Commission ENERGY 2030

— FINAL REPORT —

Executive Summary

June 19, 2007

Belgium's

Energy Challenges

Towards 2030

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Key Messages in a Nutshell[1]

The **objective** of a sound energy policy is to offer energy services for a variety of applications, based on *an energy basket that guarantees a firm security of supply, at an acceptable cost for society, and in an environmentally friendly way.* In that respect, Belgium must think in European terms and do so entirely.

The Belgian energy policy will have to consist of a **balanced mixture of contributing elements.** Four groups of "energy sources" have to be considered, each having their specific merits and limitations, and it is generally recognized by most relevant international organizations such as IEA and the EU that omitting one of them will likely lead to a sub-optimal solution, the four being energy savings, carbon-based resources, nuclear and renewables. First and foremost, **energy savings** must be advocated and implemented as much as techno-economically possible. To reflect the value of energy as an economic good and the related external costs, to keep sufficient pressure for rational use of energy, and to optimize load time management, **energy prices must be fully passed on to the customer.**

On the supply side, a diversity of primary energy sources and conversion technologies must be opted for, with a voluntaristic, but nevertheless still 'doable' integration of **renewables**. Because of limited potential of **renewables**, Belgium should implement the EU directives in a clever and justified way to contribute to a healthy European energy mix and environmental-burden reduction. Until a full CO_2 allowance market is established, Belgium may commit to *ambitious quota (in % terms) for supply of renewable energy* to the end customers but decouple it from local production, and should advocate European exchange of certificates.

Belgium should **reconsider its offshore wind policy** and be more forthcoming in the concession allocation of sites. The authorities should *reconsider the sites of the 'Wenduine Bank' and the 'Vlakte van de Raan'*, as these sites may offer a reasonable degree of technological success at an acceptable cost. *Far offshore sites* are not to be dropped, but should *be developed meticulously*. Through a carefully designed staged process, an international leading role for far offshore may be established.

Accounting for the post-Kyoto agreements, Belgium has to use the appropriate means to cope with them in the most economic way, both by stimulating greenhouse gas reduction on a national basis and by emission trading mechanisms. Regarding the use of coal for electricity generation, Belgium must collaborate strongly internationally on the **development of *Carbon Capture and Storage* (CCS).**

The circumstances when the nuclear phase-out law has been voted have **changed substantially**; the urgency for climate-change action is becoming evident and the era of very cheap fuel prices is most likely behind us. This facing with current reality and future expectations, requires a profound reconsideration of the current official Belgian standpoint on nuclear power. Phasing out nuclear power in Belgium by 2025 under a considerable post-Kyoto constraint and in the absence of CCS will be extremely expensive and strongly perturbing for our economic fabric. Therefore, it is advised to *keep the nuclear option open* and to *reconsider the nuclear phase out.*

On **security of supply**, four aspects are to be focused on as priorities.

- ***Diversity of supply of primary sources and technologies*** (type and origin) is the first and foremost rule.
- A stable ***investment climate*** must be guaranteed for competitive market players to have sufficient new *electricity generation capacity on line timely* and to keep a substantial *refinery capacity.*
- Transmission and distribution network operators must be 'allowed' to invest in extensions, adaptations, and preventive maintenance, so as to ***avoid supply interruptions***, support the connection of renewables and facilitate the European market; the Regulator must accept the

[1] These Messages and Conclusion & Recommendations of the CE2030 are endorsed by all Permanent Members and most Non-Permanent Members. Non-Permanent Member JP van Ypersele can only accept a possible delaying of the nuclear phase out by five years (without construction of new nuclear plants), if in the mean time a transition to a non-nuclear future is prepared with ambitious measures. See footnotes on point 3 of the Recommendations.

costs involved being transmitted to the customers; environmental and construction permits must be delivered timely by the competent authorities.
- A comprehensive study to find the appropriate energy mix, a.o., based on the *portfolio theory* must be carried out.

The **liberalization** process for **electricity and gas in Belgium** must be continued in line with the European common energy market concept. Industry has to be enabled to fully participate in the European *wholesale energy market*, by co-investing in generation assets, by long-term contracts, by establishing a liquid wholesale market, supported by sufficient transnational transmission capacity. Sufficient *retail market access should develop over time* to reach a good mix of suppliers in Belgium. Regulated capped prices at the retail level are advised against.

Strict supervision by a competent and independent Regulator is necessary while accounting for the development of a European regulatory institution.

Belgium should devote **much more research & development means to energy**. To maximally profit from economies of scale, substantial financial incentives must be given to research groups for participation in *European projects*. European energy research priorities must be the guideline. In order to coordinate this work and to gather the necessary data for decision makers, Belgium should establish a Strategic Energy Watching Brief.

In order to achieve all the above, the governments should take initiatives to stimulate young people to be trained in modern energy systems (technicians, engineering professionals, architects, economists, …).

Upon lifting the nuclear phase-out law, an agreement with the owners of the Belgian nuclear power plants is to be sought for, to establish a "correct" nuclear-extension concession fee, the revenues of which could be used for stimulating investments in energy savings & demand-side management, for development in renewable energy, for development & research in emerging energy technologies and carriers.

Executive summary

Terms of Reference of the Commission ENERGY 2030

The final report of the Commission ENERGY 2030 has been submitted to the Federal Government on June 19, 2007. Its conclusion and recommendations have been approved by all Permanent Members and most Non-Permanent Members.[2] The final version of this report has been released to the public on June 22. This final report has taken into account the relevant and pertinent remarks and comments put forward by the External Review Panels, which have provided their input in March 2007.

The Commission ENERGY 2030 (CE2030) has been formally set up by the Royal Decree of December 06 2005 (Moniteur Belge / Belgisch Staatsblad of December 19 2005). The main objective of the assignment given to the Commission ENERGY 2030 for studying Belgium's energy policy up to 2030, in a European context, is set out in the study's Summary Memorandum, formally enacted through the Royal Decree. The goal is to «*provide the scientific and economic analyses necessary to evaluate Belgium's options with regard to the energy policy up to 2030*». Furthermore, it is stated that the study will «*specifically focus on the economic, social and environmental aspects associated with the various options or scenarios for investment policy involving production, storage and transport while bearing in mind the different types and sources of renewable and non-renewable energy as well as examine the issues of security of supply, energy independence and technical feasibility*». The study also looks into the cost of the energy system, trends in regional and national energy demand, honoring agreements concerning the environment and the maintenance or further development of technological know-how.

Guidelines to the Reader; Structure of the Report

The main Report of the Commission ENERGY 2030 tries to address both *'comprehensively'* but relatively *'concisely'* the energy challenges of Belgium with a time horizon of 2030. Towards that end, we examine effectively all energy-related matters across the board, without repeating what has been covered in other good writings.

The aim of this report is to identify the major characteristics of the Belgian energy system (as part of the European and world energy markets), to explain the considerable challenges ahead, and to propose ambitious but realistic routes towards a 'sustainable' energy future. Based on its analyses of the whole energy chain & system, supported by scenario results provided by a simulation model, the Commission ENERGY 2030 (henceforth mostly abbreviated as *CE2030*) has acquired a good understanding of the ins and outs of the Belgian energy economy. Hereby, the past is deliberately considered as 'having occurred' (and being non 'retraceable') but valuable lessons from it have been drawn, and corrections towards a reorientation will be proposed if deemed necessary. The challenge for the CE2030 is to propose credible 'solutions' to get us safely to the year 2030 and beyond, by outlining the right directions and hence, by laying the groundwork for a longer-term energy future.

It must be stressed that the Commission ENERGY 2030 was not commissioned to perform own research work or modeling-development. The existing model PRIMES has been utilized to execute energy scenarios with plausible constraints and policy options. Modeling exercises are very important as consistency check, but as models cannot be expected to represent all the intricacies of the complex energy economy, careful judgment is required in interpreting the results. Models always follow a straightforward but unavoidably simplified modeling logic, thereby unable to deal with all feedbacks of economic agents, including policymakers. The modeling results give most valuable *indications* and *trends*. However, these findings must be complemented with qualitative evaluation and qualified expert opinion. In any case, scenario results should never be considered as predictions of the future: scenarios are modeling exercises which, given the ('mechanistic') algorithm and structure of the simulation model, the inputs, the boundary conditions and hypotheses, project what can be expected under these characteristics just mentioned. The expert judgment for qualifying the scenario results is guided by expertise, experience and the extensive existing energy-related literature.

Not counting the Executive Summary, the **Final Report** is therefore structured as follows:

[2] Non-Permanent Member JP van Ypersele does not agree with point 3 of the Recommendations on a possible lifting of the nuclear phase out as clarified by the footnotes over there. Some comments on energy efficiency by Non-Permanent Member W. Eichhammer have been made available on the website www.ce2030.be .

