. In the next section, we estimate how many new assets would be needed to keep the reserve margin always at 5% in our scenarios. For the sake of simplicity, we will ignore construction times.

3. Estimates of needed investment

The above analysis has clearly shown that - unless policymakers act swiftly - there will be a severe shortage in firm capacity in Belgium in the coming decade. In this section, we will estimate how many new assets will be needed to cope with the fast drop in the reserve margin as presented in Figure 10.

Since the Belgian government is keen on reducing the climate impact of the electricity system, we assume that no new coal plants will be built. We can also exclude new nuclear assets, since the construction times are too long. Therefore, we assume that the "gap" will be filled with new gas and (large scale) biomass assets.

We construct a model that installs a new plant of 300 MW once the reserve margin has dropped below 5%. Since the government aims to increase the share of renewables, we assume that about 1/3rd will be biomass and 2/3rd will be gas-fired (CCGT plants). This is a relatively simple model, but it shows the scale of the needed investments in the Belgian electricity market. We assume an investment cost of 900 €/kW for a CCGT plant and 2100 €/kW for a large scale biomass plant.

> *Unless policymakers act swiftly - there will be a severe shortage in firm capacity in Belgium in the coming decade*

Table 5 shows the "Shortage" in total capacity to meet the 5% reserve margin criteria in all scenarios. We find that all scenarios indicate a shortage from 2014 onwards, and that this shortage grows rapidly in the first years. If we compare the shortage levels to the maximal import capacity of Belgium (3500 MW), we see that in a "NO Restart" scenario Belgium is at risk of having a shortage above its import capacity from 2015 onwards. In the "Restart" scenario, this happens from 2017 onwards. In short, Belgium will be import dependent already this winter, and will soon have a high risk for black outs in the "worst case" scenario of rising peak demand and the inability to restart Tihange 2 and Doel 3.

Table 5: Estimated shortage in installed capacity to meet a 5% reserve margin in Belgium

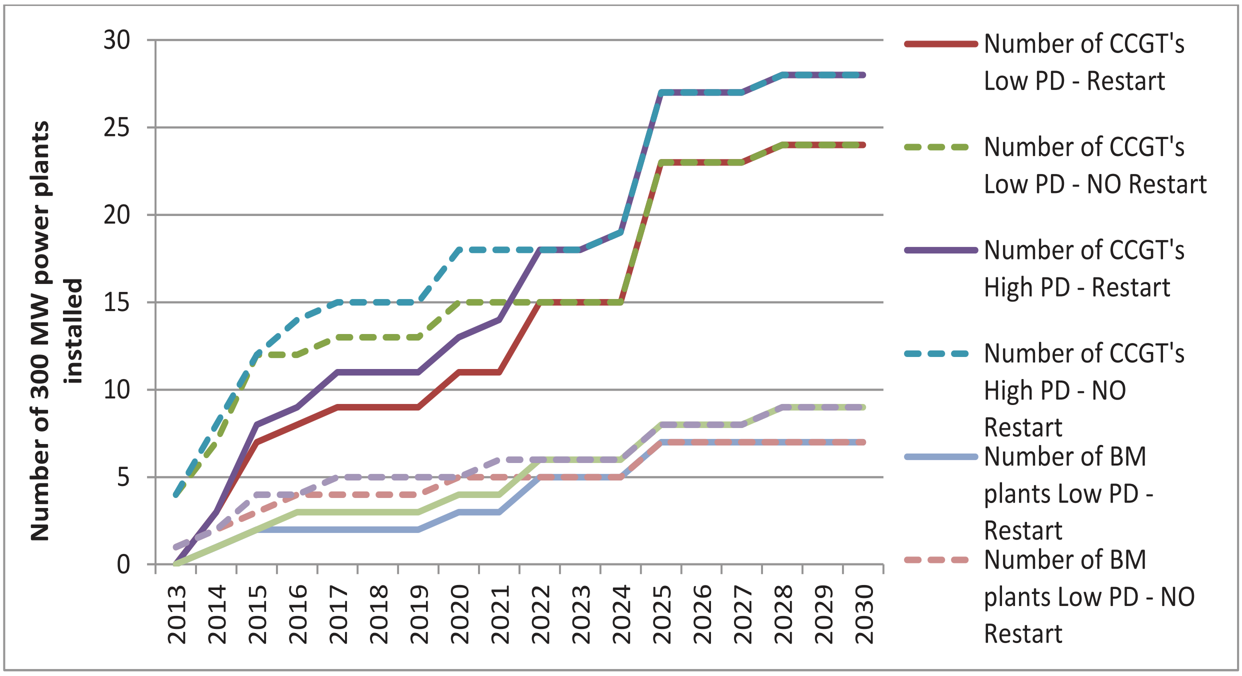
Shortage (MW)	2013	2014	2015	2016	2017	…	2020	…	2025	…	2030
Low PD - Restart	0	919	2524	2940	3203		4015		8983		9297
Low PD - NO Restart	1358	2691	4297	4712	4975		5788		8983		9297
High PD - Restart	0	1103	2892	3491	3938		4980		10338		11052
High PD - NO Restart	1358	2875	4664	5263	5710		6752		10338		11052

