Commission ENERGY 2030

— PRELIMINARY REPORT —

Executive Summary

November 13, 2006

Belgium's

Energy Challenges

Towards 2030

Commissioned by

Minister Marc Verwilghen
Federal Minister of Energy

Key Messages in a Nutshell

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 our 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**: first and foremost, **energy savings** must be advocated and implemented as much as techno-economically possible. To reflect scarcity of energy as an economic good and the related external costs, 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.** Then, 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**.

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

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 off-shore wind policy** and be more forthcoming in the concession allocation of sites. The authorities must *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 off-shore sites* are not to be dropped, but should *be developed meticulously*. Through a carefully designed staged process, an international leading role for far off-shore can be established

Belgium must collaborate strongly internationally on the **development of *Carbon Capture and Storage* (CCS).**

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 (which should be almost advocated as a slogan).
- A stable ***investment climate*** must be guaranteed for competitive market players to have sufficient new *electricity generation capacity* and to keep a substantial *refinery capacity*.
- Transmission and distribution networks must be 'allowed' to invest in extensions, adaptations, and preventive maintenance, so as to ***avoid blackouts***, support the connection of renewables and 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.
- A comprehensive study to find the appropriate energy mix, a.o., based on the *portfolio theory* must be effectuated for the Belgian situation.

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 the Regulator is necessary.

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.

Upon lifting the nuclear phase-out law, an agreement with the owners of the Belgian nuclear power plants is to be sought for, 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

This preliminary report has been submitted to the Federal Government on November 13 2006 by the permanent members of the Commission ENERGY 2030, who unanimously approve its contents. The final version of this report will be made available once the Commission has compiled the remarks and comments put forward by the external panels, which are currently reviewing the document.

The Commission ENERGY 2030 has been formally set up by the Royal Decree of December 06 2005 (Moniteur Belge / Belgisch Staatsblad of December 19 2005) and is demanded to hand in its final report 18 months after the formal establishment of the Commission, i.e., at the latest by June 19 2007. 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 will also look into the competitive position of businesses, 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, of which at present the preliminary version has been released for discussion, consultation, and review, tries to address both *'comprehensively' but* '*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 scenario's 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, but, 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 **Preliminary Report** is therefore structured as follows:

Part I. Context, Issues to be Addressed and Elements of Solution
- *1. Scope; Setting the Stage*
- *2. Current Energy-Related Situation in Belgium and Historic Evolution*
- *3. Energy-Related Challenges*
- *4. Demand for Energy and Energy Savings*

Part II. Exploring the Future by means of Scenario Analysis
- *5. Definition of the Scenarios*
- *6. Results of the Scenarios*

Part III. The Broader Belgian Picture
- *7. Additional Aspects Beyond the Scenario Analysis*

Part IV. Conclusions & Recommendations

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. And 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, one with so-called 'soaring' fuel prices, and 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. These scenarios are summarized in the table hereunder.

Summary of scenarios

Baseline:

- Base scenario in which no post-Kyoto reduction limit is imposed in Belgium and where a decommissioning of nuclear plants takes place. Fuel prices are 55$/bbl in 2005 and increase to 60$/bbl in 2030 in real terms.

Soaring fuel prices applied to baseline:

- Adjusted baseline scenario with fuel prices reaching 100$/bbl in 2030 in real terms.

Alternative:

- **-15%** / **no nuc** / **with CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 15% in 2030 compared to the 1990 level and where a decommissioning of nuclear plants takes place and carbon capture & storage (CCS) is available.
- **-15%** / **with nuc** / **with CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 15% in 2030 compared to the 1990 level, operational-time extension of existing nuclear plants + possibility of having 1 new nuclear unit of 1700 MW after 2020; and where a decommissioning of nuclear plants takes place and CCS is available.
- **-15%** / **no nuc** / **no CCS:** scenario in which Belgium reduces its energy CO_2 emissions by 15% in 2030 compared to the 1990 level, decommissioning of nuclear plants and CCS is not available in the period 2020-2030
- **-15%** / **with nuc** / **no CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 15% in 2030 compared to the 1990 level, operational-time extension of existing nuclear plants + possibility of having 1 new nuclear unit of 1700 MW after 2020 and CCS is not available in the period 2020-2030

Alternative:

- **-30%** / **no nuc** / **with CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 30% in 2030 compared to the 1990 level and decommissioning of nuclear plants and CCS is available.
- **-30%** / **with nuc** / **with CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 30% in 2030 compared to the 1990 level, operational-time extension of existing nuclear plants + possibility of having 1 new nuclear unit of 1700 MW after 2020 and CCS is available.
- **-30%** / **no nuc** / **no CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 30% in 2030 compared to the 1990 level, decommissioning of nuclear plants and CCS is not available in the period 2020-2030
- **-30%** / **with nuc** / **no CCS**: scenario in which Belgium reduces its energy CO_2 emissions by 30% in 2030 compared to the 1990 level, operational-time extension of existing nuclear plants + possibility of having 1 new nuclear unit of 1700 MW after 2020 and CCS is not available in the period 2020-2030

Having performed the scenario exercise, **Part III** then confronts the results of the modeling with the challenges revealed and evaluates and *qualifies and further interprets 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. We deal with issues such as implementation challenges (like network extensions and technology market diffusion); the Belgian liberalized markets; Security of supply and reliability; reaching post-Kyoto in practice, taking into account the flexible mechanisms and the other non CO_2 greenhouse gases; reflections on the socio-economic consequences; the potential role of nuclear power; and the often mentioned antagonism between energy efficiency and nuclear power.

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.

This Preliminary Report and its Conclusions and Recommendations are issued under the responsibility of the Permanent Members of the Commission ENERGY 2030.

In addition to this Preliminary Report proper, a set of **Supporting Documents** are 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.

As this is a Preliminary Report, it is the aim to have this version of the Report reviewed by a set of **Review Panels**, reflecting a large cross section of the relevant societal actors. To keep it independent from our activities, this review exercise runs under the responsibility of the Cabinet of the Minister of Energy. As a rule, no political parties or their think tanks have been invited for the review. The following organizations/institutions have been invited to participate in the review:

* Belgium:
  - the Federal-Regional consultation cell (ENOVER/CONCERE)
  - Central Council for the Economy (enterprises & unions)
  - National Bank of Belgium, and the Association of Belgian Banks
  - 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)

After this review, the CE2030 will analyze and evaluate the comments made by the Review Panels and will take into account the relevant and pertinent remarks for the final version of its Report. In line with the Royal Decree, this Final Report is to be submitted to the Minister at the latest by June 19 2007.

This Preliminary Report and the Supporting Documents, and much referenced material can be consulted at the CE2030 website, http://www.ce2030.be .

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President CE 2030

On behalf of its permanent members:

P. Klees (Vice-President), J-M. Streydio ,J. Albrecht, J. De Ruyck , P. Tonon

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and contribution of the advisory member F. Sonck, and the ex-officio observers, M-P Fauconnier and H. Bogaert, is greatly acknowledged. The non-permanent members who wish to write additional reflections on their particular field of expertise can do so; their produced documents will be submitted to the review process together with the Preliminary Report and the Conclusions & Recommendations, and will likewise be available on the CE2030 website.

The follow up and assistance of the Secretariat, held by M. Deprez and H. Autrique, of the DG Energy of the Ministry of Economic Affairs, is very much appreciated.

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 document has served as the major input to the activities of this Commission Energy 2030.

Conclusions

The **objective** of a sound energy policy must be 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 our society, and in an environmentally friendly way*.

Against the current situational and legal background of the following constraining elements, this aim represents a **daunting challenge** for Belgium over the coming 25 year and beyond:

- oil & gas prices that fluctuate strongly and can be very high;
- 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;
- expected substantial post-Kyoto CO_2-emission cuts;
- the existing nuclear phase-out law, starting in 2015 and fully executed in 2025;
- the creation of a common liberalized European energy market.

Belgium will have to think in European terms and has an interest to do so, since not only its primary-energy dependency is very large, but also its energy-conversion infrastructure is operated in function of the European market. Belgium has to subscribe fully to a **European energy policy**, thereby relying on an appropriate legal EU framework.

The Commission Energy 2030 has studied the energy-provision issue for Belgium using literature reviews on available technologies, and has examined the feasibility and economic costs of different scenarios with the time horizon of 2030, using the PRIMES energy model.[1]

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: no post-Kyoto and nuclear phase-out realized via massive installation of coal-fired plants.

