5 Energy (including cables and pipelines)

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Citation:

Vanbavinckhove, G., Pirlet, H., 2013. Energy (including cables and pipelines). In: Lescrauwaet, A.K., Pirlet, H., Verleye, T., Mees, J., Herman, R. (Eds.), Compendium for Coast and Sea 2013: integrating knowledge on the socio-economic, environmental and institutional aspects of the Coast and Sea in Flanders and Belgium. Oostende, Belgium, p. 131-152.

5.1 Offshore wind energy

Europe is the world leader in the offshore wind energy sector. In 2011, 1,622 turbines have been installed and connected to the power grid, with a total installed capacity of 4,995 MW in the European seas. These windmills are spread over 55 wind farms in 10 different countries (*The European offshore wind industry, EWEA 2012* 225400). The UK and Denmark are currently the main actors in Europe regarding offshore wind energy. In Belgium, two wind farms (C-Power and Belwind) were operational at the end of 2012 with 36 and 55 wind turbines and a total installed capacity of 214.5 MW and 165 MW respectively, which ranks us third in Europe (*Mathys et al. 2009* 144679 (*OPTIEP-BCP project BELSPO*), *The European offshore wind industry, EWEA 2012* 225400, *website C-Power*, *website Belwind*).

5.1.1 Policy context

Over the past 10 years, renewable energy has increasingly come from offshore wind farms. This development is largely driven by the policy that seeks to reduce the dependence on fossil fuels and the associated impact on the climate (*OSPAR QSR 2010* 198817). The European *Directive 2001/77/EC* imposed on each Member State a target figure of the electricity's proportion to be produced by renewable sources by 2010. In the case of Belgium, this share was 6% of the total energy consumption. In 2008, the European Commission launched a new climate plan (*IP/08/80* 214781), in which Europe committed itself to produce 20% of its total energy production from renewable energy sources by 2020 *(COM (2010) 639)*. Belgium has been obliged to incorporate 13% of renewable energy into its final energy consumption by 2020[1] (*Directive 2009/28/EC*, *het nationaal actieplan hernieuwbare energie 2010* 226574). This objective embraces the entirety of green power, green heat and cooling, and biofuels. The European Commission emphasised in a number of communications (*COM (2008) 768, COM (2010) 677, COM (2010) 639, COM (2012) 271, COM (2012) 494*) the importance of offshore wind energy for achieving the renewable energy targets. A roadmap for the switchover in the long term to an energy system with low CO_2 emissions by 2050 has been outlined by Europe (*COM (2011) 112, COM (2011) 885*). Moreover, the potential of offshore wind energy has been recognised hereby (*Roadmap 2050 - technisch rapport* 214624, *Roadmap 2050 - beleidsaanbevelingen* 214623). An overview of the EU and national electricity market legislation is available on the *CREG* and *FPS Economy* website.

At the European level, the policy with regard to energy is developed by the *Directorate-General for Energy*. Furthermore, the Directorate-General for Maritime Affairs (*DG MARE*) works on the so-called 'blue economy' (including offshore wind turbines) policy. In Belgium, the policy on renewable energy is in principle a competence of the regions (*Vlaamse beleidsnota energie 2009-2014* 225407). However, the Belgian part of the North Sea (BNS) is placed under federal jurisdiction so that the policy on offshore wind energy is developed at the federal level by the Minister of Energy and the Minister of the North Sea (*FPS Economy, S.M.E.s, Self-employed and Energy*, for more information: *federale beleidsnota energie 2012* 226456, *het nationaal actieplan hernieuwbare energie 2010* 226574).

5.1.2 Spatial use

Prior to the installation of the wind farms, a study has been conducted with regard to the seabed, wind supply and grid capacity in the available areas for an optimal development of the offshore wind energy (*Le Bot et al. 2004* 64266, *project BELSPO*). Such a survey is important for the choice of the foundations of the wind turbines (*Van de Walle 2011* 203247). Besides, the spatial needs of other users of the sea should also be taken into account (*Maes et al. 2004* 70936 (*MARE-DASM project BELSPO*), *De Wachter & Volckaert 2005* 78285 (*GAUFRE project BELSPO*), *Verhaeghe et al. 2011* 206186, *MERMAID project*).

The coordinates of the designated space for the installation of wind farms in the BNS are established by the *Royal Decree of 20 December 2000* (as amended by the *Royal Decree of 3 February 2011*). In the draft of the Marine Spatial Plan (*Ontwerp van koninklijk besluit tot vaststelling van het marien ruimtelijk plan, 2013* 227527), as proposed by the Minister competent for the North Sea, some spatial policy choices have been formulated concerning the wind farms in the BNS. In this plan, no additional area for the production of renewable energy has been indicated as the current concession area should first be made fully operational.

1 Target for the share of energy from renewable sources in gross final consumption of energy.

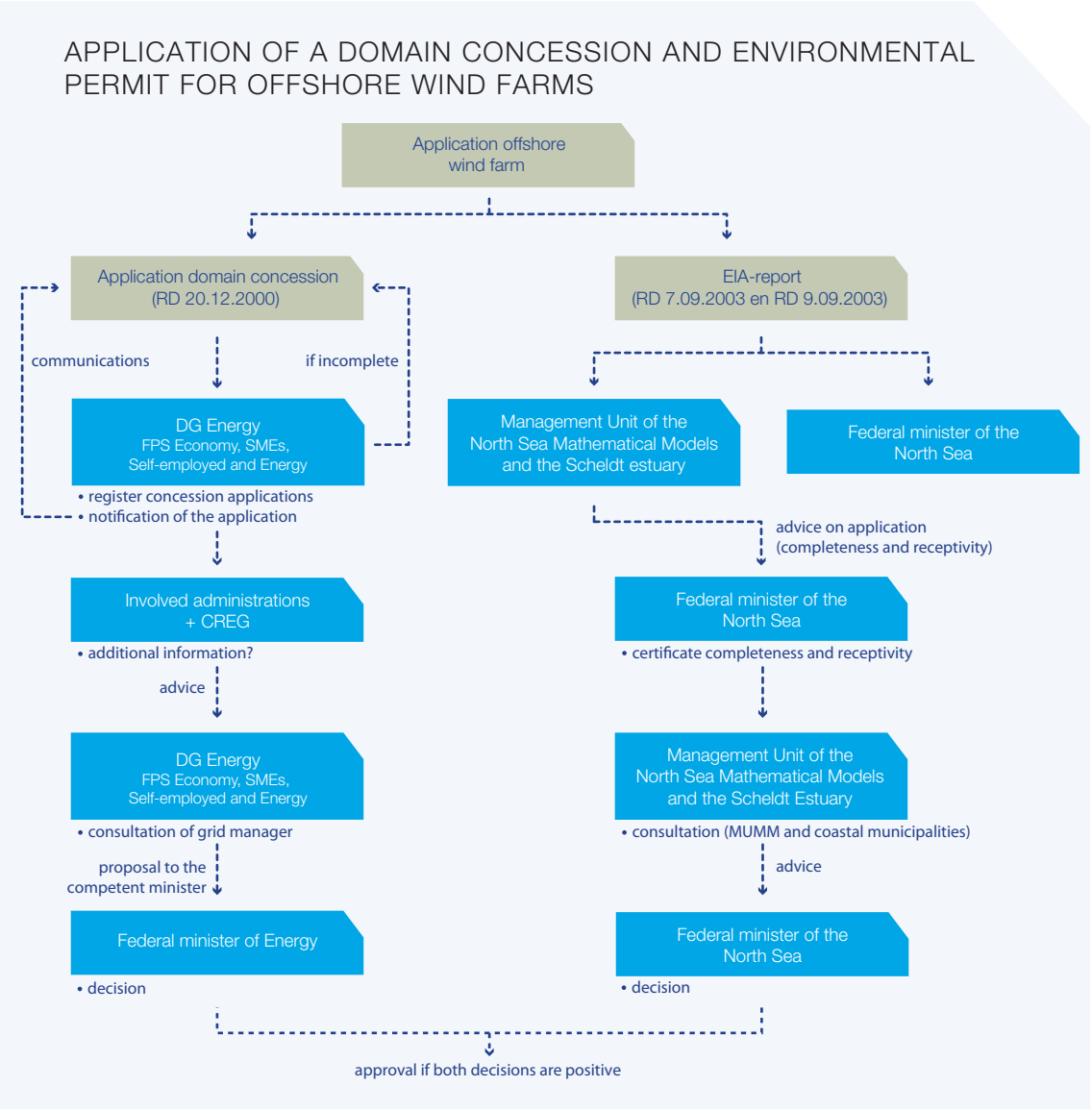

Figure 1. Flowchart for the application of a domain concession and environmental permit for offshore wind farms (*Royal Decree of 20 December 2000, Royal Decree of 9 September 2003*).