> *Belgium will be import dependent already this winter, and will soon have a high risk for black outs in the "worst case" scenario of rising peak demand and the inability to restart Tihange 2 and Doel 3*

Figure 11 shows how many new (300 MW) biomass and CCGT plants would be required to keep the reserve margin above 5% in Belgium in 2013-2030. We find a need for a fast expansion in the first 5 years, and also a strong growth in 2025, when the nuclear phase-out is complete.

In the "NO Restart" scenarios (dotted lines in the graph), about 15 new CCGT's and 5 new biomass plants would need to be installed by 2020. If it would be possible to restart Doel 3 and Tihange 2, this would drop to about 13 CCGT's and 4 Biomass plants. In total, between now and 2030, there would be a need to install about 24 new CCGT's and 7 new biomass plants in a "low peak demand" scenario and 28 CCGT's and 9 biomass plants in a "high peak demand" scenario, in order to keep the reserve margin at the 5% level.

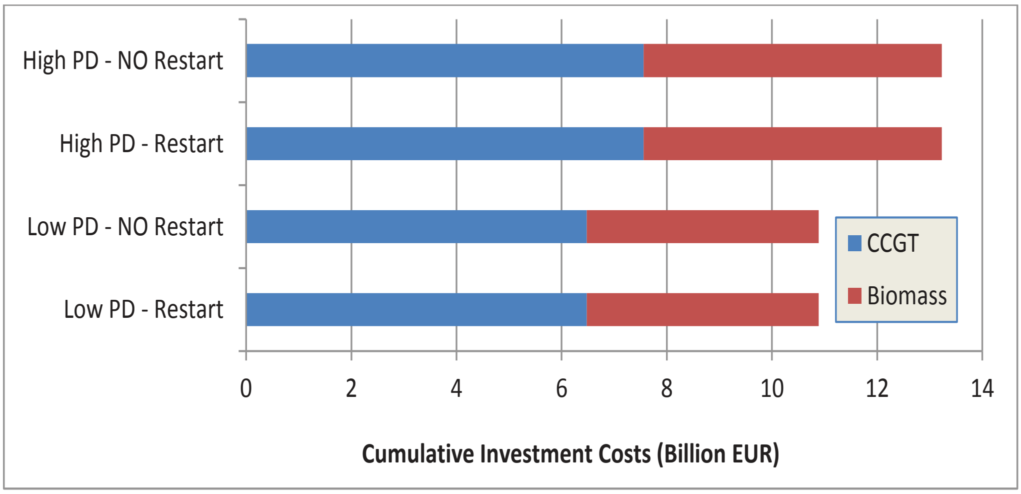
Figure 11: Needed investments in firm capacity in 2013-2030 in Belgium



If we multiply the needed power plants with the above mentioned investment costs we find that cumulative investment costs (2013-2030) reach almost € 13 billion in the High PD (high peak demand) scenario, and about € 11 billion in the low PD scenario (Figure 12). The cumulative costs in the "NO Restart" and "Restart" are obviously the same, since the reactors in Doel 3 and Tihange 2 are eventually shut down in both scenarios, and need to be replaced in any case. However, as the results from Figure 11 suggest, installing 15 new CCGT's in only 5 years time - required to replace the nuclear and fossil assets in the "No Restart" scenario - is likely to be impossible. We thus need to carefully nuance the results that this simplified model provides.