Part I is introductory in the sense that it collects all *ingredients* necessary for appropriate interpretation of the scenario simulations that are performed in a later part. Important therefore is a situation sketch of the Belgian energy economy, considering the evolutionary behavior of primary-energy demand, final-energy consumption, petroleum, gas and electricity carriers and markets, and the current energy prices in Belgium. Appropriate reference is made to the legal and regulatory framework of the energy theater. Before being able to launch into the analysis exercise, one must then identify the future challenges that we face to obtain a sustained and sustainable energy provision. In pragmatic translation of 'sustainable energy provision', we consider three important elements: a firm *security of supply*, both in the long run as to primary-energy delivery and concerning power reliability, so as to avoid blackouts. This energy provision must occur in a *clean* manner, whereby the threat for climate change is the most urgent 'constraint' on our energy system. In the end, the whole energy system must provide energy at *affordable prices* and be acceptable for the overall economy of the country. As a major component of energy provision in the wide sense, the consumption part is of uttermost importance. Therefore, in a separate chapter, the issue of energy demand and the opportunities and difficulties to establish energy savings are identified.

Part II then launches into a major *scenario exercise*, whereby first a baseline is considered that lets the energy system evolve based on existing legislation & measures and boundary conditions. In the baseline for Belgium, this means that no post-Kyoto limits are set and that the nuclear phase-out law is assumed to be fully enacted. A variety of other scenarios has then been considered, whereby two approaches have been taken. In a first approach, eight variants, with a domestic energy-related CO_2 emission reduction by 15% and 30% in 2030 compared to 1990, and with each time the nuclear phase out enacted or lifted, and with CO_2 capture and storage assumed to be available or not, have been performed. In a second approach, a EU-wide reduction by 30% of Greenhouse Gases (GHG) is imposed, whereby it is investigated how the Belgian energy theater responds to such obligation. In this second approach, domestic reductions of GHG are limited, but (depending on the type of burden sharing within the EU, if any) that will likely have to be compensated by emission reductions abroad, thereby effectively purchasing emission allowances. The results of these scenarios are summarized in the Conclusions hereunder.

After having performed the scenario exercise, the results of the modeling are confronted with the challenges revealed and we evaluate, qualify and further interpret the obtained results. Specifically, a mathematical model cannot include all parameters required to draw up a coherent energy policy (e.g. energy independence, security of supply, nature of electricity as a commodity and the impact of the liberalization of relevant markets, development of know-how, comparative analysis of practices in Europe and throughout the world). Therefore, a considerable additional interpretative analysis has been considered along with the results of the theoretical scenarios.

In **Part III** of the report, the Broader Belgian energy picture is looked at. We deal with issues such as 'Elements of the Belgian Liberalized Energy Markets', 'Import Dependency', 'Security of Supply & Reliability', 'Reaching Post-Kyoto in Practice', 'Socio-Economic Consequences', and 'The Nuclear Power Option'.

The main conclusions and recommendations are grouped together in **Part IV**, but for convenience, they are set out below. It is up to the public authorities to adopt them and put them into practice.

In addition to this Final Report proper, a set of **Supporting Documents** is being provided, which serve to document the issues of the main report.

In a first collection of supporting documents, essays on particular energy-related topics have been written by the different members of the CE2030 and by DG ENERGY of the Federal Ministry of Economic Affairs (FOD/SPF Economy). These documents are the sole responsibility of the individual authors; no attempt has been made to streamline those essays. They are to be considered as inputs to the overall discussion.

Likewise, a detailed account of the scenario analysis is provided in the second part of the supporting documents. The input report dealing with the PRIMES results is under the responsibility of the Belgian Federal Planning Bureau.

The Preliminary Report of the CE2030 has been reviewed by a set of **Review Panels**, reflecting a large cross section of the relevant societal actors. The following organizations/institutions have participated in the review:

* Belgium:
    - the Federal-Regional consultation cell (ENOVER/CONCERE)
    - Central Council for the Economy (enterprises & unions)
    - National Bank of Belgium,
    - the members of the Regulatory Forum (CREG, VREG, CWaPE, IBGE/ BIM)
    - Federal Council for Sustainable Development (CFDD/FRDO)
    - Belgian Academy Council for Applied Sciences (BACAS)
* International:
    - International Energy Agency (IEA)
    - Directorate General Energy of the European Commission (DG TREN)

The CE2030 has analyzed and evaluated the comments made by the Review Panels and has taken into account the relevant and pertinent remarks for the final version of its Report. The Preliminary Report of the CE2030, the questions & answers by the Review Panels throughout the process and their comments are available on the CE2030's website, given below.

In line with the Royal Decree, this Final Report has been submitted to the Minister of Energy on June 19 2007.

This Report and the Supporting Documents, and relevant documents can be consulted at the CE2030 website, http://www.ce2030.be .

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Finally, 'last but not least', the CE2030 is very thankful and greatly acknowledges the efforts, input, reflections and analyses provided by D. Gusbin and D. Devogelaer of the Federal Planning Bureau. Their scenario-analysis documents have served as the major input to the activities of this Commission Energy 2030.

Summarizing Conclusions of the Commission Energy 2030

The Energy Issue is a Daunting Challenge

The **goal** of a comprehensive energy-provision strategy for Belgium must be to offer energy services[3] for a variety of applications, but in a 'sustainable' manner. Viewed pragmatically, a 'sustainable energy provision' relies on *an energy basket that simultaneously guarantees a firm security of supply, at an acceptable cost for our society,[4] and in an environmentally friendly way.*

Against the current situational background of the following elements:

- *oil & gas prices* that fluctuate strongly and can be very high;
- the anticipated *soaring energy-demand on a worldwide* scale to give poorer nations a well-deserved energy provision, in turn leading to possibly severe *tensions on the world energy-supply scene*;
- the lack of own energy resources, and therefore the *very large import dependency* for oil and gas from geopolitically unstable regions, with very strong oil dependence for transport, home heating and chemicals, and strong gas dependence for industrial applications and electricity generation;
- the *geographical reality of our country*, considerably limiting the natural influx of renewable flows;
- expected substantial *post-Kyoto GHG- and CO_2-emission reduction obligations*;
- the existing *nuclear phase-out law*, starting in 2015 and fully executed in 2025;
- the creation of a *common liberalized European energy market*;
- the *huge investments* needed worldwide to replace existing and ageing energy infrastructure, to develop further production investments for oil and gas, to extend transmission networks for electricity and gas;

and the *high degree of uncertainty* with many of them, the CE2030 must conclude that **the future energy provision for Belgium represents a *daunting challenge* over the coming 25 years and beyond**.

A European Approach is Imperative

As a result of its analysis of the current situation in Belgium, Europe and worldwide, and the scenarios performed and studied, the CE2030 has the conviction that Belgium cannot afford to solely think nationally in energy matters, albeit that national responsibilities should not be evaded. Indeed,

- concerning *import dependency and security of supply* (especially towards an optimal mix of long-term contracts and spot-market supply of gas, and gas storage capability; exchange of electrical fluxes to smoothen out imbalances);
- for establishing a real competitive energy market (especially on the wholesale level for gas and electricity);

[3] By "energy services" is meant the activities and applications we wish to enjoy: heat rooms to comfortable temperatures, keep food and drinks cool, drive kms, provide drive power and process heat in industry, etc. This concept here is different from the "services" provided by so-called "energy service companies (ESCOs)".

[4] The CE2030 considers the **social** aspect of energy provision as being part of the economic dimension. All scarce resources must be utilized in the most efficient way, and prosperity for society should be maximized (subject to obvious and/or reasonable constraints) and the acquired welfare must then be distributed in an equitable way, such that all members of the population could benefit from a well-functioning economy. The social issues go much broader than merely energy issues; governments must develop a broad social framework for their citizens. The energy-provision issue must not be singled out for social-policy purposes, but citizens must get equal and fair access to all energy-related opportunities. If imperfections exist, authorities should correct these distortions, and possibly compensate. However, priority must go to a broad social framework; energy-related interventions should be limited in time (except for the right to have access to a certain minimum of energy supply).

- since most of the energy-conversion infrastructure is owned by international shareholders and is operated in function of the European market, and perhaps more so in the future;
- for making its GHG-reduction commitments acceptable (to basically finance reduction emissions elsewhere);
- to demonstrate sufficient weight on the international scene for negotiations with equipment manufacturers, for launching large R&D programs, …;
- to push through necessary but difficult decisions and commitments, that are unpleasant/hard to make on a national level (similar to e.g., the Maastricht criteria);

a ***European-wide approach*** **is imperative**. The CE2030 is therefore of the firm opinion that Belgium has to fully subscribe to a **European energy policy**, thereby relying on an **appropriate regulatory EU framework**.

