



# The sustainable use of cooling water from the Wadden Sea

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# Introduction

- Cause of this workshop
  - Wadden Fund, 3<sup>rd</sup> tender (2010); Uitvoeringsplan 2010-2014
  - Theme: large-scale development and implementation of sustainable energy transition
  - Short-time goal 2014: a package of "applicable innovative techniques for sustainable energy"
  - "support projects that contribute to the development of technology and knowledge for sustainable energy transition; e.g. reduction of environmental impact"
  - "also small innovative projects are eligible for funding"
- Project proposal (Laméris) discussed with Waddenacademy
  - interesting idea, relevant subject but needs further development
- Proposition to organise a workshop on cooling water issues
- 'Position Paper': background information & knowledge gaps

# Policy

- Revised policy document SEVIII (Power Structure Plan 2008):
  - aims to support large-scale energy production and transport
  - provides a list of large-scale energy production locations
  - guarantee for 'nuclear sites' (Borssele, Eemshaven, Maasvlakte I)
    - no developments that prevent or hamper future nuclear plants
- Trend: diversification of fuel to become less dependent on gas
- Tendency to build new power stations at coastal sites
  - replacement of old power stations
  - extension and even surplus power generation
  - capacity per power station is increasing (800 - 1600 MW)
- Coastal locations are favoured
  - sufficient volumes of cooling water available
  - transport of fuel over sea with large vessels
  - large capacity to absorb thermal discharge



# Development of energy clusters

- Eemshaven develops towards energy cluster
  - Ems estuary has deep(ened) water for transport of fuel (coal)
  - several power stations, Norned cable, Cobra cable (plan), several wind farms develop in the North Sea coastal zone
- Comparable developments in the north of Germany
  - Wilhelmshaven (Jade Bay), Weser estuary, Elbe estuary
- Estuaries are connected with the Wadden Sea
- Netherlands and Germany facing similar problems



# Overview Wadden Sea region - current

| Current power stations along the Wadden Sea (estuaries) |               |               |         |             |                                   |
|---|---------------|---------------|---------|-------------|-----------------------------------|
| Name (company)  | Capacity (MW) | Water type    | Fuel    | Operational | Cooling water (m <sup>3</sup> /s) |
| Kernkraftwerk Brokdorf (E.ON)                           | 1410          | Elbe estuary  | nuclear | 1986        | 60                                |
| Kernkraftwerk Brunsbüttel (E.ON/Vattenfall)             |               | Elbe estuary  | nuclear | 1976-2007   | 33                                |
| Kernkraftwerk Unterweser (E.ON)                         | 1345          | Weser estuary | nuclear | 1979        | 64                                |
| Kraftwerk Wilhelmshaven (E.ON)                          | 747           | Jade basin    | coal    | 1976        | 33                                |
| Eemscentrale Eemshaven (Electrabel)                     | 2417          | Ems estuary   | gas     | 1977        | 55                                |
| <b>SUM</b>  | <b>5960</b>   |               |         |             | <b>245</b>                        |

# Overview Wadden Sea region - planned

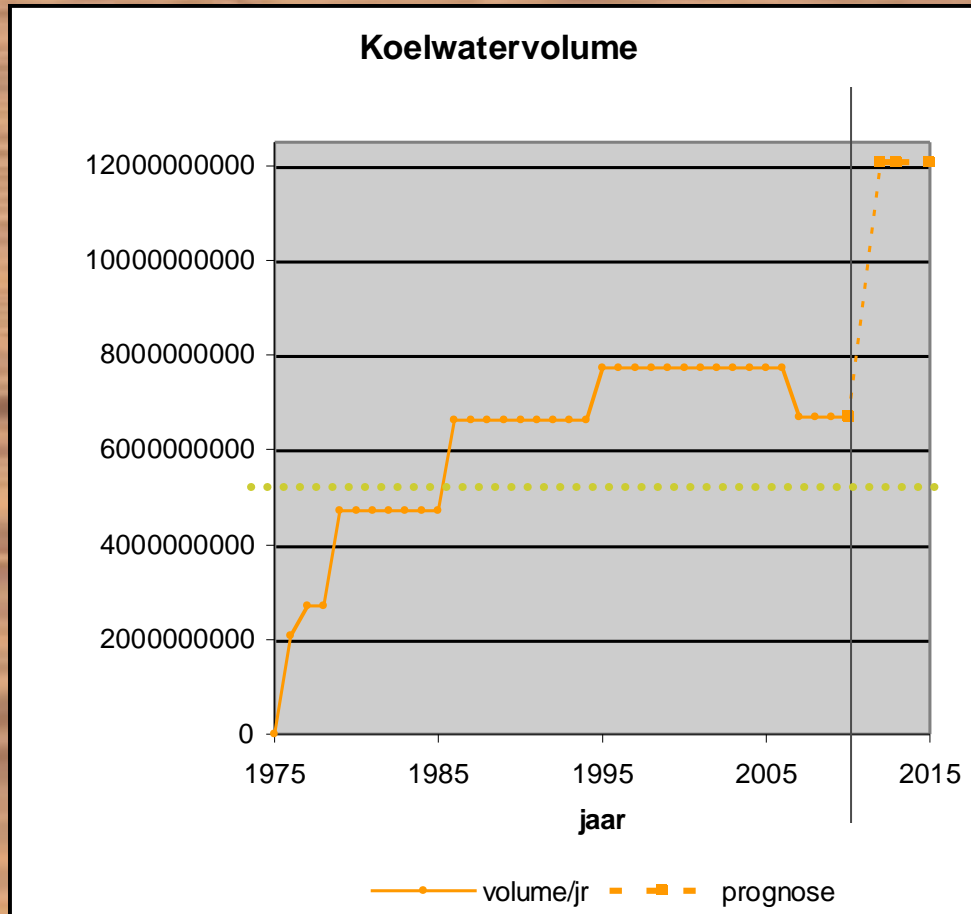
| Planned power stations along the Wadden Sea (estuaries) |               |              |           |              |                                   |
|---|---------------|--------------|-----------|--------------|-----------------------------------|
| Name (company)  | Capacity (MW) | Water type   | Fuel      | Operational  | Cooling water (m <sup>3</sup> /s) |
| Kohlekraftwerk Wilhelmshaven (GDF/Electrabel)           | 830           | Jade basin   | coal      | in procedure | 30                                |
| Kohlekraftwerk Brunsbüttel (GDF/Electrabel)             | 830           | Elbe estuary | coal      | in procedure | 30                                |
| Kraftwerk Eemshaven (RWE)                               | 1600          | Ems estuary  | coal      | in procedure | 65                                |
| Nuon Magnum Eemshaven (Nuon)                            | 1200          | Ems estuary  | multifuel | in procedure | 45                                |
| Eemsmond Energie (AP)                                   | 1300          | Ems estuary  | gas       | in procedure | 1                                 |
| <b>SUM</b>  | <b>5700</b>   |              |           |              | <b>171</b>                        |