A first so-called *baseline scenario* implements all energy- and climate-related policy measures agreed upon until the end of 2004; 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. Assumed fuel prices start from 55$/bbl in 2005, to become 60$/bbl in 2030.[2] Gas prices are coupled to oil prices.

[1] The energy-system model PRIMES has been run by the University of Athens (NTUA). The scenarios have been defined by the CE2030 after discussion with the Belgian Federal Planning Bureau, which was responsible for the detailed scenario analysis.
[2] All expressed in $ of 2005

As can be seen from the summarizing Table below, in the baseline projections, despite a considerable increase of energy-service demand, final energy demand (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[3] to about 70% of the value in 2005 for all sectors. Electricity generation increases linearly, whereby gas-fired generation strongly increases between 2010 and 2030, but remains roughly steady thereafter because of very high gas prices; coal-based generation increases fivefold between 2020 and 2030. Overall CO_2 emissions remain basically constant until 2020, after which they increase substantially from 116 to 140 Mton/year. In conclusion, 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.

A variant to this baseline, assuming *'soaring' oil prices* up to 100 $/bbl in 2030, does not lead to dramatic changes. The final energy demand is slightly lower (3% lower than the base case), 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 see what the effect of certain policy choices & technology-availability options are. 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.

No rigorous attempt as been made to define a post-Kyoto emission-reduction target in terms of GHG. However, an order-of magnitude estimate, reflecting on possibilities for burden sharing within the EU, reduction of other non-CO_2 GHG, and the possibility for relying on flexible mechanisms (Joint Implementation, Clean Development Mechanism, and Emission Trading) has made it plausible that a GHG-reduction level at the EU level of -30% by 2030 compared to 1990, is likely to correspond to domestic energy-related CO_2 reductions of about -15%. If the EU GHG-reduction requirement goes deeper than 30%, stronger domestic energy-related CO_2 reductions will be needed. Although the effects (amongst which are the costs) do not scale linearly, by presenting the results of our -15% and -30% cases, the reader will be able to get a feeling of what reductions of the order of -15% to -20%... domestic energy-related CO_2 emissions mean for our energy economy. It is not within the mandate of the CE2030 to propose whichever post-Kyoto cuts in GHG emissions, but a major component of the Terms of Reference is ***to prepare the Belgian energy system for the substantial cuts that are expected to be imposed, so as to guarantee a reliable, clean and affordable energy provision.*** The results presented here apply to the cases we have considered with its hypotheses and boundary conditions.

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 the simulation results.

Under the **existing nuclear phase-out law, and expected technological evolution**, the scenario results project a **very expensive implementation.**

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 end-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 reduces by 19% (and 32%).

For the -15% (and -30%) case(s), the energy-related cost in 2030 compared to the year 2000, as computed by PRIMES would increase by 150%, 150% and 170% (and 440%, 510% and 420%), for industry, tertiary and residential sector, respectively, compared to 24%, 31% and 63% in the baseline.[4]

Import dependency amounts to about 90% for both cases.[5] Gas dependence for electricity generation is about 80-85%, and more than 90% when the installed wind and photo-voltaic (PV) capacities are not able to deliver power.

[3] Being the energy per unit product
[4] Expressed in €2000/toe.
[5] Import dependency in the baseline (also with the nuclear phase out implemented) amounts to 95%.

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

For the -15% 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 reduction results, 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 the nuclear phase-out law is revoked, 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.[6]

It must be noted, however, that these two 'relief valves' are not equivalent though: CCS is still to be developed and will almost certainly not be routinely commercially available by 2030 (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.

We recall that the above PRIMES results are subject to the following caveats:
(1) the results only refer to domestically energy-related CO_2 emission reductions;
(2) 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 tradeable permits tend to increase the overall costs while CO_2 taxes recycled via lower labor taxes are less detrimental for the economy; and
(3) 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.
Therefore, 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. Furthermore, as regards the focus on energy-related CO_2 emissions, it is reasonable to think that at such high carbon values, options aimed at reducing non-CO_2 GHG and the resort to the flexible mechanisms will be less costly than certain domestic actions focusing on CO_2 emissions alone. To fix the mind, and as said earlier, an EU-level GHG reduction level of about 30% of GHG will, in the case of flexible mechanisms, likely correspond to a domestic energy-related CO_2 emission reduction of the order of -15% to 20%..., with the carbon values as computed by PRIMES. When there are flexible mechanisms in place on a EU level, the cost for the energy consumers will be less affected by the exclusion or unavailability of certain technological options (as nuclear or CSS), because the consumers will rely on CO_2 reductions realized abroad. There still remains an important opportunity cost for the Belgian economy in the sense that cheap CO_2 emission reductions have been excluded.