Conclusions of Scenario Analysis

The CE2030 has carefully studied the energy-provision issue for Belgium. It has done so by exploring and studying the relevant scientific, technical and economic energy-related literature, through consultation of experts in the field. Moreover it has examined the feasibility and economic costs of different scenarios with the time horizon of 2030, obtained by the PRIMES energy model.[5]

All sectors (industry, residential & commercial & service sector, transport sector, electricity sector) as well as all primary and final energy carriers (oil, gas, coal, renewables, uranium, electricity, heat) have been studied. Because of the circumstances, mainly induced by the climate-change threat, the electricity sector plays a crucial role, however, in that important switches (nuclear power and carbon capture & storage) are situated in that sector and because the gas supply for that sector is of utmost importance. Nevertheless, the interaction between all sectors and carriers is properly taken into account.

The CE2030 has furthermore reflected attentively upon the comments made by the Review Panels, and has taken into account the pertinent remarks in its final report.

All scenarios considered assume a reasonable projection of future demand for energy services (related to GDP growth, demographics, etc), identical to the recent PRIMES scenarios published by the European Commission DG TREN in May 2006. The results are clearly related to this basic hypothesis; a slower growth will lead to less pressure on the energy system; if growth turns out to be higher, then reality may be more demanding than what the model results show.

Baseline Scenario

A first so-called ***baseline scenario*** (basically a further endogenous future energy-system development, designed to allow comparison with later alternative scenarios) implements all energy- and climate-related policy measures and instruments agreed upon until 01.01.2005. It assumes no extra policy measures and does not impose any post-Kyoto constraints on greenhouse gases (GHG). In this scenario, the nuclear phase out is assumed to be fully effectuated.[6] [7]

In the baseline projections, despite a considerable increase of energy-service demand, the final energy demand itself (at the level of the consumer) increases only moderately. This means that relatively cheap options for energy efficiency are taken up, leading to a considerable decrease by 2030 in energy intensity[8] by 30% compared to the value in 2005 for all sectors. In the baseline

[5] The actual scenario runs with the energy-system model PRIMES have been executed by the University of Athens (NTUA). The scenarios were defined by the CE2030 after discussion with experts of the Belgian Federal Planning Bureau (FPB), which was responsible for the detailed scenario analysis. At the present time, there is no appropriate modeling alternative since the PRIMES approach has been selected by the FPB and the renewed version of MARKAL/TIMES was not ready for detailed examination within the CE2030 framework. Moreover, PRIMES is a widely recognized European model, frequently used by the European Commission as a tool for helping to design its energy policy.

[6] The Baseline is not designed to meet medium-term targets (e.g., in 2012); in principle, it provides a means to check whether the measures are sufficient to meet the targets.

[7] Assumed fuel prices start from 55$/bbl in 2005, to become 60$/bbl in 2030. Gas prices are coupled to oil prices. All prices are expressed in constant terms in $2000.

[8] Being the energy demand per unit GDP.

scenario, coal-based electricity generation basically replaces most of the nuclear capacity and increases fivefold between 2020 and 2030. Overall CO_2 emissions increase substantially from 116 Mton/a in 2005 to 140 Mton/a in 2030 (being an increase by 32% compared to 1990). In this baseline scenario, the higher oil & gas prices and the nuclear phase out put a certain pressure on the energy system, but the absence of a post-Kyoto limit allows a 'convenient' escape route through the massive installation of coal power plants for electricity generation. ***Clearly, the Baseline is not sustainable*** with regard to CO_2 emissions.

A variant to this baseline, assuming *'soaring' oil prices* up to 100 $/bbl in 2030, does not lead to a dramatic difference. The final energy demand is slightly lower but the overall CO_2 emission remains at the same level as in the baseline.

Alternative Scenarios with Post-Kyoto Obligation

To contrast with the baseline, several *'alternative' scenarios* have been considered in order to find out what the effect of certain policy choices & technology-availability options are.

Two types of scenarios have been examined. In a first approach only domestic reductions of energy-related CO_2 emissions on the Belgian territory have been implemented. In a second approach, a European-wide Greenhouse-Gas reduction (GHG) obligation has been imposed. Part of these reductions has been materialized in Belgium; the remaining obligations are to be satisfied by purchasing emission allowances abroad.

a. Domestic CO_2 Reduction Constraint

Two post-Kyoto targets of 15% and 30% of domestically energy-related CO_2 reductions in 2030 compared to 1990 have been investigated, with for each case the implementation of the nuclear phase-out law, and the possibility for Carbon Capture and Storage (CCS) as additional 'turn-on/switch-off' variables. Such scenarios have the advantage of being transparent and they show the degree of difficulty to meet the imposed constraints domestically.

The scenario results show indeed that domestically effectuated CO_2 cuts up to 30% are not affordable for Belgium if nuclear power is phased out and if carbon capture & storage (CCS) turns out to be unavailable. This is a proof 'ex absurdo'.

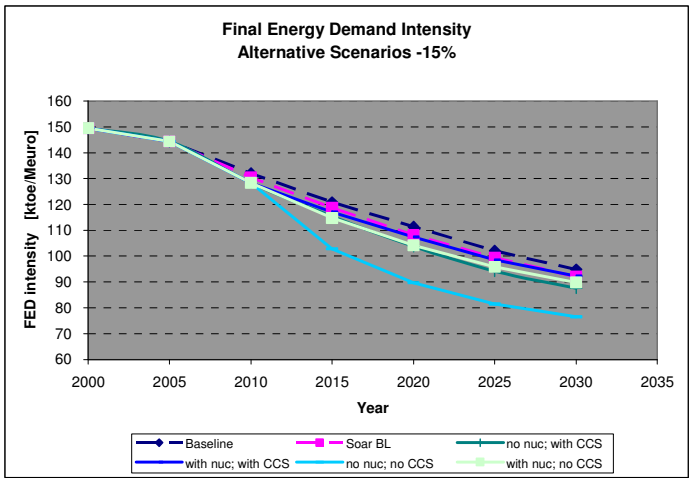
Without nuclear power and without CCS, marginal CO_2 abatement costs (or market price for CO_2 permits, here called 'Carbon Value', or CV) of up to 500 to 2000 €/ton CO_2 for the -15% and -30% scenario, respectively, are reported. For the same increasing energy-service demand as in the baseline, these very high carbon values force a drastic final-energy demand reduction, well beyond those demand reductions doable at reasonable cost, and thereby imposing a high cost on our economy.

With such pressure on the energy system, final energy demand for the 15%-reduction case diminishes by 20%, and the energy-related cost in 2030 compared to the year 2000, would increase by 150% in industry, 150% in the tertiary sector and by 170%, in the residential sector, compared to 24%, 31% and 63%, respectively, in the baseline.[9]

For the 30% CO_2 reduction case, these numbers are much more dramatic. The final energy reduces by somewhat more than 30%, while the energy-related cost in 2030 would increase by an astounding 440%, 510% and 420%, for industry, tertiary and residential sector, respectively, again compared to 24%, 31% and 63% in the baseline.[10]

Primary-energy import dependency (in terms of average energy per year) amounts to about 90% for both cases.[11] Gas dependency for electricity generation is about 80-85%, again in average annual energy terms, but more than 90% when the installed wind and photo-voltaic (PV) capacities are not able to deliver power.

[9] Expressed in €2000/toe.
[10] Expressed in €2000/toe.
[11] Import dependency in the Baseline (also with the nuclear phase out implemented) amounts to 95%.



Energy prices per unit energy per sector

Values for 2030	**Industry** [€2000/toe]	**Tertiary** [€2000/toe]	**Residential** [€2000/toe]
	In 2000: 540	In 2000: 820	In 2000: 960
Baseline	660 (24%)	1100 (31%)	1600 (63%)
-15% no nuc / no CCS	1300 (150%)	2100 (150%)	2600 (170%)
-30% no nuc / no CCS	2900 (440%)	5000 (510%)	5000 (420%)

(% change between 2000 and 2030) ; 1 toe = 41.868 J = 11.63 MWh

If a ***nuclear phase out*** is implemented**,** and given expected technological evolution, the scenario results show that domestic CO_2 reductions are ***very expensive.*** The numbers, as produced by PRIMES under the given hypotheses, show that a domestic CO_2 reduction of up to 15% would be barely tolerable; but also the 'unreasonableness' of a domestic 30% CO_2 reduction scenario by 2030 (compared to 1990).

After having utilized the other 'solution paths', such as energy savings and renewable energy, to a maximum reasonable extent according to PRIMES, substantial relief of this extremely heavy task to reduce domestic CO_2 emissions can be further obtained if ***carbon capture and storage (CCS) would be available*** or if ***nuclear power were allowed*** to continue operation beyond 2015 and 2025.

For the 15% CO_2 reduction cases, marginal abatement costs (CVs) of about 50 to 100 €/ton result, whereas the -30% case still leads to CVs of the order of 200 to 500 €/ton. Still a 'respectable' end-energy demand reduction occurs, albeit at a lower cost.

To go from 2000 to 2030, the projected energy-system costs for the end-use sectors are as follows. For the -15% case, the cost is 'slightly' higher than the cost in the baseline (although still up to 50% higher for industry) if nuclear power were allowed, whereby the no CCS case is yet somewhat more costly; the case without nuclear power but with CCS, has a system cost that is 2 to 4 times more expensive than the baseline.