In order to actually realise an offshore wind farm, a project ought to have multiple permits. Currently the following federal permits are required:

- A Ministerial Decree for the granting, as a result of an environmental impact study, of a permit by the FPS Environment for the construction of the wind farm, the cabling and the operation;
- A Ministerial Decree for the granting of a concession zone by the DG Energy of the FPS Economy;
- (A Ministerial Decree for the granting of a permit for the installation of offshore cables by the DG Energy of FPS Economy (see also **Pipelines and cables**)).

ENVIRONMENTAL PERMIT

Each project must go through an environmental permit procedure in accordance with the law on the protection of the marine environment (*law of 20 January 1999*), the *Royal Decree of 7 September 2003* (procedure for the licensing and authorisation of certain activities in the BNS) and the *Royal Decree of 9 September 2003* (rules of the environmental impact assessment). The environmental impact assessment (EIA) is performed by the Management Unit of the North

Sea Mathematical Models (MUMM, RBINS) which subsequently advises the competent minister (*website MUMM*) (for more information: coastal codex, theme *EIA*).

DOMAIN CONCESSION

Each project should also pass the procedure for the designation of a domain concession for the proposed project area (see figure 1). The latter procedure and the conditions for granting a concession have been stipulated in the *Royal Decree of 20 December 2000*. As a result of the modification of the *Royal Decree of 28 September 2008*, applications for a domain concession for the construction and operation of offshore installations in the BNS should no longer be addressed to the Commission for the Regulation of Electricity and Gas (*CREG*). According to the new procedure, they have to be directed to and handled by the delegate of the Minister, who advises the Minister of Energy (see also the *Ministerial Decree of 16 March 2009*).

When additional permits are required by other legislation for installations in the domain concession (e.g. the environmental permits), the permit of the domain concession remains suspended until any additional license or authorisation has been granted. Moreover, a notification of this authorisation should be made in accordance to the applicable law. If any of the additional required permits or final permissions are refused, the domain concession expires on the date of notification of this refusal. In Belgium, 7 domain concessions have already been granted to different project developers (table 1, figure 2).

Table 1. An overview of the location and use of space of the various domain concessions for offshore wind farms in the BNS.

NAME PROJECT	LOCATION	USE OF SPACE	MORE INFORMATION
Mermaid	Above the Bligh Bank	28.39 km²	
Belwind	Bligh Bank	35.4 km²	*MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *website Belwind*
Seastar	Between the Lodewijkbank (former Bank Zonder Naam) and the Bligh Bank	16 km²	*Website electrawinds*, *website 4c offshore*
Northwind (vroeger Eldepasco)	Lodewijkbank (former Bank Zonder Naam	14.5 km²	*MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *website Northwind*
Rentel	Southwest Schaar	18 km²	*Website electrawinds*, *website 4c offshore*
C-Power	Thorntonbank	13.79 km²	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *website C-Power*
Norther / North Sea Power	South of the Thorntonbank	28.2 km² (38 km² including cables and pipelines)	*MER Norther project en wijzigingsMER*, *Website 4c offshore*

In Belgium, a ban on shipping has been established in the area of wind turbines and wind farms (*Verhaeghe et al. 2011* [206186], *Royal Decree of 11 April 2012*). From the operational phase onwards, a safety zone of five hundred meters is established around artificial islands, installations or infrastructure for the generation of energy from water, currents and winds (such as wind turbines and wind farms) (*Decree of 11 April 2012*) (figure 2).

5.1.3 Societal interest

THE ENERGY PRODUCTION OF OFFSHORE WIND FARMS

According to a study by the European Environment Agency (EEA), the economically feasible potential of offshore wind production amounts to 2,600 TWh in 2020 and 3,400 TWh in 2030. This corresponds to 60-70% of the total

THE LOCATION OF THE DIFFERENT WIND FARMS IN THE BNS

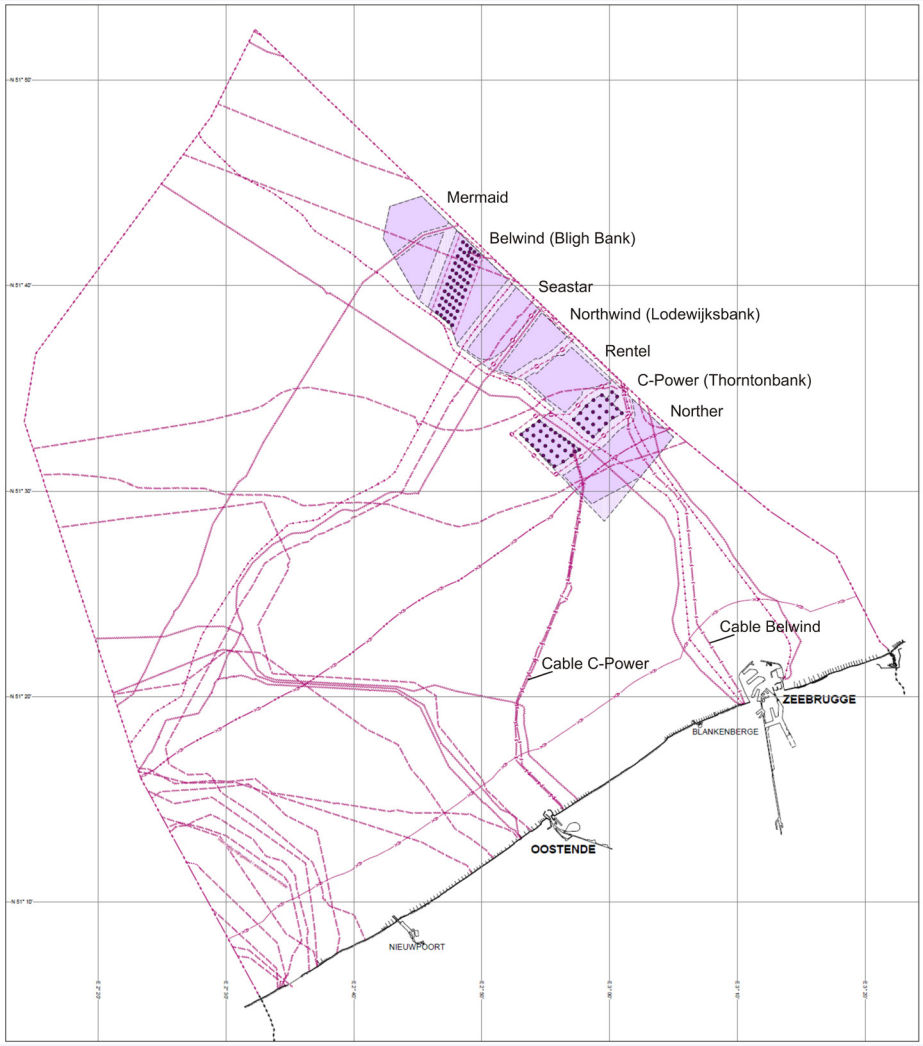

Figure 2. The location of the different wind farms in the Belgian Part of the North Sea with an indication of the turbines that were already constructed in May 2013. The cables of C-Power and Belwind are indicated as well (*Continentaal Plat & Vlaamse Hydrografie 2013* [227521]).

European electricity demand in 2020 and 80% in 2030. The hypothetical (unlimited) technical potential for offshore wind energy in Belgian waters based on the average wind speed is 251 TWh (*studie energiepotentieel EMA* [206643]).

The total installed capacity that could be theoretically installed if all available area in the BNS was used for wind farms is 21 GW. In a more realistic approach, where only the available surface with a depth of less than 20 m and less than 40 km from the coast is considered, a potential capacity of 2.1 to 4.2 GW is calculated (*Mathys et al. 2009* [144679], *OPTIEP-BCP project BELSPO*) (it should be mentioned that some of the current wind turbines are situated in a water depth of more than 20 m and / or more than 40 km away from the coast). The total capacity of the projects which were already granted a domain concession in early 2011, is approximately 1.8 GW (table 2, for more information: *Brouwers et al. 2011* [225406]). At the end of 2012, two wind farms were partially operational with an installed capacity of 214.5 MW and 165 MW (*Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*), *The European offshore wind industry, EWEA 2012* [225400], *website C-Power*, *website Belwind*) (figure 3). The production of the existing wind farms in 2009 amounted to 82 GWh; in 2010: 188 GWh (estimated); in 2011: 690 to 760 GWh (estimated) (Source: DG Energy, FPS Economy). The expected production of the first three wind farms should be about 2.8 TWh per year (estimated) at the end of 2014 (*brochure FOD Economie 2012* [225395]).

