Greening Blue Energy

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IUCN
The World Conservation Union

In collaboration with:

IUCN Environment, Energy & Ecosystems, Stockholm University, E.ON, Sida, Umeå Marine Research Centre, Umeå University, Sweden, Plymouth University, Stanford University, SDMRI, University of Dar es Salaam etc.

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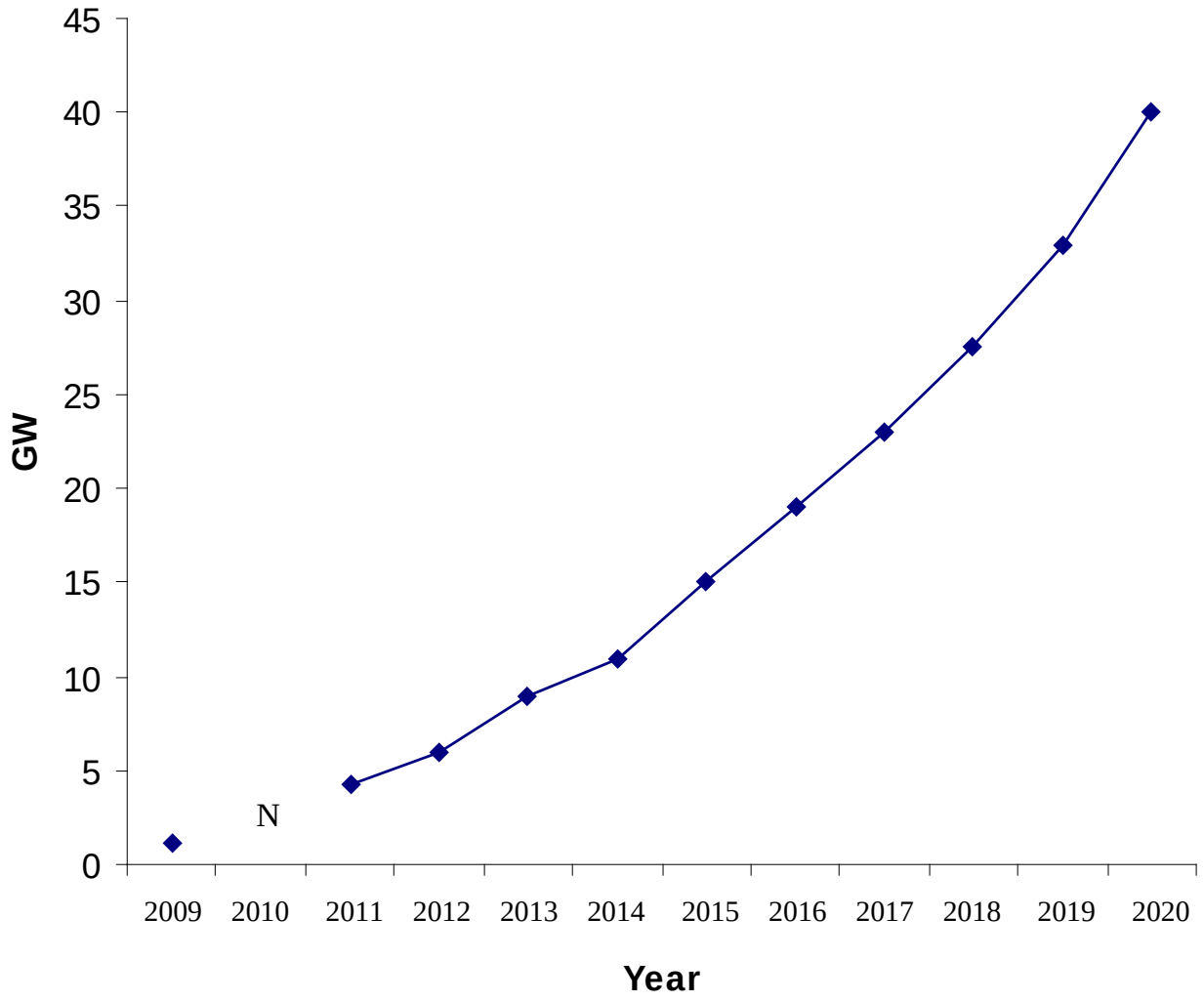
e·on Climate & Renewables