For the 30% reduction case, costs with nuclear power allowed range from about 2 to 4 times the cost of the baseline (compared to a factor 15 to 20 without nuclear power and without CCS), with the case with both nuclear and CCS available, being the cheapest.

The import dependency reduces to about 65-70% when nuclear power is allowed.[12]

[12] Here, import dependency over a time scale of about one to two years is meant. Nuclear generated electricity is considered of domestic origin on this time scale.

Energy prices per unit energy per sector

Values for 2030	**Industry** [€2000/toe]	**Tertiary** [€2000/toe]	**Residential** [€2000/toe]
	In 2000: 540	In 2000: 820	In 2000: 960
-15% with nuc / with CCS	730 (37%)	1100 (36%)	1600 (71%)
-15% with nuc / no CCS	790 (47%)	1200 (43%)	1700 (79%)
-15% no nuc / with CCS	970 (81%)	1500 (83%)	2000 (110%)
-30% with nuc / with CCS	930 (73%)	1400 (73%)	2000 (100%)
-30% with nuc / no CCS	1200 (120%)	1800 (120%)	2400 (150%)
-30% no nuc / with CCS	1300 (130%)	2000 (140%)	2500 (160%)

(% change between 2000 and 2030) ; 1 toe = 41.868 J = 11.63 MWh

It must be noted, however, that these two 'alleviating options' are not equivalent though. Carbon capture and storage is still to be developed and it is very risky to assume that it will be routinely commercially available by 2030 in Belgium (especially the storage part). Nuclear power is currently operating, meaning that this is an option that the Belgian policy makers can make available to the electricity generation sector.

To give the system model some liberty to find an outcome, not too many constraints on potentials were imposed. In a post-model interpretative analysis, a pertinent situation sketch, concentrating on the challenges revealed, has qualified these simulation results. By confronting the challenges revealed with plausible 'real-life' difficulties, such as taking into account the grid-extension costs for massive expansion of offshore wind capacity (> 900 MW) and PV installed power (> several 100 MW), the rate of technology manufacturing, and the offers asked from the consumers to pay extra for a particular new type of energy provision, the situation will be more critical, both for import dependency and system cost.

The system cost to adapt the high voltage network for 3,800 MW offshore wind power is estimated to be about 700 M€; the adaptation of the distribution grid to accommodate more distributed generation, amongst which massive utilization of PV, is estimated to be about 2,000 M€ over a period of 10-20 years.

The commitments for green certificates may be overwhelming and policy makers must realize what they promise, so as to remain correct to investors, on the one hand, and with regard to the offers they ask from the final energy consumers, being reflected in higher energy tariffs/prices, on the other hand. Assuming that the current legal framework of guaranteed buy-back prices[13] is kept, are in constant € and if paid during 20 years, then the following daunting cost figures would apply:

- the current 846 MW of offshore wind farms with concession ~ 6,000 M€[14]
- the next 3000 MW offshore wind power ~ 21,000 M€
- for 2000 MW onshore wind ~ 7,000 M€
- for 1000 MW PV ~ 7,200 M€
- for 1500 MW biomass ~ 9,600 M€

In total, for the 'foreseen' renewable expansion, the end customer will have to contribute via green certificates, and thus increased tariffs, something in the order of a total of ~ 50,000 M€ over 20 years, or about 1/5 of the GDP of 2000, or roughly 1/10 of the estimated GDP of 2030, or 0.7% of the average GDP/a over the period 2000-2030.

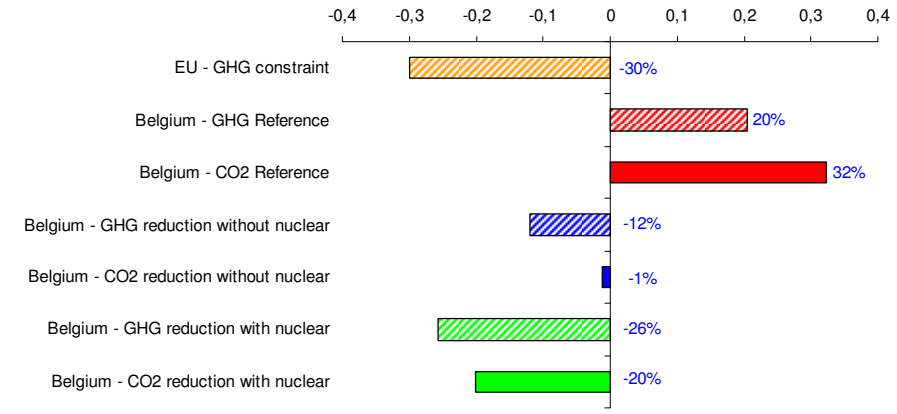
This exercise also shows that the simulation results of 10,000 MW PV (with a similar support scheme) are quite unrealistic. Indeed, such support would add up to ~ 72,000 M€, which together with

[13] Note that this is effectively equivalent to a feed-in tariff.
[14] M€ stands for one million €. The comma represents thousands (English language convention). 1,000 M€ = one "milliard" in French and one "miljard" in Dutch.

the above amounts to about ~ 115,000 M€ or ~ 1/3 of the average GDP/a of the period 2000-2030, or about 40% of our national debt.

b. European GHG Reduction Constraint

In a second approach, an overall European GHG reduction target of 30% in 2030 compared to 1990 has been investigated.[15] After an estimate of the decline of the non-CO_2 GHG, taking into account the marginal abatement costs of all European countries, and by freely allowing European exchange of climate reduction efforts through flexible mechanisms, it is found how the CO_2 reductions are distributed over the countries. In all scenarios here, no CCS is considered to be available.



GHG = greenhouse gases
Reference = Baseline

Hatched ////// : GHG emission change
Full color : CO_2 emission change

Orange = Imposed GHG constraint on EU level
Red: Baseline (no post-Kyoto constraint imposed)
Blue: without nuclear
Green: with nuclear

In the Baseline (being the same as already considered; labeled as "Reference" in the figure), GHG emissions in Belgium would increase by 20% while CO_2 emissions would increase by 32% compared to 1990.

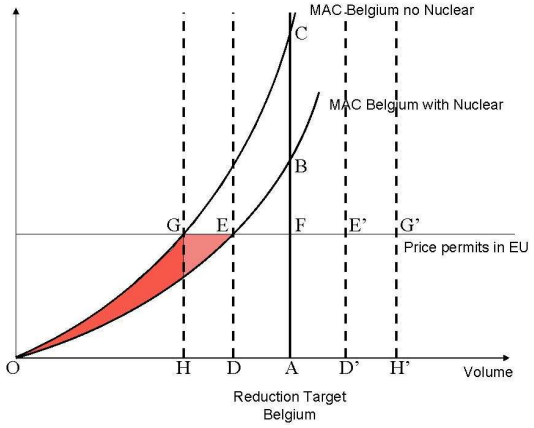
With the nuclear phase-out law implemented and without CCS (implying an increase of the Belgian marginal abatement cost to reduce energy-related CO_2 compared to the current situation and to its EU neighbors), most reductions will take place abroad, with only a 12% reduction of GHG and a mere 1% reduction of CO_2 on the Belgian territory.

With nuclear power allowed (and without CCS), the cost to reduce energy-related CO_2 in Belgium becomes much smaller, giving rise to a GHG reduction by 26% and a CO_2 reduction amount of 20% on the Belgian territory.

These results show that the nuclear phase-out law prevents cheap domestic CO_2 reductions, leading/forcing Belgium to implement and finance reductions abroad. Under the hypothesis that Belgium will have to accept a similar GHG-reduction obligation as its European trade partners, which we take for simplicity equal to the EU level of 30%,[16] the European approach means that GHG reductions can be obtained at lower costs than effectuated domestically. However, the emission reductions abroad must be paid for by Belgium via equivalent emission allowances, at a price of the equilibrium marginal abatement cost (MAC). The extra cost is approximately given by the colored triangular area OGE of the figure below and with a European emission allowance price of 200 €/ton CO_2-eq in 2030 (being the equilibrium value found by PRIMES), the extra cost due to the nuclear

[15] The CE2030 is grateful to Dr. Dominique Gusbin of the Federal Planning Bureau for having made these results available for incorporation in the final CE2030 report.
[16] For the wealthier EU countries, amongst which Belgium, a burden sharing based on equal GHG abatement cost per personal income, could lead to an even more severe reduction obligation/responsibility. For details, see main report, Chapter 3. .

phase out will be of the order of ~ 2,000 M€ in 2030.[17] For the last five years 2025-2030 of the horizon considered in this report, i.e., after the nuclear phase out in 2025, these amounts will be of the same order, leading already to a cumulated extra cost of ~ 10,000 M€. Integrated from the post-Kyoto period 2010, with a first phase out in 2015, the next one in 2023 and a final one in 2025, till 2030, this would lead to an extra cost for CO_2 abatement of about ~ 15,000 - 20,000 M€.[18]



This extra cost is about 6% to 8% of the GDP of 2000, or 4% to 5% of the GDP of 2030. On an annual basis, during the period 2025-2030, this amounts to roughly 0.5% of the annual GDP of that period.