Table 2. An overview of the status, the number of turbines and the total capacity of the wind farms in the BNS.

NAME PROJECT	STATUS	NUMBER OF TURBINES	TOTAL CAPACITY	MORE INFORMATION
C-Power	36 turbines operational, 3th phase under construction	54	325 MW	*brochure FOD Economie 2012* [225395], *MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *website C-Power*
Northwind (former Eldepasco)	Start construction in April 2013, financed	72	216 MW	*MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *website Northwind*
Belwind	55 turbines operational since December 2010 (first phase), 2nd phase: 2014	110	330 MW	*brochure FOD Economie 2012* [225395], *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *website Belwind*
Rentel	Planning / Concession and environmental permit granted	47-78	288-550 MW	*Milieueffectenrapport windmolenpark Rentel 2012* [225506], *Website electrawinds*, *website 4c offshore*
Norther / North Sea Power	Planning / Concession and environmental permit granted	100 (86-74-47)	300 (258-470 MW)	*MER Norther project en wijzigingsMER*, *Website 4c offshore*
Seastar	Planning / Concession granted	41	246 MW	*Website electrawinds*, *website 4c offshore*
Mermaid	Planning / Concession granted	49-73	449-490 MW	DG Energy, FPS Economy

EMPLOYMENT

In 2011, figures about the employment associated with three offshore wind projects in the BNS were as follows:

- C-Power: 1,036,650 man-hours (phase 1) and 1,400 man-years (phase 2 and 3) (*website C-Power*);
- Belwind: 1,300 man-years (*Website Belwind*);
- Northwind (former Eldepasco): 700 man-years (*Vergunningsaanvraag* Eldepasco).

Figures about employment in the offshore wind energy sector are also available in *Hutsebaut & De Decker (2010)* [225505].

THE ECONOMIC POTENTIAL OF OFFSHORE WIND ENERGY

The cost of offshore wind energy varies widely depending on the study. Indeed, there are several input parameters and factors that affect the price of a project: the size of the entire wind farm, the distance from the coast, the water depth, time of construction, etc. In addition, the profitability of offshore wind energy also depends on a number of other parameters: cost reductions over time by increasing experience and newer technology, fuel prices, raw material prices, CO_2 emission trading fees, the policy, the electricity price, capacity factor, interest rates, etc. (*Verrips et al. 2005* [108727]), *Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*), *Van de Walle 2011* [203247].

The studies of *Le Bot et al. (2004)* [64266] (*project BELSPO*) and *Soens (2005)* [105575] estimate the cost of investment for state-of-the-art technology in 2005 between 1,500 and 2,400 euro/kW (installation of windmill + connection to land). According to these studies, the costs in 2015 should drop to 900 to 1,600 euro/kW as a result of technological innovation. The study *Mathys et al. (2009)* [144679] (*OPTIEP-BCP project BELSPO*) reports a range of the prices per installed capacity from about 1,000 euro/kW to 4,800 euro/kW. In the BNS, the C-Power project was estimated at 2,666 euro/kW and the RENTEL project at 3,472 euro/kW. The construction, production and damage costs for offshore wind energy are discussed in *Brouwers et al. (2011)* [225406] (table 3).

Table 3. The production costs and damage costs of offshore wind energy in 2010 in Flanders (Nijs et al. 2011 in *Brouwers et al. 2011* [225406]).

€ 2009/MWU	INVESTMENT AND FIXED COSTS	VARIABLE COSTS	FUEL COSTS	PRODUCTION COSTS	DAMAGE COSTS
Nearby offshore wind farm	74	0.7	0	74	2
Medium-distance offshore wind farm	79	0.7	0	80	2
Distant offshore wind farm	99	0.7	0	100	2

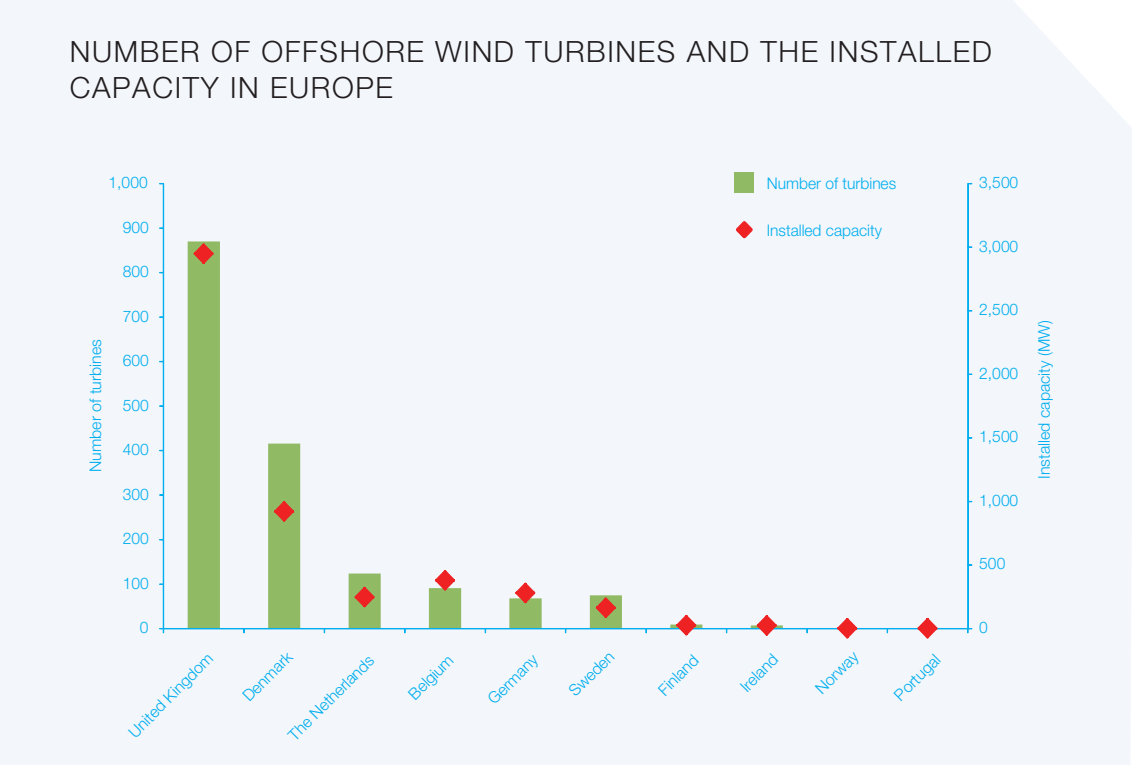

Figure 3. The number of offshore wind turbines and the installed capacity in Europe in 2012 (*The European offshore wind industry, EWEA 2012* [225400]).

5.1.4 Impact

The installation of wind farms in the BNS has a number of effects on the ecosystem and on the users of the sea (table 4 and 5). The impacts on the marine environment that should be addressed in the environmental impact assessment (EIA) have been stipulated in the *Royal Decree of 9 September 2003* on the environmental impact assessment. The EIAs and related documents are available on the website of *MUMM*. In addition, numerous scientific studies have been performed in order to elucidate the impact of wind turbines on the marine environment (table 4).

5.1.5 Sustainable use

MEASURES AS TO THE IMPACT ON THE MARINE ENVIRONMENT

At an international level, OSPAR has published a guide (*OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development* [206720]) in which the impact of wind turbines on the marine environment is discussed.

Table 4. An overview of the effects of offshore wind turbines on the environment.