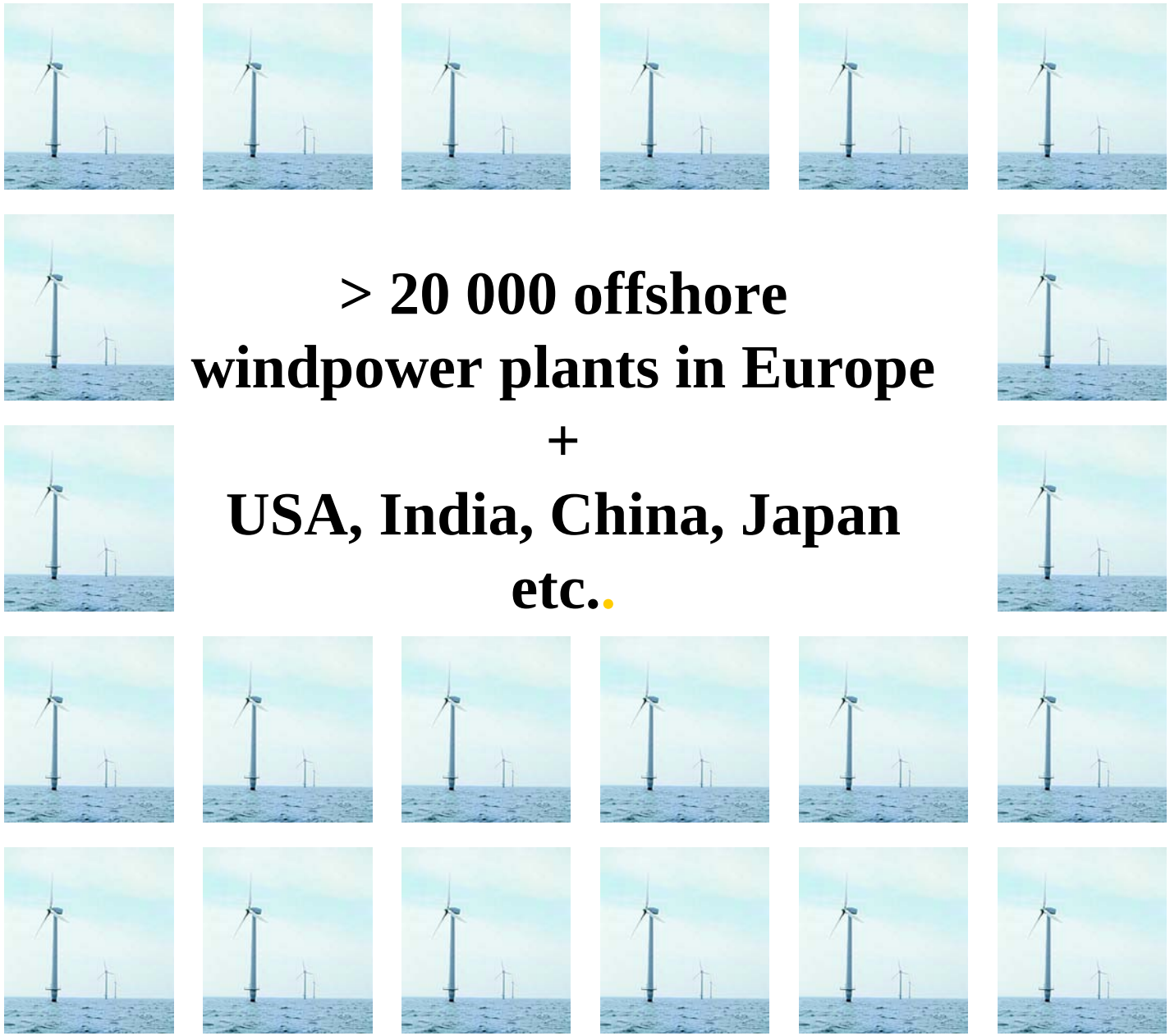
Technology	Theoretical Estimated Global Energy Potential (TWh)	% of Global Electricity Demand
Tidal	300+	2%
Current	800+	4%
Wave	8000-80000	42-421%
Thermal	10000	53%
Salinity	2000	11%
Wind*	37000	195%