For these GHG and CO_2 reductions on a EU level, it is assumed that no flexible mechanisms outside the EU are applied. The 30% reduction of GHG is assumed to be effectuated within the EU.

Concerning GHG reductions on a EU scale, Belgium could hope to bargain for a smaller GHG reduction obligation as part of a negotiated burden-sharing agreement, using the argument that its domestic abatement costs are very high due to the nuclear phase out.[19] Besides the fact that with the horizon of 2030, and with a likely full use of flexible mechanisms within the EU by that time, such a lenient treatment will very unlikely be granted by the other EU member states and one should question whether such viewpoint is ethical at all. The correct attitude would be that Belgium takes the same burden in terms of GHG-reduction cost per personal income as its most important EU trade partners (thus, in terms of reduction responsibility). In doing so, it will then only reduce GHGs domestically in accordance with the lowest abatement cost, at the same time relying on buying emission allowances abroad, to satisfy the balance.

In any case, because of the uncertainty on the future GHG reduction obligation for Belgium by 2030, Belgium should not adopt an ostrich attitude and prepare its energy system for a severe reduction, to be ready in time. Consequently, ***the costs for severe GHG reduction obligations will be very high, unless appropriate policy choices are made, as suggested in our recommendations.***

Modeling Caveats

A possible re-injection of carbon-related revenues into the economy, may lead to some relief, but it turns out to be limited, and actually in this case of second order. First, the extra allowances to be bought abroad to mitigate the effect of the nuclear phase out, do not lead to revenues for the Belgian authorities. Furthermore, a re-injection into the economy (e.g., to lower labor charges) of its carbon-emission revenues for the GHG that Belgium is allowed to emit, may lead to a lower cost for the overall Belgian economy than if no re-injection had occurred, but, because of still existing distorting

[17] The amount HD equals 20 Mton/a in 2030 since the Belgian GHG emissions in 1990 amounted to 144.3 Mton, and the triangular-like area ≈ (HD*HG)/2 (i.e., base*height/2) ~ 20Mton * 200 € / 2 = 2 000 M€. For details, see report, Chapter 6.
[18] Expressed in constant €2000.
[19] In fact, according to environmental economics logic, the decision to phase out nuclear power should lead to the contrary, i.e., a larger GHG commitment in terms of obligation for Belgium. See report, Chapter 3.

taxes, the overall cost for the Belgian economy will nevertheless be larger than what PRIMES has computed.

We recall that the above PRIMES results are subject to the following caveats:
(1) the Belgian domestic scenarios only refer to energy-related CO_2 emission reductions;
(2) the estimated carbon values referred to above should not be interpreted as actual costs of policy implementation but rather as an indicator of the relative difficulty of achieving the constraints;
(3) the CO_2 abatement costs are a function of the type of policy instruments that are used to reduce the emissions; in the scientific economics literature, one accepts that subsidies, regulations and grandfathered tradable permits tend to increase the overall costs while CO_2 taxes recycled via lower labor taxes are less detrimental for the economy than if no recycling would take place; and
(4) the environmental benefits of taking appropriate actions to reduce the negative impacts of climate change are not taken into account. It is important to recall that the benefits depend on the world-wide carbon-reduction effort; so climate-change benefits for Belgium are only guaranteed if not only the EU, but all industrial (and developing) nations make an effort.

Security of Supply (SoS)

Assuming severe GHG reduction obligations, and under a nuclear phase out without the availability of routine commercial CCS, the import dependency will be very high, especially for gas for electricity generation. This will require a careful policy for contracting the gas supply, via an optimal mix of long-term contracts and spot-market supply of gas. In addition, timely decisions for gas infrastructure (pipelines and storage) will be needed. As to electric power transmission, the three functions of the grid must be kept in mind: contracted import/export (i.e., trade), the balancing of massive correlated intermittent generation in Europe, and keeping sufficient reserve transmission capacity to cope with incidents (i.e., the reliability issue). Timely investment decisions for substantially increased cross-border transmission capacity will be necessary. In case of a nuclear phase out, the full electricity generation system must be replaced by 2030, and even more to cope with the expected electricity demand increase.

These investment challenges require that the authorization permits should be granted in time and under a stable regulatory framework. Also, investors must get a fair return; for natural monopolies, the system operators must be allowed to transfer these costs to the customers.

In case the nuclear phase-out law would be lifted, many of these SoS challenges would still remain, but the pressure would be considerably less, such that the investments are more easily absorbed by the economy.

It must be understood that questioning the actual implementation of the nuclear phase-out law does not hamper the further build up of renewable investments, since that type of investment is not market driven but entirely "subsidy/support" driven. The build up of renewable sources is entirely a consequence of policy-makers' decisions. As already hinted, policy makers must understand what they promise and then abide by their promises.

Liberalized Markets

It must be emphasized that in liberalized markets, the price is set by the short-term marginal cost.[20] Only in the long run, average price equals average cost[21], and only so in fully competitive markets.

This means that higher prices in liberalized markets are not unusual if marginal costs increase. If production quotas are limited, then prices may go higher as is the case with current oil prices.[22] Gas

[20] The marginal cost is the extra cost to produce one extra unit.
[21] The return on investment for the shareholders is considered here as an opportunity cost, in the sense that a company can borrow money from the financial market (with a certain interest) or from its shareholders (at a certain return rate) who will only invest if the return is at least as high as it would be for other opportunities that exist somewhere else.
[22] For the oil market, other factors such as risk premiums, available stocks, financial speculation etc. also play a role.

prices tend to align with oil prices. These primary energy-price increases are reflected in higher electricity prices. In addition, the price of GHG emission allowances is added. [23]

Examination of e.g., the wholesale prices in the NW-European market shows that the Belgian prices are in line with its immediate neighbors. This is due to enhanced import capacity as of 2005. For the day-ahead market, the coupling via BELPEX appears to have a beneficial effect as well. The wholesale market seems to operate correctly. Even with dominant local players, the liberalization process on the wholesale market seems to function on a NW-European scale.

A well functioning retail market needs sufficient suppliers with reasonable market share. This should be the medium-term goal. Via the electricity exchanges, suppliers must be able to provision themselves at the correct price. Regulators must monitor this carefully. It must be stated, however, that given the overall price increases for gas and electricity, the distribution costs for infrastructure upgrade, and the extra levies, customer prices are not unreasonably high compared to the neighboring countries.

A well functioning liberalized market requires efficient regulators and a correct understanding between governmental services, regulators, TSO's and market players. The fragmentation of responsibilities in Belgium is not efficient for a good market operation.

Cost of the Nuclear Phase-Out Law

Considering the major challenges faced by the Belgian energy economy, it must be concluded that, especially in the light of the daunting challenges mentioned before, and mainly the very stringent GHG-reduction efforts expected, an actual implementation of the Belgian nuclear phase out turns out to be expensive. In fact, Belgium will pay a substantial amount for the premature closure of its nuclear power plants:

> By phasing out so much cheap base-load capacity, the electricity supply curve will shift to the left. Because of not-unlimited transmission capacity, phasing out 6000 MW will lead to an increase in electricity prices.
> Belgium gives up a cheap way to reduce CO_2 emissions domestically; as a consequence, emission allowances must be purchased abroad.
> Allowing nuclear stations to continue would allow the state to bargain for a concession fee (basically skimming part of the revenues). Not doing this, amounts to an opportunity cost for the Belgian state;
> Giving up nuclear power increases our import dependency; this reduced security of supply has a cost.
> By postponing decommissioning, the decommissioning fund will grow substantially. Not taking advantage of this possibility leads to an opportunity cost of the order of about 1,000 M€.

Although not really an actual cost, but an important point in terms of interest for the Belgian state, letting a future government negotiate with nuclear plant owners by using the 'carrot' of a nuclear operation extension, can keep certain elements of the energy system under the control of the Belgian authorities.

This extra financial burden of a nuclear phase out appears to be too high a price to pay, even when considering a disadvantage of keeping nuclear power as an option, namely an increase of the nuclear waste. Indeed, in the final count, the amount of high level nuclear waste will be increased by the same proportion as the operation extension of the plants; i.e., if existing plants are allowed to operate for 60 years the increase will be 50%.[24] But this is a relatively minor incremental cost; and furthermore, it is paid for by nuclear operators (reduction of their profit in a liberalized market).

In any case, a further relying on nuclear power must continue to be subject to the following imperative requirements:
- Strict safety regime as before, under international supervision.

[23] Which reflect an opportunity cost.
[24] The increase of the low-level and medium-level waste is relatively minor.

- Guarantee that nuclear provisions are available when needed (foreign owner, but also utilization by government).