ENVIRONMENTAL IMPACT	LITERATURE
Effects on the hydrodynamic regime	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Vandeneynde et al. 2010* [199743], *Verhaeghe et al. 2011* [206186], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Effects on the sediment transport and geomorphology	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Vandeneynde et al. 2010* [199743], *Verhaeghe et al. 2011* [206186], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Underwater noise	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Haelters et al. 2009* [142995], *Norro et al. 2010* [199744], *Norro et al. 2011* [207277], *Verhaeghe et al. 2011* [206186], *Haelters et al. 2012* [218683], *Norro et al. 2012* [218684], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Effects on the fish and benthos (introduction of hard substrate, habitat loss, disturbance, etc.)	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Kerckhof et al. 2009* [142997], *Reubens et al. 2009a* [142998], *Reubens et al. 2009b* [142999], *Vandendriessche et al. 2009* [143001], *Kerckhof et al. 2010* [199745], *Reubens et al. 2010* [199747], *Coates & Vincx 2010* [199748], *Derweduwen et al. 2010* [199750], *Reubens et al. 2011a* [202018], *Kerckhof et al. 2011* [207279], *Reubens et al. 2011b* [207280], *Vandendriessche et al. 2011* [207288], *Coates et al. 2011* [207283], *Van Hoey et al. 2011* [207293], *Verhaeghe et al. 2011* [206186], *Kerckhof et al. 2012* [218676], *Coates et al. 2012* [218677], *Vandendriessche et al. 2012* [218679], *Derweduwen et al. 2012* [218680], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Effects on seabirds	*Stienen et al. 2002a* [39505], *Stienen et al. 2002b* [39506], *MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *Everaert & Stienen 2007* [117811], *Stienen et al. 2007* [111966], *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Vanermen et al. 2009* [138529], *Vanermen & Stienen 2009* [134402], *Brabant & Jacques 2009* [143009], *Vanermen et al. 2010* [199751], *Vanermen et al. 2011* [207290] *Verhaeghe et al. 2011* [206186], *Vanermen et al. 2012* [218681], *Brabant et al. 2012* [218682], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Effects on marine mammals	*Stienen et al. 2002a* [39505], *MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Evans 2008* [206639], *Haelters 2009* [143010], *Haelters et al. 2010* [199753], *Haelters et al. 2011* [207292], *Verhaeghe et al. 2011* [206186], *Haelters et al. 2012* [218683], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Impact on the water and air quality	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *Maes et al. 2004* [70936] (*MARE-DASM project BELSPO*), *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Verhaeghe et al. 2011* [206186], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]

Table 5. An overview of the effects of offshore wind turbines on other users of the sea and coast.

IMPACT ON USERS	LITERATURE
Impact on the seascape	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Di Marcantonio 2009* [143011], *Vanhulle et al. 2010* [199754], *Houthaeve & Vanhulle 2010* [206727], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]
Maritime safety	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *van Iperen & van der Tak (2009)* [206730], *Verhaeghe et al. 2011* [206186], *Milieueffectenrapport windmolenpark Rentel 2012* [225506] (see also theme **Maritime transport, shipping and ports**)
Spatial impact (e.g. conflicts with other users)	*Seys 2001*, *MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *Maes et al. 2004* [70936] (*MARE-DASM project BELSPO*), *De Wachter & Volckaert 2005* [78285] (*GAUFRE project BELSPO*), *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Vandendriessche et al. 2011* [207288], *Milieueffectenrapport windmolenpark Rentel 2012* [225506]

Within the context of the *ASCOBANS* agreement (on the conservation of small cetaceans), the impact of wind turbines on marine mammals has been evaluated (*Evans 2008* [206639]). In 2009, a *resolution* [206635] was issued against the negative effects on marine mammals of underwater noise during the construction of offshore energy installations.

At the European level, the *Marine Strategy Framework Directive* (*2008/56/EC*) (MSFD) provides a framework to reduce or avoid the impact of offshore wind farms on the environment. Underwater noise and other forms of energy are hereby identified as one of the descriptors for a good environmental status (GES) (*Tasker et al. 2010* [202493]). Other descriptors in the *MSFD* which are relevant for the installation of wind turbines at sea are the integrity of the seabed (*Rice et al. 2010* [202490]), non-indigenous species (*Olenin et al. 2010* [202485]) and the permanent alteration of hydrographic conditions.

At the Belgian level, a monitoring programme has been set up in the BNS to estimate the impact of wind turbines on the marine environment. This programme is coordinated by MUMM and has a twofold objective:

- To adjust, reduce or even stop the activities if extreme damage occurs to the marine environment;
- To gain insight into the impact of offshore wind turbines on the environment in order to support the policy, management and design of future wind turbines.

The monitoring programme examines both the physical, biological and socio-economic aspects of the marine environment (*Degraer & Brabant 2009* [142990], *Degraer et al. 2010* [199194], *Degraer et al. 2011* [207257], *Degraer et al. 2012* [218670]) compared to a reference condition (e.g. *De Maersschalck et al. 2006* [225398], *Henriet et al. 2006* [199011], *Van den Eynde 2005* [226451]).

Within the framework of the *Actieplan Zeehond* [216403], the windmills at sea are used as a laboratory for testing the effects of artificial reefs and artificial resting places in order to increase the biodiversity and productivity. The draft of the Marine Spatial Plan (*Ontwerp van koninklijk besluit tot vaststelling van het marien ruimtelijk plan, 2013* [227527]), as proposed by the Minister in charge of the North Sea, further elaborates on the multiple use of space in the wind farms (aquaculture (there is still feedback needed with regard to the ban on shipping, *Royal Decree of 11 April 2010*), development of nature, wave and tidal energy, etc.).

THE DEVELOPMENT OF OFFSHORE WIND ENERGY - CONFLICTS AND MEASURES

At the European level, a number of obstacles have been identified that hinder the development of offshore wind energy (*COM (2008) 768*):

- Offshore wind energy is facing particular industrial and technological challenges;
- A lack of integrated strategic planning and cross-border coordination (need for marine spatial planning, see also *COM (2007) 575* on an integrated maritime policy);
- A lack of knowledge and information sharing hampers a smooth application of the EU environmental legislation;
- Dealing with bottlenecks and power balancing in the onshore electricity grids.

In the European project *windspeed*, a policy-supporting tool (*Schillings et al. 2010* [226571]) and a roadmap (*Veum et al. 2011* [225503]) have been designed which take into account the spatial conflicts with other users, the grid capacity and ecological, technological and economic aspects of wind energy development in the central and southern part of the North Sea. In other European projects such as *MERMAID*, *TROPOS* and *H_2Ocean*, the multiple use of marine space and new technological developments in offshore wind farms have been investigated.

In Belgium, the production of renewable energy is supported through 'Green Current Certificates' (GSC). Regarding energy generated by offshore wind turbines (organised at the federal level), the network operator is obliged by the *Royal Decree of 16 July 2002* to purchase the 'green current certificates' from the offshore wind energy producer, at a minimum price of 107 euro/MWh for the production coming from the first 216 MW of installed capacity and 90 euros/MWh from an installed capacity above the first 216 MW. This purchase obligation must constitute a part of a contract between the concessionaire and the network operator and should be approved by the Commission for the Regulation of Electricity and Gas (CREG) (*website CREG*). Furthermore, the *Decree of 30 March 2009* regulates a tolerance system for the production anomalies of electricity from offshore wind energy.

Moreover, the *law of 29 April 1999* on the organisation of the electricity market stipulates that the transmission system operator has to finance a third of the cost of the submarine cable, up to a maximum amount of 25 million euros for a project of 216 MW or more. This funding of 25 million euros will be reduced proportionally if the project is less than 216 MW (*brochure FOD Economie 2012* [225395], see also **Pipelines and cables**).

The potential of wind energy in the BNS is currently limited by the available grid capacity of the electricity network. Both on land and offshore, there is a need for grid reinforcement. Depending on the study, the current grid capacity of the electricity network on land is estimated between 600 and 900 MW (*Soens 2005* [105575], *Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*)). A single offshore connection for marine cables from the offshore wind farms is currently being created to reduce the number of cables (see also **Pipelines and cables**) (*visie Elia offshore grid 2012*, *brochure FOD Economie 2012* [225395]). In the future, the subsidy system described above will be revised, *inter alia* because of this offshore connection. In the future, the connection could be connected to the offshore North Sea grid (an integrated energy grid that connects offshore wind farms and other offshore renewable energy producers in the North Sea) (*Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*), *Offshore Electricity Grid Infrastructure in Europe 2011* [225405]).

5.2 Natural gas installations in Zeebrugge

In Belgium, more than 17 billion m³ of natural gas is consumed each year and about 95 billion m³ of natural gas has been reserved in the long term for border-to-border transport. This includes Dutch and Norwegian gas for France and Spain, British gas for continental Europe, Russian gas for the UK, as well as natural gas for the Grand Duchy of Luxembourg. Zeebrugge plays an important role in the European gas market. The landing capacity at Zeebrugge corresponds to approximately 10% of the total border capacity which is needed to supply the European Union (*België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010* [225394]).