Upon scrutinizing the PRIMES results from a different side, however, and by confronting the challenges revealed with plausible 'real-life' difficulties, such as taking into account the grid-extension costs for massive expansion of off-shore wind capacity (> 900MW) and PV installed power (> 400 MW) and the rate of technology manufacturing, the situation will be more critical, both for import dependency and system cost.

The combination of relaxing arguments on the abatement cost because of non-CO_2 GHG and flexible mechanisms, on the one hand, and the mentioned additional 'real-life' difficulties, on the other hand, leads to the plausible conclusion that the overall costs as computed by PRIMES give a reasonable

[6] 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.

estimate of what is to be expected: ***the costs for severe GHG reduction cuts will be very high, unless appropriate policy choices are made, as suggested in our recommendations.***

If in addition, the above observation is combined with common-sense reflections on security of supply, we must conclude that no simple solutions exist; there is no silver bullet. ***The only reasonable option seems 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 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 will be extremely expensive and strongly perturbing for our economic fabric*. It is not literally impossible, but the risks of not succeeding are indeed very large, and likely at a very high cost, or by 'exporting' our CO_2 problem.

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 paradigm shift of the current official Belgian standpoint on nuclear power.

In the Recommendations, a proposal will be made to 'neutralize' the often quoted antithesis/contradiction between nuclear power, on the one hand, and energy efficiency & renewables, on the other hand, through a win-win situation, whereby the latter can benefit from the cost savings obtained by the former.

	Absolute values		Year 2030 % compared to Baseline			
	Baseline 2005	Baseline 2030	-15% no nuc; no CCS	-15% with nuc; no CCS	-30% no nuc; no CCS	-30% with nuc; no CCS
Primary energy consumption (PEC) [Mtoe]	59.2	55.4	-19.5	6.3	-29.2	-2.3
Primary energy intensity of GDP [toe/M€'00]	221.2	128.4	-19.6	6.7	-29.2	-2.3
Overall system cost [% of GDP]		10	16	11.5	31.5	15
Final energy demand (FED) / ***total***	38.6	40.9	-19.3	-5.3	-31.9	-17.3
Industry energy consumption	13.8	13.9	-20.9	-8.6	-29.7	-19.4
Industry energy related costs/toe			99.3	18.8	334.8	76.7
Residential energy consumption	10.0	10.0	-22.0	-5.7	-36.3	-19.9
Residential energy related costs/toe			64.5	9.4	219.8	49.8
Tertiary energy consumption	4.5	5.8	-23.7	-3.5	-40.7	-18.4
Tertiary energy related costs/toe			92.4	9.2	364.8	70.2
Transport energy consumption	10.4	11.3	-12.7	-1.7	-26.2	-12.0
			Year 2030 Other key results			
Structure of PEC (%)						
Coal	11.9	20.8	1.7	2.5	0.8	1.3
Oil	38.9	38.6	39.0	33.1	37.1	31.4
Natural gas	25.0	35.5	48.3	29.5	48.8	28.2
Nuclear	21.4	0.0	0.0	27.9	0.0	30.5
RES	1.7	5.3	11.0	7.0	13.3	8.7
Import dependency (%)	78.8	95.3	90.5	68.7	88.7	65.3
Structure of elec. generation (%)						
Nuclear	57.2	0.0	0.0	50.9	0.0	49.5
RES (incl waste)	2.5	11.8	28.3	20.3	32.8	22.3
Fossil fuels	40.3	88.2	71.7	28.8	67.2	28.2
% of electricity from CHP	9.0	18.2	14.5	15.0	14.1	12.4
Net CO_2 emissions in power sector (Mton)	23.5	52.4	27.0	12.8	18.6	12.7
Installed power capacity (MW)	14 998	22 999	29 998	27 912	32 367	31 913
Renewables total	554	3 926	13 392	7 612	17 299	11 159
Wind onshore	113	1 388	2 058	2 045	2 049	2 049
Wind offshore	0	1 019	3 800	3 800	3 800	3 800
Solar PV	4	209	5 903	209	9 880	3 792
Biomass (incl waste)	437	1 310	1 631	1 575	1 570	1 518
Coal fired	1 955	7 054	0	0	0	0
Gas fired	4 983	11 240	12 562	11 834	11 844	11 992
Nuclear	6 075	0	0	7 775	0	7 775
Carbon value ([€/ton CO_2]	5	5	524	105	2 150	490
Carbon value [$/bbl] - approx.	2	2	202	40	827	188