Overall Conclusion: a Diverse Energy Policy is Needed

All things considered, we must conclude that no simple solutions exist; there is no silver bullet. ***The only reasonable option appears to be to go for an 'and-and' approach rather than for an exclusive 'either-or' one. It is to be avoided to put all eggs in the same basket, and a maximal diversity should be opted for.***

The Belgian energy policy will have to consist of a **balanced mixture of contributing elements**. First, if important post-Kyoto carbon-reduction limits are pursued, **energy savings** will have to be an important component of the policy. Then, a diversity of primary-energy sources and conversion technologies should be opted for, with a cost-effective integration of **renewables**, whereby the cost effectiveness is best geared by carbon prices rather than absolute objectives. *Given the existing constraints and the costs reported, taking into account all hypotheses*[25] *and uncertainties involved, and based on the combination of scientific, technical and economic arguments, we are led to conclude, that in case the* ***nuclear*** *phase out is implemented, the expected post-Kyoto constraint is expected to be extremely expensive and strongly perturbing for our economic fabric.* Even after having incurred a major part of the very high costs, the risks of not satisfying a reliable energy provision under the assumed constraints, are indeed very large.

The circumstances when the nuclear phase-out law has been voted into law have indeed **changed significantly**; the urgency for climate-change action is becoming more apparent and the era of very cheap oil and gas prices is almost certainly behind us. This facing with current reality and future expectations, requires a reconsideration of the overall Belgian energy policy, including nuclear electricity generation.

[25] Assuming that CCS is not available.

Recommendations of the Commission Energy 2030

General Guiding Principles

Major guiding principles must apply for the Belgian energy policy with horizon towards 2030.

Because of its limited scale and impact, the existence of a European environmental policy, the European energy policy 'in the making', and the common European energy market, Belgium is recommended to ***fully align itself to the European energy framework***. This applies to the domains of the common energy markets, energy efficiency, renewable energy, energy infrastructures and nuclear safety, amongst others. The transposition into Belgian law of the EU Directives and Regulations should always be undertaken in a timely manner. Belgium should use the EU context to establish a coherent energy policy of its own, and already start reflecting seriously (and even proactively) when EU policy documents are launched (Commission Communications etc). Also, Belgian ideas should be launched on an EU scale to have the scrutiny of the other EU members and to get support & momentum (if the proposed measures make sense) of the full EU. In addition, Belgium must 'profit' from the EU dimension to negotiate its primary-energy deals with producing countries; unilateral deals must be carefully reflected upon, but Belgium must not be too naive if other Member States go their own way.

Given all challenges, i.e., the need for a reliable, clean and affordable energy provision already discussed in this report, and the scenario results & interpretation, it is clear that ***Belgium cannot afford to put all the eggs in the same basket***. We must go for an ***'and-and' approach***; we do not have the luxury to have too many exclusions. For an effectively almost 100% energy-dependent country, diversity is the only helpful strategy: reduce energy demand, 'produce' indigenous energy (through renewables), choose for a sufficient fraction of storable primary energy in the portfolio, rely on a diversified mix of technologies and primary sources, coming from different geographical regions and all of this in an affordable way and sufficiently environmentally friendly.

Aim for stable legislation and regulatory framework based on a coherent long-term vision. Set clear long-term targets and let the market actors then invest within that frame setting.

The ***Belgian energy responsibilities must be streamlined and harmonized***.

Different philosophies and approaches seriously hamper a coherent energy policy. Amongst others, four typical examples can be given:

- Concerning transmission and distribution of electricity there is confusion. Everything equal and lower than 70 kV is a regional competence, but the lines with a voltage of 30 to 70 kV (both values included) are operated within the framework of the integrated TSO Elia.
- All tariffs are set by the Federal Authorities, regardless of which level is competent.
- The introduction of liberalization for supply and retail has been at a different speed in the Regions, not helping the effectiveness and efficiency of the whole transition.
- The support schemes for green electricity and cogeneration differ in the Regions, hampering a good development of renewable and CHP-based electricity generation in Belgium.

For all these domains, independent of the political choice to put the responsibility at a particular level, the approaches should be harmonized, and even considered in a broader European context. Exchange of green and CHP certificates in Belgium and on a European scale is a good example.

Given the long lead times for implementation of infrastructure investment decisions, and with the concern for security of supply regarding all energy carriers, but especially electricity and gas, Belgium should prepare for a considerable post-Kyoto GHG reduction effort, thereby avoiding an ostrich attitude. Also, Belgium should not count/rely on 'generous' EU burden-shift escape routes since such attempts might in the end not be accepted by the other EU Member States (especially if high abatement costs are a consequence of deliberate own choices). ***Belgium should define its medium***

to long-term energy policy taking into account a substantial domestic GHG reduction effort and/or keeping in mind the possible costs for financing emission reductions abroad through, e.g., emission trading.

Concrete recommendations

1. **Belgium must do all that is 'reasonably acceptable' to exploit its potential on energy savings.**

First and foremost, a behaviorally conscientious attitude with respect to energy use should be advocated through education and general information transfer, in schools and towards the public at large. Energy is a scarce good and should be highly valued; automatic reflexes for unwise/inadvertent use of energy are to be discouraged. Demand for energy services[26] should possibly be mitigated and the desired level of energy services should be provided by using efficient technology.

Timely transposition of all EU efficiency-related directives is called for and novel, effective, efficient and non-conflicting own supplementary measures must be considered.

In particular, matters such as *energy-performance standards for buildings* must be implemented earnestly and strictly enforced, as required by the related EU directive. Especially given the long-term consequences of this sector for energy efficiency, these transpositions should be done in a harmonized way and in collaboration with the building sector. This energy-performance concept includes the appliances within the buildings.[27] Determinate action is required now, but short-term expectations should be tempered because of the long time constant in the building sector. Even in the time frame of 2030, although considerable progress can be made, miracles cannot be expected. Special attention is required for the education & training of more energy-technical-oriented architects and energy-conscientious contractors.

In line with the current EU directives, *Public Service Obligations* regarding an energy-savings (and not only electricity-savings) target should be put, based on market-compatible measures, implemented by e.g., distribution grid operators, and the results must be closely monitored. A comprehensive impact analysis of a net energy-savings target of …1.5…% per year requirement (compared to business as usual projections) must be studied as part of the strategy.

Quality *Cogeneration* is to be continually encouraged and supported to implement the energetic potential based on the heat demand existing at the time of implementation.

Transport-related energy use is linked to the more global issue of *mobility*. Air & noise pollution, GHG emissions and road congestion are major problems in this context, especially for Belgium with a logistic function in Europe. This requires a holistic approach, including road, rail, water and air transport, passenger and freight transport, private and public transport, congestion control, road safety etc. Well thought-through measures, without taboos must be considered. Solving the mobility issue appropriately, may lead to energy savings and emission reductions.

As examples, we mention the following (not all necessarily equally efficient) measures:

a. To discourage 'superfluous' use of road vehicles, road-congestion charges and road taxes (per driven km) may have to be levied;
b. The offer of public transport and non-motorized transport means in priority areas should be increased;
c. To reduce emissions of vehicles, the annual traffic tax on heavily polluting vehicles, as a function of their emissions, may be considered;
d. Increasing fuel efficiency standards, based on agreements with car manufacturers can be encouraged. Targets should be ambitious, but cost efficient and realistic. Belgium should

[26] By "energy services" is meant the activities and applications we wish to enjoy: heat rooms to comfortable temperatures, keep food and drinks cool, drive kms, provide drive power and process heat in industry, etc. This concept here is different from the "services" provided by so-called "energy service companies (ESCOs)".

[27] Although separate standard and labeling directives exist, to put pressure on the manufacturers and to better inform the potential buyers of efficient equipment.

play a stimulating role in the EU to establish the criteria based on sound cost-benefit analyses.

Industry must be incited to further concentrate on energy efficiency, both energy-intensive and the smaller industries. The voluntary and audit covenants are welcome tools when cleverly combined with the allocation of emission allowances.

For all of the above, general strict rules must be set, with 'appropriate' exceptions or compensations for especially sensitive segments or sectors (energy-intensive sector, particular types of transportation). The main determinant here is the international extent of the post-Kyoto efforts. If the efforts are limited to the EU (and even the EU + USA), there are severe limits on the carbon-reduction efforts that can be imposed on certain sectors.

2. To reflect scarcity of energy as an economic good as well as the external costs due to various energy-conversion processes, to avoid wasting of energy and keep sufficient pressure for rational use of energy, and to optimize load time management, **energy price increases must be fully passed on to the customer.**

A pilot project on *'real time pricing*[28], to assess the potential of the instrument should be undertaken.

Rebates and special lower tariffs on energy should be avoided, unless there are justified reasons to do so and unless other means for social correction have been exhausted. It may be necessary to foresee certain financial compensations for the lower income groups. Also, appropriate measures may have to be foreseen such that lower income groups can equally benefit from energy-efficiency measures.