5.2.1 Policy context

The European gas market is regulated by the so-called third European legislative package on energy that consists of *Directive 2009/73/EC* (common rules for the internal market in natural gas), *Regulation 715/2009* (conditions for access to the natural gas transmission networks) and *Regulation 713/2009* (establishing an Agency for the Cooperation of Energy Regulators).

The federal government (FPS Economy, SMEs, Self-employed and Energy) is responsible for the large infrastructures for energy storage, transportation and production, and sets the tariff policy for the managers (in this case, Fluxys and Fluxys LNG) (*federale beleidsnota energie 2012* [226456]). The transport of gaseous products is regulated by the federal *law of 12 April 1965* (the Gas Act) and by a number of Royal Decrees concerning rates and the more technical aspects of network access (code of conduct) (for more information: *website Fluxys*, *website CREG*, *website FPS Economy*, *Fluxys Jaarlijks financieel verslag 2010* [225401]). Furthermore, there is a federal regulator: the Commission for the regulation of electricity and gas (*CREG*). Flanders is competent for the public distribution of gas, which is managed by the so-called 'intercommunales', as well as for the rational use of energy (more information: *website fluxys*, *Fluxys Jaarlijks financieel verslag 2010* [225401]).

5.2.2 Spatial use

The LNG (Liquefied Natural Gas) terminal is located in the eastern harbour of the port of Zeebrugge. The peninsula on which the LNG terminal is located covers an area of approximately 32 ha (non-technical summary EIA Zeebrugge LNG terminal). There are currently plans for a new extension with a new storage tank, landing platform and additional transmission capacity (*Open season: second capacity enhancement of the Zeebrugge LNG terminal. Binding phase: offer description 2011* [226568]). In the draft of the Marine Spatial Plan (*Ontwerp van koninklijk besluit tot vaststelling van het marien ruimtelijk plan* [227527]), as proposed by the Minister of the North Sea, space will be provided for the development of the LNG terminal in the port of Zeebrugge. In addition, terminals of the Zeepipe and Interconnector gas pipelines are located in Zeebrugge (see **Pipelines and cables**).

5.2.3 Societal interest

Zeebrugge is a cornerstone in the supply chain of natural gas to Northwest Europe with the LNG terminal and the terminals of the Zeepipe and Interconnector gas pipelines (see **Pipelines and cables**). Furthermore, the Zeebrugge Hub is one of the leading short-term markets in Europe (*België als aardgasdraaischijf voor Noordwest-Europa: de weg vooruit 2010* [225394], *Brouwers et al. 2011* [225406]). In 2010, a total of 62 billion m³ of gas was traded in the Zeebrugge Hub (*Open season: second capacity enhancement of the Zeebrugge LNG terminal. Binding phase: offer description 2011* [226568]).

The installations of the LNG terminal in Zeebrugge are equipped for the reception of ships carrying liquefied natural gas (LNG). Since 2008, there are four active storage tanks with a total handling capacity of 9 billion m³ of natural gas per year, equaling 110 LNG ships with a capacity of up to 217,000 m³ of liquefied natural gas. At present there are plans for an additional storage tank of 160,000 m³ of LNG (*website Fluxys*, *Fluxys Jaarlijks financieel verslag 2011* [225402], *Open season: second capacity enhancement of the Zeebrugge LNG terminal. Binding phase: offer description 2011* [226568], *Brouwers et al. 2011* [225406]). Fluxys has opted for a model of cooperation for the development of an LNG terminal in Dunkirk and participates for 25% in this project. A pipeline connection between the two terminals is being prepared through a new interconnection point in Alveringem and Maldegem. Fluxys LNG, the owner and operator of the LNG terminal in Zeebrugge, recorded a net profit of 17.0 million euro in 2011 (15.8 million euro in 2010) (*Fluxys Jaarlijks financieel verslag 2011* [225402]).

5.2.4 Impact

The installation of an LNG terminal, at a small distance from the nearest habitation on the seawall of Heist, entails a number of environmental effects that are addressed in the EIA (non-technical summary EIA Zeebrugge LNG terminal). These include noise and vibration, air pollution, wastewater production, pollution of soil and groundwater, disturbance of fauna and flora, disruption of the landscape, production of light, heat and radiation, etc.

5.2.5 Sustainable use

In the EIA, a number of measures to mitigate or avoid the impact of the LNG terminal on the environment have already been listed (non-technical summary EIA Zeebrugge LNG terminal). In accordance with the Kyoto Protocol, the peak-shaving installation in Zeebrugge was closed down in 2010. Furthermore, the construction of an 'open rack vaporiser' at the LNG terminal was started in order to reduce the energy consumption and the emissions of NO_x and

CO_2 (*Fluxys Jaarlijks financieel verslag 2011* [225402]). Much attention is also given to safe operation. Because of the amount of natural gas, the LNG terminal is regarded as a Seveso installation, which must comply with specific safety requirements (*Fluxys Jaarlijks financieel verslag 2011* [225402]). Furthermore, LNG vessels must undergo a ship clearance procedure in order to load or unload at the LNG terminal in Zeebrugge (*website Fluxys*).

5.3 Pipelines and cables

In the OSPAR area, the 1,300 oil and gas platforms are connected with a pipeline network of more than 50.000 km (*OSPAR QSR 2010* [198817]). In the Belgian part of the North Sea (BNS), there are 3 gas pipelines with a total length of 163 km (*Verfaillie et al. 2005* [78284], *GAUFRE project BELSPO*):

- The Zeepipe pipeline connects the Distrigaz terminal in the port of Zeebrugge to a pipeline on the Norwegian shelf and has a total length of 814 km;
- The Interconnector pipeline is 215 km long and is located between Zeebrugge and Bacton (south coast, UK);
- The Norfra pipeline (now also called Franpipe) is a 840 km long pipeline between the Norwegian shelf and the port of Dunkirk which partially crosses the BNS (*Maes et al. 2000* [18619]).

In addition, the North Sea and the North Atlantic Ocean are intersected by telecommunication and power cables. Telecommunication cables are mainly situated in the southern part of the North Sea, in the Celtic Seas and in the