Keep in mind that the investment estimates mentioned here are a sub-estimate of all the costs that are required to keep the lights on. We ignored other costs such as the costs for expanding the network, the cost of subsidizing the use of biomass feedstock, …

<u>Figure 12</u>: Cumulative investments in firm capacity in Belgium (2013-2030)



"Cumulative investment costs (2013-2030) reach almost € 13 billion in the High PD (high peak demand) scenario, and about € 11 billion in the low PD scenario"

4. Conclusion and discussion

This paper confirms the issues of security of supply in Belgium already mentioned in some studies [23] [20] [21]. We expand this literature by incorpotating the safety issues regarding the possible preliminary closure of two important nuclear reactors (Tihange 2 and Doel 3) into our analyisis. Also, we have expanded the scope of the study beyond 2017. Finally, we have made a basic assessment of the scale of the needed investments in order to guarantee security of supply in Belgium, i.e. always securing a minimal reserve margin of 5%.

We find that the 'abnormalities' found in the reactors of Tihange 2 and Doel 3 result in drop of the reserve margin from +8% to -5% this year. After the phase-out of Doel 1 and 2 (according to the Plan Wathelet) and other fossil assets the reserve margin will drop to about -30% in 2015-2016 if the reactors in Tihange 2 and Doel 3 remain closed. This is a very critical situation.

> *Import dependency of Belgium will increase rapidly in the next years*

The short term issues adressed here are aggravated further due to the ongoing economic crisis in the EU and the sharp drop of the wholesale electricity prices, as shown in Figure 5. Belgium, being a relatively small and well connected nation, needs to compete with cheap coal and nuclear from it's neighbouring countries in times of sufficient supply. When there is a shortage risk, the interconnectors are congested and prices in the CWE-region diverge. The maximal import capacity of Belgium is only 3 500 MW. The results from Table 5 show that the import dependency of Belgium will increase rapidly in the next years.

From our investment model we can see that a huge number of new assets will be required to replace al the nuclear and fossil assets that are planned to be phased-out between 2013 and 2030. The total amount of needed new capacity by 2030 reaches 9 GW in a "Low Peak Demand" case and 11 GW in a "High Peak Demand" case. Filling this capacity gap with biomass and gas assets between 2013 and 2030 would result in cumulative investment costs of € 11-13 billion. Here we only include investment costs, not operational costs or 'external' costs such as grid expansion or reinforcements grid or the costs of the growth in intermittent renewables that do not contribute (much) to the reserve margin.

This simplified analysis is not complete. Investments in additional interconnection, massive storage systems and effective demand-response instruments can partly alleviate the problematic situation. Electricity prices can strongly recover after 2018 or effective capacity renumeration schemes can possibly trigger the needed investments. Nevertheless, it is unlikely that all these evolutions start tomorrow. Furthermore, each possible solution can increase the level of uncertainty for investors. With new interconnections, building new generation assets in Belgium is more risky than with a stable level of interconnections. Massive storage systems can eliminate the running hours of peakers and even of CCGT. Capacity renumeration schemes risk to lock-in assets in such a way that other investors face no ability to run their new power plants for sufficient amount of hours.

Since part the problem relates to market dynamics that keep old assets long on-line for too long – old coal-powered plants have higher load factors – the most pragmatic solution includes the coordination of phase-out schemes among EU Member States. In the Dutch Energieakkoord, the closure of several old coal-powered plants is annouced. Germany has to phase-out old coal-powered plants since these assets lead to increasing CO2 emissions despite massive investments in renewable generation. This situation is not sustainable, not to say very embarassing. A coordinated and credible effort to phase-out old assets can provide sufficient market signals to trigger new investments.

Bibliography

1. CIA. (2010) Electricity from nuclear fuels. [Online]. https://www.cia.gov/library/publications/the-world-factbook/rankorder/2239rank.html?countryname=Belgium&countrycode=be&regionCode=eur&rank=2#be

2. Nuclear Forum. (2014) Nuclear Forum - Energy. [Online]. http://forumnucleaire.be/nl/forum/de-kerncentrale-van-tihange

3. Aviel Verbruggen, "Belgian nuclear power life extension and fuss about nuclear rents," Energy Policy, pp. 91-97, 2013.

4. Reinhard Haasa et al., "A historical review of promotion strategies for electricity from renewable energy sources in EU countries," Renewable and Sustainable Energy Reviews, pp. 1003-1034, 2011.

5. Eurostat. (2014) Share of renewable energy in gross final energy consumption. [Online]. http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables

6. EPIA. (2014) EPIA. [Online]. http://www.epia.org/news/publications/

7. Ruben Laleman, Johan Albrecht, and Jo Dewulf, "Life Cycle Analysis to estimate the environmental impact of residential photovoltaic systems in regions with a low solar irradiation," Renewable and Sustainable Energy Reviews, pp. 267–281, 2011.