Note on Climate Policy Study versus CE2030 Scenarios

In parallel with this CE2030 study, the Federal Planning Bureau (FPB) has developed a different PRIMES-based study as part of the report, "The Climate Policy beyond 2012", by order of the Environment Minister Tobback. It must be stressed that those PRIMES results have little relationship with the activities of the CE2030 and the study performed by the FPB for our purposes, because of a totally different aim and boundary conditions.

First, the time horizon is 2020 instead of 2030.

Second, by 2020, less stringent GHG reduction limits are expected than in 2030.

Third, all scenarios for that study implement the nuclear phase out, but since the time horizon is only 2020, only about 1/4 of the nuclear installed capacity would have been taken out of service. This means that the situation is not nearly as critical as in 2030, after a complete phase out, and when more stringent CO_2 limits are likely to be imposed.

Fourth, because of the limited time horizon 2020, the assumed fuel prices (oil and gas) are only 80%of what they would be in 2030.

Fifth, that study considers reductions of all GHG in a European context, whereas our PRIMES scenarios focus on domestically energy-related CO_2 reductions. (In our work, the other GHG aspects are considered in a post-scenario qualitative analysis.) Furthermore, that study starts with an analysis of GHG emission reductions in Belgium according the principle of equal marginal abatement costs throughout Europe, and then explores the impact of specific policies and measures to achieve further reductions. Effectively, this equal marginal abatement costs approach gives rise to a lower burden sharing for domestic CO_2-reduction commitments for Belgium as a consequence of higher Belgian abatement costs (which are to some extent due to the already executed partial nuclear phase out).

Sixth, that study assumes revenues from the CO_2-abatement policy, being the integral/sum of the marginal abatement costs, which are then re-injected into the Belgian economy. This can only be done if indeed CO_2 taxes are imposed (or emission certificates are auctioned) so that revenues are collected. Note, however, that the choice of instruments is a complex issue because: 1) re-injecting the revenues into the economy only matters if there are important labor and other taxes; 2) but if there are important labor and other taxes (which is effectively the case), the cost to the economy of any environmental improvement is higher than presented in a partial equilibrium model like PRIMES even if the revenues are recycled; 3) so we run the risk of stating that costs become lower because of re-injection of revenues, but this is only part of the story.

Seventh, the scenario 'designated' -30% in that study reaches only a CO_2 reduction of 25%, by qualitatively invoking the flexible mechanisms, because of steeply rising CO_2 abatement costs. In our case, we force the PRIMES model to satisfy the imposed reduction, but only afterwards make the relationship with GHG reductions on an EU level.

In conclusion, the PRIMES part of the Climate Policy study calls on the same energy model, but addresses different issues than in our study, where the behavior, the reliability of the energy system and the security of supply issue, with all its intricacies, is primordial. As regards the climate issue, the two studies complement rather than contradict each other.

Recommendations

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 environment 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, a.o. 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.

Aim for stable legislation and regulatory framework based on a coherent long-term vision. The Belgian authorities are advised to refrain from haphazardly changing energy-related laws or from intervening in an ad-hoc manner. 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. Four elements come to mind immediately. 1) 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 30 to 70 kV (both values included) are operated within the framework of the integrated TSO Elia. 2) All tariffs are set by the Federal Authorities, regardless of which level is competent. 3) 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. 4) 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 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 sufficiently storable supply routes, rely on different mix of technologies and primary sources, coming from different geographical regions and all of this in an affordable way and sufficiently environmentally friendly.

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). Flexible mechanisms should be used, and there is a need to study the reform of present instruments used which are not optimal (abolition of subsidies, use of tax revenues, etc.). Nevertheless, **Belgium should define its medium to long-term energy policy taking into account a substantial domestic CO_2 reduction effort**.