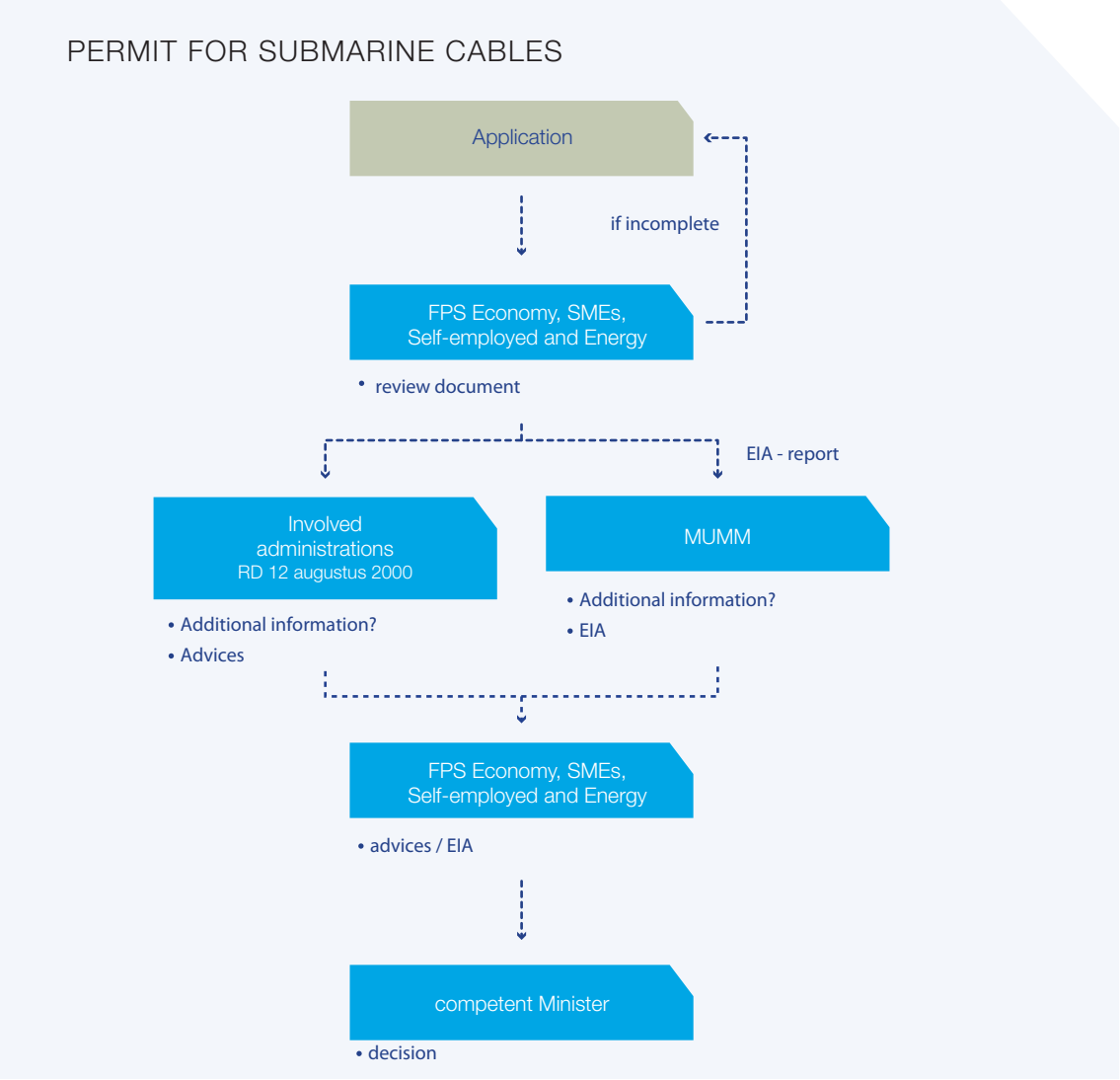

Figure 4. Flowchart of the permit for submarine cables (*Royal Decree of 12 March 2002*).

trans-Atlantic corridor. Power cables can be found in the North Sea and Celtic Seas (*OSPAR QSR 2010* [198817]). On the Belgian Continental Shelf (BCS), there are 27 telecommunication cables, 16 of which are in use, with a total length of 914 km (*Verfaillie et al. 2005* [78284], *GAUFRE project BELSPO*). In the future, the share of electricity cables will expand due to the installation of offshore wind turbines (see **Offshore wind energy**). In early 2013, four cable licenses had already been delivered (2 C-Power cables, 2 Belwind cables, 1 Northwind cable and 2 Norther cables) of which three cables are in use (2 for C-Power and 1 for Belwind).

5.3.1 Policy context

The procedure for the installation of electric cables in the BCS has been stipulated in the *Royal Decree of 12 March 2002* (see also *Ministerial Decree of 8 May 2008*) (figure 4). The applications are sent to the Minister of Energy or his delegate. The documents for the application are submitted to the Minister. The dossier is accompanied by the evaluation of the impact on the environment and the advice of all administrations involved. The granting of the permit is motivated by a Ministerial Decree that specifically takes into account the conclusions of the environmental impact assessment (EIA). The EIA is performed by the Management Unit of the North Sea Mathematical Models (MUMM) (more information: coastal codex, themes *EIA* and *cables and pipelines*).

The procedure for the construction of pipelines is determined by the *law of 12 April 1965* on the transport of gas and other gaseous products by pipeline. This law was supplemented by various Royal Decrees. One of those decrees concerns the safety of facilities for gas transport, namely the *Royal Decree of 11 March 1966*, on the measures to be taken during the construction and operation of gas transport by means of pipelines. The *Royal Decree of 11 March 1966* is currently being reviewed. Technological progress and the use of international standards are taken into account, as well as certain elements which have been brought to the attention as a result of the disaster in Ghislenghien, and the need for administrative simplification. There are also similar decrees for the transport of other substances.

5.3.2 Spatial use

In the draft of the Marine Spatial Plan (*Ontwerp van koninklijk besluit tot vaststelling van het marien ruimtelijk plan, 2013* [227527]), as proposed by the Minister competent for the North Sea, some spatial policy choices have been formulated with regard to cables and pipelines in the BNS. New cables and pipelines should be bundled as much as possible in corridors, so to create the shortest possible connection between departure and arrival points. The plan provides no specific routes but takes into account an area for a new power cable between Belgium and Britain (the NEMO

Table 6. An overview of the use of space around cables (*Royal Decree of 12 March 2002*).

CABLES		PIPELINES (not legally defined)	
Protected area (250 m on either side)	Reserved area (50 m on either side)	Protected area (1,000 m on either side)	Reserved area (500 m on either side)
Anchoring prohibited	No installation, no cable or pipeline construction	No sand extraction	No other infrastructures unless they cross the pipeline
No activity that puts the cable at risk (except the installation of a cable under certain conditions).		No other pipelines	
Exception: interventions of the owner for operation	***Exception:*** unipolar cables on the same safety switch, arrival of cables from and departure of cables to a wind turbine in parallel with others, point of arrival from and departure to an infrastructure with one or more cables, convergence point of several cables that are part of the same mechanism to return to the mainland, repaired cables		***Exception:*** maintenance dredging and interventions of the owner for operation

project, see **Sustainable use**). Furthermore, additional cables and power stations (the single offshore connection for wind farms, see **Sustainable use**) are expected in view of the development of a European energy grid and a new pipeline between Zeebrugge and Norway. Ostend (Sluikens) and Zeebrugge have been selected as landing points on the coast.

The spatial restrictions around the power cables in the BNS are determined by the *Royal Decree of 12 March 2002* (table 6). The spatial use around pipelines is not legally defined.

The agreement between Norway and Belgium with regard to the Norfra pipeline has been formalised in the *law of 13 May 2003* and in the *law of 19 September 1991* concerning the Zeepipe pipeline. The agreement related to the transport of gas in the Interconnector pipeline between Britain, Northern Ireland and Belgium has been formalised in the *law of 26 June 2000*. For a complete overview of the legislation on the pipelines in the BNS, see coastal codex, theme *cables and pipelines*.

CABLES AND PIPELINES IN THE BNS

Figure 5. The cables and pipelines (in blue) in the BNS (*Continentaal Plat & Vlaamse Hydrografie 2013* [227521]).

5.3.3 Societal interest

Due to the increasing importance of offshore wind turbines, there is a growing demand for submarine power cables for the transport of energy to the mainland. In addition, submarine cables are also important for transnational energy and communication networks (*OSPAR QSR 2010* [198817]).

The transport of gaseous products to our country via submarine pipelines:

- The Zeepipe is managed by Statoil and transports approximately 13 billion m³ of gas per year with a daily capacity of 41 million m³;
- The Norfra pipeline has been operational since 1998 and transports 40 million m³ of gas per day between Dunkirk and the Norwegian shelf. The pipeline has a capacity of 15 billion m³ per year;
- The Interconnector pipeline has been operational since October 1998 between the south coast of England and Zeebrugge. This pipeline is bidirectional and can thus be used for the import / export of gas from / to England. In winter there is import from England with a capacity of 8.5 billion m³ per year and in summer there is export to England with a capacity of 20 billion m³ per year.

(*Verfaillie et al. 2005* [78284] (*GAUFRE project BELSPO*), *Brouwers et al. 2011* [225406])

5.3.4 Impact

The construction and operation of pipelines and cables has some (local) impact on the marine environment. The effects are described in table 7.

Table 7. An overview of the effects of the construction and operation of cables and pipelines on the (marine) environment.