# Overview Wadden Sea region - future?

| Uncertain plans for power stations along the Wadden Sea (estuaries) |               |              |      |                     |                                   |
|---|---------------|--------------|------|---------------------|-----------------------------------|
| Name (company)  | Capacity (MW) | Water type   | Fuel | Status              | Cooling water (m <sup>3</sup> /s) |
| Kohlekraftwerk (Südweststrom/ Iberdrola)                            | 1800          | Elbe estuary | coal | exit Iberdrola      | ?                                 |
| Kohlekraftwerk Brunsbüttel (Getec Energie)                          | 800           | Elbe estuary | coal | no procedure        | ?                                 |
| Kohlekraftwerk Stade (E.ON)   | 800           | Elbe estuary | coal | no procedure        | ?                                 |
| Kohlekraftwerk Stade (Dow)  | 1000          | Elbe estuary | coal | exit EnBW (partner) | ?                                 |
| <b>SUM</b>  | <b>4400</b>   |              |      |                     | <b>?</b>                          |
| <b>Grand TOTAL</b>  | <b>16060</b>  |              |      |                     | <b>416 + (150)?<br/>= 666</b>     |



# Trend in cooling water volume



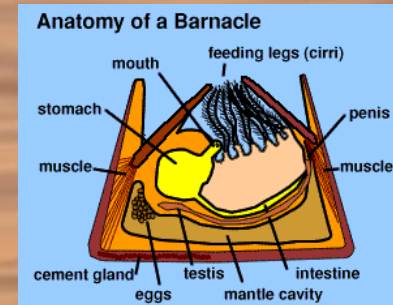
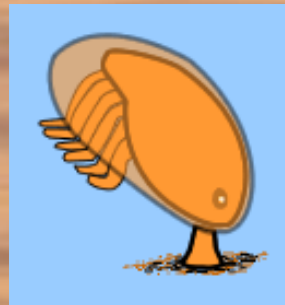
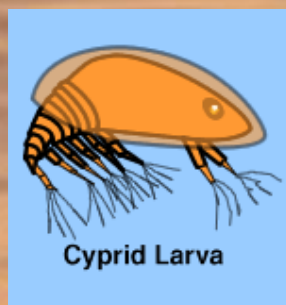
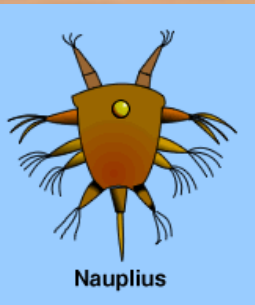
- Annual cooling water volume
  - current: 7.5 billion m<sup>3</sup>
  - prognosed: 13 billion m<sup>3</sup> + ???
- Wadden Sea volume
  - 5.4 billion m<sup>3</sup>
- What does this mean for the ecosystem?



# Entrainment

Planktonic stages: eggs, (fish)larvae, crustaceans, molluscs

- organisms are drawn through the system
  - operational risk
    - settlement of bacteria, algae and larvae in cooling system;
    - fouling of barnacles, mussels, Pacific oyster
  - environmental risk
    - damage and mortality of organisms
    - anti-fouling treatment with toxic substances or thermoshock



# Impingement

Fish larvae, juvenile fish, shrimps, jellyfish, crabs, eelgrass

- organisms are retained by sieve (6 mm)
  - operational risk
    - clogging of sieve
    - pressure difference over sieve, if too large:
    - shut-down of power station
  - environmental risk
    - damage and mortality (direct, indirect)
    - take-away for birds and seals





# Discussion

- Surplus power generation at the border of the Wadden Sea?
  - low refreshment rate, nursery for (shell)fish, foraging area for birds
  - UNESCO World Heritage list (2009)
- Impact assessment ?
  - is it possible to quantify the impact of prolonged, large-scale withdrawal
  - what about cumulative effects of 10 (ca. 10000 MW) power stations
- Continue with flow-through cooling or look for alternatives?
  - Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling (adopted 4 May 2010, California USA)
  - at coastal sites: stop using flow-through cooling from 2015
  - applies to 19 power stations, withdrawal 15 billion gallons per day
  - eq.  $56 \times 10^6 \text{ m}^3$  per day, or  $20 \times 10^9 \text{ m}^3$  per yr
  - versus future Wadden Sea area:  $15 \times 10^9 \text{ m}^3$  per yr (?)
- Technical aspects of cooling water & alternatives: Frides Laméris