Concrete recommendations

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 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. This energy-performance concept includes the appliances within the buildings.[7] 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 EU directive, *Public Service Obligations* regarding an energy savings (and not only electricity savings) target should be put on *distribution grid operators* (9% over 9 years) and the results must be closely monitored. A comprehensive impact analysis of a minus …1.5…% per year requirement 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 heating demand existing at the time of implementation.

Transport-related energy use is linked to the more global issue of *mobility*. Road congestion is here the main problem. 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.

Industry must be incited to 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.

To reflect scarcity of energy as an economic good and the related external costs, 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.**

Real time pricing should be a goal in the near term.

Rebates and special lower tariffs on energy must be avoided, unless there are justified reasons to do so (and unless other means for social correction have been exhausted).

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 to charge them, by the Regulator.

According to the present analysis, the achievement of more stringent post-Kyoto policies in Belgium without nuclear power is expected to be extremely expensive.

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

Therefore, **Belgium has to keep the nuclear option open and it is advised to *reconsider the nuclear phase out.***

To keep sufficient pressure on the energy system towards the transition to a more sustainable energy basket, an agreement with the owners of the Belgian nuclear power plants is to be sought for, for stimulating investments in energy savings & demand-side management, for development in renewable energy, for development & research in emerging energy technologies and carriers. The *Dutch Borssele agreement*, explicitly established via a Covenant and the *establishment of a sustainability fund*, may serve as a good guide. As in the Netherlands, the Government should also commit to an extra effort towards that fund on as 50-50 basis.

Operation of nuclear power, before and beyond an operation time of 40 years, 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).

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.

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, so that investors are stimulated to invest at the best locations in Europe.

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, should be carefully assessed, however.

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

In order to be serious about off-shore wind power development, the authorities must *reconsider seriously 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 off-shore sites are not to be dropped, but should *be developed meticulously*. Through a carefully designed staged process, an international leading role for far off-shore can be established: 1) start with a pilot project for a dozen far off-shore wind turbines (using 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 MW only when the results of the first phase are successful; 3) make an in-depth 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 off-shore investments, starting from the pilot plant all the way to the massive build up, could be socialized if the costs remain acceptable to society. Here, contribution from the above mentioned 'nuclear phase-out repeal fund' could be a welcome financial injection.

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 *one experimental pilot CC plant operating no later than 2030* on Belgian territory, privately or publicly funded.[8] 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.

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

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 (which should be almost advocated as a slogan).

A ***stable investment climate*** must be guaranteed for competitive market players to have sufficient new *electricity generation capacity* and to keep a substantial *refinery capacity.*

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.

A comprehensive study to find the appropriate energy mix, a.o., based on the *portfolio theory* must be effectuated for the Belgian situation.

The ***liberalization*** process for **electricity and gas in Belgium** must be developed in line with the European common 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. 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 must be legally unbundled (as prescribed by the EU Directive). Full ownership unbundling is not necessary as long as strict corporate governance rules are applied.

With most of Belgian energy-provision equipment and operation in dominantly 'non-Belgian' hands, appropriate guarantees for security of supply in all circumstances must be sought for, either by strict guarantees through the European institutions or via a golden share.[9]

Belgium should devote **much more *research & development* means in *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 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;
- 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 embedded generation;
- phased off-shore wind energy development;
- 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 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.

[9] The golden share formula, however, has been put in doubt through a recent ruling of the European Court.

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

Rather than solely relying on ad-hoc Committees (like the AMPERE Commission and this CE2030 Commission), it is recommended to establish a 'permanent' 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 the Federal and Regional Energy Administrations and Energy Regulators, the Energy Committee within the Central Council for the Economy, the Federal Council for Sustainable Development, the Federal Planning Bureau, Energy Scientists & Economists, amongst others. 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 gathering of correct and coherent energy-related data must be transferred timely to the Federal Administration, which must be given sufficient means to establish a reliable data center.

As these are the Conclusions & Recommendations (C&R) of the **Preliminary** CE2030 Report, the Report and its C&R will be reviewed by the designated **Review Panels**, reflecting a large cross section of the relevant societal actors. The CE2030 will analyze and evaluate the comments made by the Review Panels and will take into account the relevant and pertinent remarks for the final version of its Report. This Final Report is foreseen to be submitted to the Minister at the latest by June 19 2007.