IMPACT	LITERATURE
Toxic pollution due to the pipeline's zinc coating	*Maes et al. 2004* [70936] (*MARE-DASM project BELSPO*)
Introduction of hard substrate on the bottom (pipeline) => non-indigenous species	*Maes et al. 2004* [70936] (*MARE-DASM project BELSPO*), *OSPAR QSR 2010* [198817]
Sediment disturbance during the construction and removal of cable / substrate (including increased turbidity and release of pollutants adsorbed by soil particles)	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Milieueffectenrapport windmolenpark Rentel 2012* [225506], *Milieueffectenrapport - NEMO LINK 2012* [227877]
Effect on the temperature of the surroundings	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *OSPAR QSR 2010* [198817], *Milieueffectenrapport windmolenpark Rentel 2012* [225506], *Milieueffectenrapport - NEMO LINK 2012* [227877]
Electromagnetic field around the cables	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *OSPAR QSR 2010* [198817], *Milieueffectenrapport windmolenpark Rentel 2012* [225506], *Milieueffectenrapport - NEMO LINK 2012* [227877]

IMPACT (continuation)	LITERATURE
Underwater noise when installing cables / pipelines	*MER voor een Offshore Windturbinepark op de Thorntonbank. Deel 2: Hoofddocument MER 2003* [226563] + *MER - Wijziging & uitbreiding offshore windturbinepark Thorntonbank. C-Power N.V. 2010* [227509], *MER Norther project en wijzigingsMER*, *MER Offshore Windmolenpark Bligh Bank. Belwind NV 2007* [227510], *MER – Offshore Windturbinepark Bank zonder Naam. Eldepasco NV 2008* [226564], *Milieueffectenrapport windmolenpark Rentel 2012* [225506], *Milieueffectenrapport - NEMO LINK 2012* [227877]
Impact on other users	*Verfaillie et al. 2005* [78284] (*GAUFRE project BELSPO*), *Milieueffectenrapport - NEMO LINK 2012* [227877]

5.3.5 Sustainable Use

MEASURES AS TO THE IMPACT ON THE MARINE ENVIRONMENT

At present there are no common programmes or measures to address the impact of pipelines and cables on the marine environment at an international level (*OSPAR QSR 2010* [198817]).

At the European level, the *Marine Strategy Framework Directive* (*2008/56/EC*) (MSFD) can be regarded as a framework to address the impact of submarine cables and pipelines. This directive comprises the following descriptors of a good environmental status of the marine environment: underwater noise and other forms of energy (*Tasker et al. 2010* [202493]), the integrity of the seafloor (*Rice et al. 2010* [202490]) and non-indigenous species (*Olenin et al. 2010* [202485]).

At a Belgian level, the effects of power lines on the marine environment are briefly addressed in the monitoring programme for offshore wind farms (*Degraer & Brabant 2009* [142990], *Degraer et al. 2010* [199194], *Degraer et al. 2011* [207257]) and in the EIA of offshore wind farms (*website MUMM*).

A SINGLE OFFSHORE CONNECTION FOR POWER CABLES

The individual connection of the various offshore wind farms to the power stations on the coast would eventually lead to an inefficient use of materials. Such a network of cables is also expensive (cost multiplied by the number of connections), harmful to the environment (accumulation of cables on the seabed and in the coastal zone near the power stations on land) and technically not optimal (e.g. in terms of operational safety). Therefore, a solution that is technically, economically and environmentally viable has been taken into consideration. This reflection process has led to the vision of Elia, which intends to gradually build a meshed offshore grid. In such a scenario, the various wind farms are connected to each other in power stations on offshore platforms that are close to the various concessions. The offshore grid is subsequently integrated into the network managed by Elia on the mainland.

The latter process may lead to the establishment of two platforms in the BNS, alpha and beta, which will be interconnected and connected by cables of 220 kV to the Stevin station, situated close to the port of Zeebrugge. The two platforms will be gradually developed, so that each phase constitutes a part of the overall solution. The connections to the onshore grid are Zeebrugge and Stevin. On each of these offshore platforms, a high-voltage power station of the GIS type will be installed, with the transformers necessary to receive cables of 66 kV or 220 kV from the nearby offshore wind farms (for more information: *visie Elia offshore grid 2012* [213665], *brochure FOD Economie 2012* [225395]).

THE NEMO PROJECT

The NEMO project is a two-way submarine cable between Zeebrugge and Richborough (United Kingdom) of approximately 1,000 MW DC. Economic studies have shown the usefulness of such a connection. The application has been completed and the construction should take place in 2017/2018. For the grid connection on the Belgian side, the available capacity created by the Stevin project between Zeebrugge and Zomergem would be partly used (Source: DG Energy, FPS Economy, *Milieueffectenrapport - NEMO LINK 2012* [227877]).

Furthermore, an offshore North Sea grid (an integrated energy grid that connects offshore wind farms and other offshore renewable energy producers in the North Sea) is also being considered (*Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*), *Offshore Electricity Grid Infrastructure in Europe 2011* [225405]). An overview of the policy framework, the technical and economic aspects is given in the *Offshore Electricity Grid Infrastructure in Europe (2011)* [225405]. European plans to develop an offshore network are addressed in the blueprint for an integrated European energy network (*COM (2010) 677*).

5.4 Tidal and wave energy and energy storage

The potential of wave energy is impressive. According to *Cruz et al. (2008)* [120366] and *Brouwers et al. (2011)*[225406], the total available wave power of all coastlines in the world is comparable to the current world electricity consumption. The importance of further research into offshore renewable energy technologies other than wind energy has been highlighted in the European Communication on Blue Growth (*COM (2012) 494*). Currently there are no wave energy converters at the Belgian coast, however, research is being conducted with regard to the wave climate in the Belgian part of the North Sea (BNS) (*Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*), *De Backer et al. 2008* [124316], *Beels 2010* [143250], *Fernandez et al. 2010* [203824], *Mathys et al. 2012* [202292] (*BOREAS project BELSPO*)). In addition, the appropriate wave energy converters are also studied (*De Backer et al. 2008* [124316], *Beels 2010* [143250], *De Backer 2004* [199170], *De Backer & Mertens 2006* [100270], *De Backer 2009* [143261], *Mathys et al. 2009* [144679] (*OPTIEP-BCP project BELSPO*), *Mathys et al. 2012* [202292] (*BOREAS project BELSPO*)). Within the framework of the *FlanSea project* [206722] ('Flanders Electricity from the Sea'), a wave energy converter is being developed specifically for moderate wave climates such as in the BNS (*Brouwers et al. 2011* [225406]). The energy platform *Power-Link* provides for a valorisation phase for the *FlanSea project* [206722] between 2015 and 2018 through the creation of a micro production park. The THV MERMAID has included 20 MW FlanSea-wave energy converters between the windmills in its application to obtain a domain concession.

In addition to the extraction of energy from waves, research on tidal power is also conducted. The studies *Mathys et al. (2009)* [144679] (*OPTIEP-BCP project BELSPO*) and *Mathys et al. (2012)* [202292] (*BOREAS project BELSPO*) provide an overview of the different tidal energy converters. In addition, the potential of tidal energy in the BNS is estimated on the basis of numerical hydrodynamic models.

A *study* by the Environmental and Energy Technology Innovation Platform of the Flemish government examined the feasibility of energy storage in a so-called energy atoll in the BNS. It is a hydro-electric power station that serves as an energy buffer to counter the discontinuity or unpredictable variability of the energy production from renewable energy sources such as wind and solar energy.

In the draft of the Marine Spatial Plan (*Ontwerp van koninklijk besluit tot vaststelling van het marien ruimtelijk plan, 2013* [227527]), as proposed by the Minister competent for the North Sea, a reservation zone has been provided for research on alternative forms of energy and energy storage. In the first place, such tests may be accommodated in the windmill zone. Furthermore, new concession zones for energy atolls in front of De Haan and Blankenberge and/or Zeebrugge have been planned. These islands would also have a function with regard to nature development.

5.5 Renewable energy in the coastal zone

The coastal zone has a number of natural features that make it an interesting region for some forms of renewable energy. A study about the average wind speeds in Flanders (*Windplan voor Vlaanderen* [214785]) has concluded that the coast has a significantly higher wind range (see also *Dehenauw 2002* [26621]). In our wind climate, a production factor of ± 11% in the inland, ± 23% near the coast and ± 34% at sea is taken into account (*Brouwers et al. 2011* [225406]). On the other hand, measurements revealed that the sunshine duration in the coastal zone is on average 1,700 hours per year compared to 1,550 hours in Uccle (inland). The differences are greatest during summer when the coast receives up to 20 hours more sunshine per month (*Dehenauw 2002* [26621]). Hence, the coastal zone has an increased potential for solar energy. Of course, other forms of energy production are also present in the coastal zone (e.g. biomass, biogas, etc.). However, as the coast does not constitute a specific climate for these energy forms, they will not be further discussed here.

At the European level, the policy on energy is developed by the *Directorate-General for Energy*. The promotion of energy from renewable energy sources is mainly covered by *Directives 2001/77/EC* and *2009/28/EC* (see also *COM*

(2011) 31). Unlike offshore energy production, renewable energy on land is a Flemish competence (*Environment, Nature and Energy Department*, *Vlaamse beleidsnota energie 2009-2014* [225407]). The Flemish Energy Agency (VEA) implements this policy (*website VEA*). A comprehensive overview of the laws and regulations on renewable energy can be found on the *website of VEA* .