Detailed but neatly arranged *information on the price breakdown* (commodity, transmission & distribution charges, levies, (excise) taxes & VAT) on the invoices is to be optimized/provided.

To optimize demand-side management on the retail side, ample attention to metering and interaction between supplier and customer is needed. Combined with the progressive introduction of distributed generation, sufficient investment for the *modernization of the distribution grids* for electricity and gas (towards eventually a smart grid) is inescapable. The cost for these infrastructure investments will be high and must be imputed to the customers.

Connections to the high voltage or high pressure networks for electricity and gas, respectively, must contain *price signals reflecting congestion* and other costs in certain areas. TSOs should have the permission by the Regulator to charge them.

3. According to the present analysis, the achievement of stringent post-Kyoto targets of the order of 15-30% by 2030, for domestic reduction in Belgium without nuclear power and in the absence of CCS, is expected to be extremely expensive. (Reaching these post-Kyoto targets will already maximize the technical potential use of renewables and a considerable part of energy savings as shown by the energy intensity decrease.) Furthermore, if similar European reduction targets are considered with the possibility of emissions trading, also without nuclear and CCS in Belgium, GHG abatement for Belgium will likewise be very expensive, unless the EU burden sharing turns out to be very favorable for Belgium.

Non-nuclear and non-CCS scenarios result in an overwhelming dependence (90% in instantaneous power terms) of natural gas for electricity generation and conflicts with the objective of security of supply.

[28] Real-time pricing assumes that customers have appropriate meters for gas and electricity, whereby an instantaneous and thus fluctuating price, at any moment of the day, rather than an average or fixed tariff, is paid.

To alleviate these burdens, and in addition to relying on energy savings and renewables, ***Belgium is therefore advised to***

- ***reconsider the nuclear phase out,*** *and*
- ***to stimulate the timely development of CCS***

Lifting the Nuclear Phase Out

When reconsidering the nuclear phase out, to keep sufficient pressure on the energy system towards the transition to a more sustainable energy basket, a negotiated agreement with the owners of the Belgian nuclear power plants is to be sought for, to make them pay a "correct"[29] concession fee/rent. The thereby collected revenues could be used by the government for stimulating investments in energy savings & demand-side management, for development in renewable energy, for development & research in emerging energy technologies and carriers.[30] The *Dutch Borssele agreement*, explicitly established via a Covenant and the *establishment of a sustainability fund*, may serve as an exemplary source of inspiration.

As part of this agreement, earlier agreements that were made in the context of the nuclear phase out should be revisited.

The operational lifetime of the existing plants should be left non-limited a priori[31], in the sense that the prime requirement should be the *continued safe operation* of the plants. The safety of plants is to be thoroughly examined on a ten yearly basis (by means of the 10-year overhauls) and the state of the plants (thereby requiring possible upgrading investments) must be approved by the nuclear supervisory bodies (amongst which the Nuclear Regulator), possibly confirmed by an international audit.[32]

Operation of nuclear power must continue to live up to internationally accepted standards, for safety aspects, radiation protection, waste management, proliferation, and be subject to both national and international scrutiny and supervision (through bodies such as the 'Recognized Safety Authority', FANC/AFCN, NEA/OECD, IAEA, Euratom, WANO).

Although the current nuclear liability coverage is already substantial, it is recommended that in an EU or OECD context, Belgium advocates the idea to set up an EU or OECD-wide but nuclear operator/owner-funded and -managed liability fund to cover the extra liability in case of a severe accident. This nuclear liability partnership should be funded pro rata of the nuclear installed capacity within the EU or OECD.

[29] The level of such fee/rent is to be evaluated by an independent international commission, as discussed under point 6 of these recommendations.

[30] According to economic theory, this is not the most efficient way of spending these revenues. The magnitude of the rent or tax revenue may be larger by several factors than the needs for subsidies for renewables, energy savings and demand-side management. Caution must be expressed against over-subsidizing because of this earmarked money; any justifiable investment —including for renewables, energy savings and demand-side management— must pass a cost-benefit test, also accounting for its environmental benefits. The remainder of this nuclear rent may be devoted to other valuable means, such as lowering labor charges or reducing the national debt.

[31] Note that "non-limited" is to be distinguished from "unlimited".

[32] J.P. van Ypersele (JPvY) disagrees with the idea contained in this paragraph that the nuclear plants operational lifetime should not be constrained at all. The reasons invoked by the law of 2003 to limit the lifetime of existing plants are still valid in JPvY's view. However, JPvY observes that the Belgian authorities have taken very few measures to avoid a large increase of CO_2 emissions when the nuclear power plants are closed down, in particular if ambitious energy-efficiency improvements and carbon capture and storage (CCS) techniques are not implemented by then. The indicative numbers coming out of the PRIMES modelling study prepared by the Federal Planning Bureau for this report reflect this lack of foresight and political courage. If Belgium wants to reduce its greenhouse gas emissions by factors of 2 to 6 in the coming decades to meet the climate challenge, the present trends in energy consumption (not only electricity) are clearly unsustainable. Given the time lost since 2003, and the time needed to obtain results, JPvY thinks that the operational lifetime of those Belgian nuclear power plants which can tolerate it without reduction in safety or large investments should be **extended now by five years only** (over the 40-year lifetime decided in the law of 2003), with ***significant*** amounts collected through the "Borssele" system to fund part of the transition of the Belgian energy system towards a much lower energy usage, a higher renewable energy usage, and much lower greenhouse gas emissions (such as described in the "backcasting" scenarios developed by the Federal Planning Bureau for 2050 at the request of Minister Tobback). It would also allow for ambitious measures to be taken to facilitate this transition, without increasing too much the final consumers' energy bills. This five year extension only makes sense if the delay is not just used to save time and continue doing almost nothing in other areas of energy, transport, and climate policy. JPvY is convinced that the tax or rent revenues from the "Borssele" system should ***preferentially*** be used to fund the energy transition evoked above, in the most cost-effective way, as the budgets needed for the transition will most likely be much larger than the "Borssele" funds.

In case new nuclear units are considered, a clear and transparent regulatory framework must be set. The economics of such project must be left to the investors' market. To support such framework, a participatory process with societal stakeholders should be undertaken, based on a broad cost-benefit analysis, with the aim towards a "sustainable" energy provision. Such process should lead to advises upon which policy makers can base themselves to set the conditions for new nuclear build.[33]

Carbon Capture and Storage (CCS)

Although lacking power-plant manufacturers, Belgium must collaborate strongly internationally on the development of Carbon Capture and Storage (CCS).

A commitment must be made to have at least *one experimental pilot carbon capture plant operating no later than 2030* on Belgian territory, privately or publicly funded.[34] Administrative and scientific *research on possible geological CO_2 storage sites* must be amplified strongly, so as to know clearly by 2015 what the possibilities for CO_2 storage in Belgium are, with the possibility to then launch a pilot research program in situ, if justified by the results of the research.

Screening of potential gas-storage sites in nearby/neighboring countries and study of transport costs of CO_2, not neglecting the possible competition/interaction with natural-gas flexibility requirements, is to be undertaken in order to have a reasonable idea of long-term possibilities.

4. Because of limited domestic potential of **renewables**, Belgium should implement the EU directives in a clever and justified way to contribute to a healthy European energy mix and environmental-burden reduction.

Towards an efficient long-term perspective, Belgium should not commit to quota for local 'production' of renewable energy, but rely on market mechanisms where carbon value is the best guide for the expansion of renewable energy in Belgium and abroad. As a first step, one could accept and should plead for (perhaps ambitious) *quota (in % terms) for supply of renewable energy* to the end customers coupled to *full EU exchangeability of green certificates or certificates of origin*, so that investors are stimulated to invest at the best locations in Europe. [35]

In a transition period, judicious local production of renewable energy at acceptable locations must be steered through the penalty value of the green certificates. Depending on the source, subsidy must be tailor made; over-subsidy leads to improper use of public money.

Blending of biofuels for transportation should be aligned on a European scale and the impact of excise tax breaks for the public finances must be comprehensively evaluated. The cost effectiveness for CO_2 abatement of the full life cycle and the sustainability of the supply chain (taking into account

[33] J.P. van Ypersele strongly disagrees with this paragraph about a new nuclear plant. He really does not think that new nuclear units should be built in Belgium. In his opinion, nuclear energy should not play a major role in the efforts to reduce greenhouse gas emissions at world level. The last IPCC report (IPCC WG3, 2007) puts much more emphasis on the potential of energy efficiency, carbon capture and storage, and renewable energy to reduce global emissions, than it did to a nuclear expansion. In the long term, we have to contribute in the development of a world energy system that relies much less on ***stocks*** of fossil and fissile fuel, because they are inherently finite. We need instead to learn to harness the ***flow*** of solar (and other renewable) energy which equals about 8000 times the total world energy consumption per year. It is important to capture that renewable flow in the most efficient way, and some of that is probably best done out of the Belgian territory. Harnessing this flow will reduce the risk of "running out" of fuel (the Sun will indeed continue to provide its energy to us for another 5 billion years), reduce the risk of proliferation of nuclear material, reduce the risk of large scale accidents or nuclear terror activities, and reduce the amount of nuclear waste we leave to future generations. To make this possible, we need to dramatically increase energy efficiency, and manage demand so that energy usage per capita converges towards sustainable levels, taking into account local circumstances. In the transition period to such an efficient world energy system relying mostly on renewable energy, and as advocated by the European Union, we urgently need to use carbon capture and storage on our fossil fuel plants, and participate in the diffusion of this technology in all countries with large fossil-fuel reserves. Building a new nuclear plant in Belgium would only postpone the needed transition towards a more sustainable world energy system.