8. Wathelet. (2012, July) Melchior Wathelet let de kernuitstap vast. [Online]. http://wathelet.belgium.be/nl/2012/07/20/persbericht-20-juli-2012-melchior-wathelet-legt-de-kernuitstap-vast/

9. Wathelet. (2013, July) Goedkeuring van het Plan Wathelet door de kern. [Online]. http://wathelet.belgium.be/nl/2013/07/05/goedkeuring-van-het-plan-wathelet-door-de-kern/

10. Wathelet. (2013, December) Met de strategische reserve voltooit Melchior Wathelet de uitvoering van zijn plan. [Online]. http://wathelet.belgium.be/nl/2013/12/16/met-de-strategische-reserve-voltooit-melchior-wathelet-de-uitvoering-van-zijn-plan/

11. ANC. (2014, July) Doel 3 and Tihange 2 still temporally shut down until further notice. [Online]. http://www.fanc.fgov.be/GED/00000000/3600/3657.pdf

12. European Commission. (2004) Quarterly Review of European Electricity Prices. [Online]. http://ec.europa.eu/energy/observatory/electricity/electricity_en.htm

13. European Commission. (2006) Quarterly Review of European Electricity Prices. [Online]. http://ec.europa.eu/energy/observatory/electricity/electricity_en.htm

14. European Commission. (2008) Quarterly Review on European Electricity Markets. [Online]. http://ec.europa.eu/energy/observatory/electricity/electricity_en.htm

15. European Commission. (2013) Quarterly report on european electicity markets, 2nd quarter 2013. [Online]. http://ec.europa.eu/energy/observatory/electricity/doc/20130814_q2_quarterly_report_on_european_electricity_markets.pdf

16. The Economist. (2013, October) How to lose half a trillion euros. [Online]. http://www.economist.com/news/briefing/21587782-europes-electricity-providers-face-existential-threat-how-lose-half-trillion-euros

17. FOD Economy. (2012) Rapport over de middelen voor elektriciteitsproductie 2012 -2017. [Online]. http://economie.fgov.be/nl/binaries/Rapport_middelen_elektriciteitsproductie_2012-2017_20120702_NL_tcm325-186312.pdf

18. CREG. (2012, June) Studie (F)120621-CDC-1164 over het eerste deel van het tussentijds rapport van de FOD Economie, K.M.O., Middenstand en Energie (Algemene Directie Energie) over de productiemiddelen voor elektriciteit 2012-2017 en aanbevelingen. [Online]. http://www.creg.info/pdf/Studies/F1164NL.pdf

19. Bureau Fédéral du Plan. (2013, September) Working paper 4-13: Analyse de l'adéquation de la production électrique en Belgique à l'horizon 2030. [Online]. http://www.plan.be/admin/uploaded/201311060918440.WP_1304_FR.pdf

20. Bureau Fédéral du Plan. (2014, March) een kwantitatieve analyse van stroompannes in België. [Online]. http://www.plan.be/admin/uploaded/201403170843050.WP_1403.pdf

21. KU Leuven Energy Institute. (2013) Security of Electric Power Supply. [Online]. http://set.kuleuven.be/ei/images/EI_factsheet2_eng_def.pdf

22. EIA. (2012, June) Reserve electric generating capacity helps keep the lights on. [Online]. http://www.eia.gov/todayinenergy/detail.cfm?id=6510

23. ENTSO-E, "Winter Outlook Report 2012/2013 and Summer Review 2012," 2012

24. European Commission, "Delivering the internal electricity market: making most of public intervention," 2013.

25. DENA. (2010) Deutsche Energie-Agentur GmbH. [Online]. http://www.dena.de/fileadmin/user_upload/Projekte/Energiesysteme/Dokumente/KurzanalyseKraftwerksplanungDE_2020.pdf

26. Eurelectric, "Eurelectric Electricity Market Data ," 2013.

27. IHS. (2013, March) bruegel. [Online].http://www.bruegel.org/fileadmin/bruegel_files/Events/Presentations/130322_ECE/130321_IHS.pdf

ITINERA | Policy Think Tank
Paving New Ways

Itinera Institute VZW-ASBL
Hertogsstraat • Rue Ducale 31
B-1000 Brussel - Bruxelles
www.itinerainstitute.org