On 1 January 2012, there were 48 large wind turbines present in the coastal zone in Zeebrugge (harbour), Bruges, Gistel, Diksmuide and Middelkerke. These account for an installed capacity of 54.46 MW or 16% of the capacity of the Flemish large windmills (*website VEA*).

In addition to the photovoltaic panels for electricity generation from sunlight by private individuals, a number of solar parks are present in the coastal zone. In early 2013, there were approximately 300 manufacturing plants of more than 10 kW present in the coastal zone, for a total installed capacity of nearly 50 MW. Most of these installations are located in municipalities in the hinterland (Source: *Flemish Regulator of the Electricity and Gas, VREG*).

Legislation reference list

Table with international agreements, conventions, etc.

INTERNATIONAL AGREEMENTS, CONVENTIONS, ...			
Abbreviations (if available)	Title	Year of conclusion	Year of entering into force
ASCOBANS	Agreement on the conservation of small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas	1991	1994

Table with European legislation. The consolidated version of this legislation is available on *Eurlex*.

EUROPEAN LEGISLATION			
Abbreviations (if available)	Title	Year	Number
Directives			
	Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market	2001	77
Marine Strategy Framework Directive	Directive establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)	2008	56
	Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC	2009	28
	Directive concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC	2009	73
Regulations			
	Regulation establishing an Agency for the Cooperation of Energy Regulators	2009	713
	Regulation on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005	2009	715
Other (Decisions, Communications, White Papers, etc.)			
	Communication from the Commission (COM): An Integrated Maritime Policy for the European Union	2007	575
	Communication from the Commission (COM): Offshore Wind Energy: Action needed to deliver on the Energy Policy Objectives for 2020 and beyond	2008	768
	Communication from the Commission (COM): Energy 2020 - A strategy for competitive, sustainable and secure energy	2010	639
	Communication from the Commission (COM): Energy infrastructure priorities for 2020 and beyond - A Blueprint for an integrated European energy network	2010	677
	Communication from the Commission (COM): Renewable Energy: Progressing towards the 2020 target	2011	31
	Communication from the Commission (COM): A Roadmap for moving to a competitive low carbon economy in 2050	2011	112
	Communication from the Commission (COM): Energy Roadmap 2050	2011	885
	Communication from the Commission (COM): Renewable Energy: a major player in the European energy market	2012	271
	Communication from the Commission (COM): Blue Growth opportunities for marine and maritime sustainable growth	2012	494

Table with Belgian and Flemish legislation. The consolidated version of this legislation is available on *Belgisch staatsblad* and the *Justel-databanken*.

BELGIAN AND FLEMISH LEGISLATION	
Date	Title
Laws	
Wet van 12 april 1965	Wet betreffende het vervoer van gasachtige producten en andere door middel van leidingen.
Wet van 19 september 1991	Wet houdende goedkeuring van de overeenkomst tussen de regering van het Koninkrijk België en de regering van het Koninkrijk Noorwegen inzake het vervoer per pijpleiding van gas van het Noorse Continentaal Plat en uit andere gebieden naar het Koninkrijk België, en van wisseling van brieven inzake de uitlegging van artikel 2, §2 van deze overkomst, ondertekend te Oslo op 14 april 1988
Wet van 20 januari 1999	Wet ter bescherming van het mariene milieu en ter organisatie van de mariene ruimtelijke planning in de zeegebieden onder de rechtsbevoegdheid van België
Wet van 29 april 1999	Wet betreffende de organisatie van de elektriciteitsmarkt, inzonderheid op artikel 6
Wet van 26 juni 2000	Wet houdende instemming met de Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van het Verenigd Koninkrijk van Groot-Brittannië en Noord-Ierland inzake het vervoer van aardgas door middel van een pijpleiding tussen het Koninkrijk België en het Verenigd Koninkrijk van Groot-Brittannië en Noord-Ierland, ondertekend te Brussel op 10 december 1997
Wet van 13 mei 2003	Wet houdende instemming met de Overeenkomst tussen de Regering van het Koninkrijk België en de Regering van het Koninkrijk Noorwegen inzake het leggen van de « Norfra » gaspijpleiding op het Belgische continentaal plat, en de Bijlagen 1, 2 en 3, ondertekend te Brussel op 20 december 1996
Royal Decrees	
KB van 11 maart 1966	Koninklijk besluit betreffende de te nemen maatregelen bij de oprichting en de exploitatie van installaties voor gasvervoer door middel van leidingen
KB van 20 december 2000	Koninklijk besluit betreffende de voorwaarden en de procedure voor de toekenning van domeinconcessies voor de bouw en de exploitatie van installaties voor de productie van elektriciteit uit water, stromen of winden, in de zeegebieden waarin België rechtsmacht kan uitoefenen overeenkomstig het internationaal zeerecht
KB van 12 maart 2002	Koninklijk besluit betreffende de nadere regels voor het leggen van elektriciteitskabels die in de territoriale zee of het nationaal grondgebied binnenkomen of die geplaatst of gebruikt worden in het kader van de exploratie van het continentaal plat, de exploitatie van de minerale rijkdommen en andere niet-levende rijkdommen daarvan of van de werkzaamheden van kunstmatige eilanden, installaties of inrichtingen die onder Belgische rechtsmacht vallen
KB van 16 juli 2002	Koninklijk besluit betreffende de instelling van mechanismen voor de bevordering van elektriciteit opgewekt uit hernieuwbare energiebronnen
KB van 7 september 2003	Koninklijk besluit houdende de procedure tot vergunning en machtiging van bepaalde activiteiten in de zeegebieden onder de rechtsbevoegdheid van België
KB van 9 september 2003	Koninklijk besluit houdende de regels betreffende de milieu-effectenbeoordeling in toepassing van de wet van 20 januari 1999 ter bescherming van het mariene-milieu in de zeegebieden onder de rechtsbevoegdheid van België
KB van 28 september 2008	Koninklijk besluit tot wijziging van het koninklijk besluit van 20 december 2000 betreffende de voorwaarden en de procedure voor de toekenning van domeinconcessies voor de bouw en de exploitatie van installaties voor de productie van elektriciteit uit water, stromen of winden, in de zeegebieden waarin België rechtsmacht kan uitoefenen overeenkomstig het internationaal zeerecht
KB van 30 maart 2009	Koninklijk besluit betreffende productieafwijkingen op installaties voor de productie van elektriciteit uit wind in de zeegebieden
KB van 3 februari 2011	Koninklijk besluit tot wijziging van het koninklijk besluit van 20 december 2000 betreffende de voorwaarden en de procedure voor de toekenning van domeinconcessies voor de bouw en de exploitatie van installaties voor de productie van elektriciteit uit water, stromen of winden, in de zeegebieden waarin België rechtsmacht kan uitoefenen overeenkomstig het internationaal zeerecht
KB van 11 april 2012	Koninklijk besluit tot instelling van een veiligheidszone rond de kunstmatige eilanden, installaties en inrichtingen voor de opwekking van energie uit het water, de stromen en de winden in de zeegebieden onder Belgische rechtsbevoegdheid

BELGIAN AND FLEMISH LEGISLATION (continuation)	
Date	Title
Decrees	
Decreet van 8 mei 2009	Decreet houdende algemene bepalingen betreffende het energiebeleid (het Energiedecreet)
Ministerial Decrees	
MB van 8 mei 2008	Ministerieel besluit houdende aanstelling van ambtenaren bedoeld in artikel 25 van het koninklijk besluit van 12 maart 2002 betreffende de nadere regels voor het leggen van elektriciteitskabels die in de territoriale zee of het nationaal grondgebied binnenkomen of die geplaatst of gebruikt worden in het kader van de exploratie van het continentaal plat, de exploitatie van de minerale rijkdommen en andere niet-levende rijkdommen daarvan of van de werkzaamheden van kunstmatige eilanden, installaties of inrichtingen die onder Belgische rechtsmacht vallen
MB van 16 maart 2009	Ministerieel besluit houdende aanwijzing van de ambtenaren die ermee belast zijn de Minister te vertegenwoordigen en toe te zien op de toepassing van het koninklijk besluit van 20 december 2000 betreffende de voorwaarden en de procedure voor de toekenning van domeinconcessies voor de bouw en de exploitatie van installaties voor de productie van elektriciteit uit water, stromen of winden, in de zeegebieden waarin België rechtsmacht kan uitoefenen overeenkomstig het internationaal zeerecht