[34] Note that the experimental nature of such plant does not permit to rely on it for routine carbon capture.

[35] This means that all suppliers must demonstrate that at least x% of the electricity delivered to their end customers originates from renewable sources, regardless of where these are generated. With such schemes, and free exchangeability of European green certificates or certificates of origin, Belgium may be subject to the same level of renewable obligation (e.g., 20%) as the EU. It must be understood that these 20% need not be produced domestically, however.

possible competition with the food chain, deforestation, and other applications), should be carefully assessed, however.

Belgium should **reconsider its offshore wind policy** and be more forthcoming in the concession allocation of sites.

In order to be serious about offshore wind power development, the authorities should re-examine *the sites of the 'Wenduine Bank' and the 'Vlakte van de Raan'*, as these sites may offer a reasonable degree of technological success at an acceptable cost.

Far offshore sites are not to be dropped, but should *be developed meticulously*. Through a carefully designed staged process, an international leading role for far offshore can be established. 1) In the context of the current projects, it should be encouraged to use different technological options, which are to be observed very carefully (measurements, maintenance, corrosion, etc) during a sufficiently long period to be defined on a technical basis, and during which careful comparisons with international projects are made. 2) Continue up to a few hundreds of MW only when the results of the first phase are successful. 3) Make an in-depth study of the grid connections: link with the possible HV cable to the UK, study of the connection with "Supergrid"[36], possibility of organizing a common connection point offshore, high-voltage-network absorption & extension and power-generation back-up study, with clear cost figures before embarking on >900 MW plans. If prospects are positive, go for it with strong determination; if prospects range from dubious to negative, have the realism to call it off and reorient.

The costs for sea cables for far offshore investments, starting from the pilot plant all the way to the massive build up, could be socialized[37] if the costs remain acceptable to society. Here, however, contribution from the above mentioned 'nuclear phase-out repeal fund' could be a welcome financial injection.

5. On **security of supply**, four aspects are to be focused on as priorities.

Diversity of supply of primary sources and technologies (type and origin) is the first and foremost rule. Especially the gas provision must be carefully observed. An optimal mixture of long-term and spot-market contracts must be strived for.

A ***comprehensive study*** to find the appropriate energy mix (including renewables, gas, oil, coal, uranium), based on the ***portfolio theory*** must be effectuated for the Belgian situation.

A ***stable investment climate*** must be guaranteed for competitive market players to have sufficient new *electricity-generation capacity,* to keep a substantial *refinery capacity* and to have sufficient *gas-storage capacity*. For supported technologies, such as renewables, governments must guarantee that commitments for support made are honored.

Transmission and distribution networks must be 'allowed' to invest in extensions, adaptations, and preventive maintenance, so as to ***avoid blackouts*** and to allow the connection of renewables and to facilitate the European market; the Regulator must accept the costs involved being transmitted to the customers; environmental and construction permits must be delivered timely by the competent authorities.

6. The **liberalization** process for **electricity and gas in Belgium** must be developed in line with the common European energy market concept.

A *stable and transparent regulatory framework*, properly harmonized between the Regions and the Belgian Federal level, and at the EU level, is called for. Efficient regulators, sufficiently independent of the government (but properly held accountable for their actions), are expected to enforce and supervise regulation. Harmonization of Belgian regional and federal regulatory decisions is imperative.

[36] Supergrid is an initiative to connect all sides for offshore wind along the Atlantic coast and beyond.
[37] In the sense that eventually, costs may have to be transmitted to the final electricity customers.

Both for domestic and international regulatory level, review/recourse/appeal by/to the European Commission must be defended by the Belgian Member State at the European Union level.

One single wholesale market, at least in NW-Europe must be advocated, by establishing sufficient cross border transmission capacity. Regulators must oversee potential abusive behavior, while allowing the investments for building cross-border lines as a basic element for market development. Imposed regulated prices at the wholesale level are advised against, but possibilities of partnership between large energy consumers and producers should be envisaged (guaranteeing security on long-term pricing).

Sufficient *Retail market access should develop over time* to reach a good mix of suppliers in Belgium. Regulated capped prices at the retail level are advised against. Strict supervision by the Regulator is necessary.

Vertical unbundling is necessary in the sense that only generation and retail can remain inside the same company. The transmission and distribution activities for electricity and gas must be legally unbundled (as prescribed by the EU Directive). Full ownership unbundling does not seem to be necessary as long as strict corporate governance rules are applied. The presence of large shareholders is an advantage to raise capital for infrastructure investments. If such approach proves to be impossible or unrealistic in practice, other routes such as 100% ownership unbundling or the establishment of an Independent System Operator (ISO)[38], should be examined.

An independent multi-international examination on the issue of alleged “unreasonable” windfall profits as a consequence of earlier depreciated generating capacity now operating in a liberalized environment (so-called possible stranded benefits) must be undertaken. The experts commission must preferentially be populated by non-European experts, i.e., well recognized energy-economics and/or corporate-financing university professors and Regulators of OECD countries with liberalization experience (e.g., USA, Canada and/or Australia). Both the Belgian Regulators and the generator concerned must be heard by this commission to express their viewpoints. It must be recognized, though, that the existence of these “inframarginal rents”[39] is independent of the number of electricity-generating operators.

7. Belgium should devote **much more <u>research & development</u> means in <u>energy</u>**.

To maximally profit from economies of scale, substantial financial incentives must be given to research groups for participation in *European projects*. European energy research priorities have been identified [CEU, 2005 & 2006].

Supplementary Belgian energy research, development & demonstration should be prioritized:

- behavioral research on public willingness to opt for rational use of energy and ways to stimulate it;
- energy research should cover all relevant sectors such as transportation, residential, commercial & service sectors, industry, gas and electricity sectors;
- individual R&D grants for selected manufacturers to develop further 'super efficient' equipment;
- clever interaction of suppliers and customers through smart grids for electricity and gas, comprising active demand-side management and distributed generation;
- further research on renewable energy, such as phased offshore wind-energy development, high-efficiency conversion of biomass, advanced grid-integrated PV and others;
- comprehensive system and grid integration of non-dispatchable generation;
- carbon-capture pilot plant and CO_2 storage research;
- nuclear-system development for further improvement of the nuclear route;
- energy-system model development should be supported to have a strong Belgian basis in order to acquire sound mastery of the ins and outs of comprehensive energy

[38] In the sense as defined in the EU Commission energy package of January 10, 2007. The concept of ISOs has not been proven anywhere, however, as far as investment incentives, maintenance etc. is concerned.
[39] See Informative Box in Report

modeling. Own Belgian model development work is to be encouraged, whereby later European integration with other models should be kept in mind from the outset. Interaction within international/European frameworks is therefore to be encouraged.

8. **Education & Training** in energy

Although not actually studied, the CE2030 nevertheless expresses its concern about appropriate education in energy matters, both for the public at large and for energy professionals.

High-school education programs should contain an important segment on the scientific & technical aspects of energy provision, the overall energy issue, and the relationship with prosperity, development and sustainability etc. Non-biased education based on facts and figures and the laws of nature is called for.

The authorities are invited to make an effort to stimulate (advanced) studies in energy science and engineering. Lack of a sufficiently capable professional pool of experts will hamper us in meeting the energy-related challenges faced in the future.

9. Belgium should establish a **sustained/permanent *Strategic Energy Watching Brief***

Rather than solely relying on ad-hoc Committees (such as the AMPERE Commission and this CE2030 Commission), it is recommended to **establish a 'permanent' and structural follow-up process** to guarantee conscientious observance (or disregarding) of the recommendations of 5 to 8 year interval Major Review Exercises. This Watching Brief must be organized such that it involves at least the Federal and Regional Energy Administrations and Energy Regulators, the Federal Planning Bureau, Energy & Environmental Scientists & Economists, perhaps enlarged with other stakeholders of society. This Watching Brief exercise is best **supervised by an independent core group**. A limited-size but formal follow-up document to the government should be established on an annual basis.

To make this follow up successful, **sufficient and efficient gathering of correct and coherent energy-related data** must be transferred **timely** to the Federal Economy Administration, which must be given sufficient means to **establish a reliable database**.