Sources: Luetz et al, 2001, IEA-OES, Annual Report 2007, CIA World Factbook 2007

Cumulative capacity (GW) of **projected installation of offshore wind power within the European Union**, 2009-2020. N=No data.

(EWEA 2009, Snyder & Kaiser 2009).





> 20 000 offshore windpower plants in Europe

+

USA, India, China, Japan etc..

Principal issues to consider

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Nature of wind/wave resources
Seabed structure/geology
Water depth
Distance to shore
Distance to service port
Grid connection
Tide and currents
Shipping/navigation routes
Recreational boating
Location of existing subsea cables and pipelines
Fisheries
Dredging
Coastal landscape
Local military activity (e.g. firing ranges, offshore training)

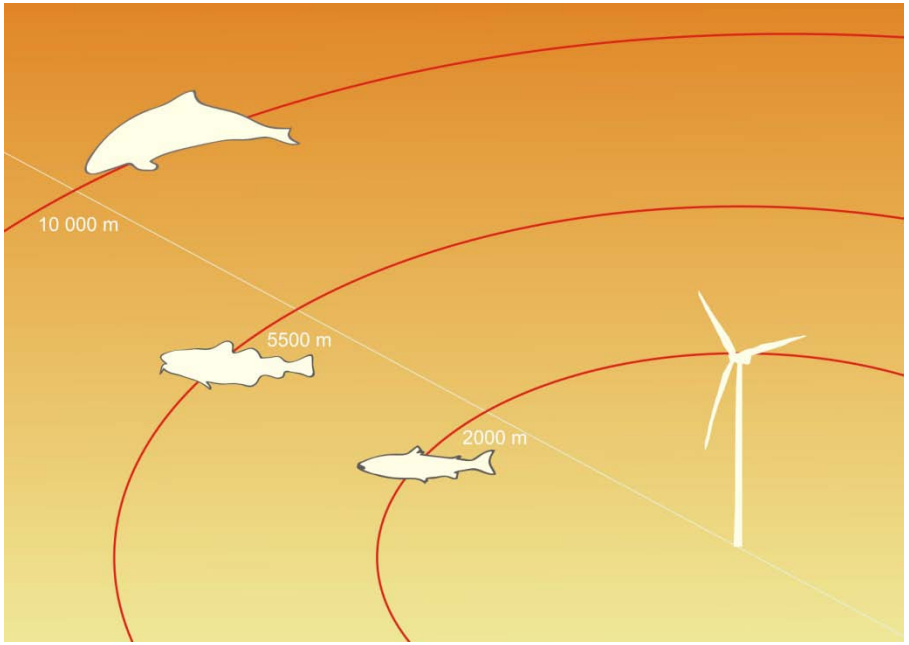
Environmental concerns

Percentage reduction of environmental impacts of windpower versus the electricity mix of Spain in 2000. After Martínez et al. 2009

Impact category	**Reduction in percent of environmental impact**
Global warming (GWP100)	98.76
Ozone layer depletion (ODP)	96.73
Human toxicity	89.26
Freshwater aquatic eco-toxicity	94.06
Marine aquatic eco-toxicity	99.34
Terrestrial eco-toxicity	92.68
Photochemical oxidation	99.24
Acidification	99.28
Eutrophication	97.78

Construction phase:

Noise and other disturbance (e.g. sediment dispersion) due to construction activities (marine mammals, fish, birds) *(e.g. Wahlberg & Westerberg 2005, Madsen et al .2006, Stewart et al. 2007, Gill et al. 2009, Tougaard et al. 2009)*



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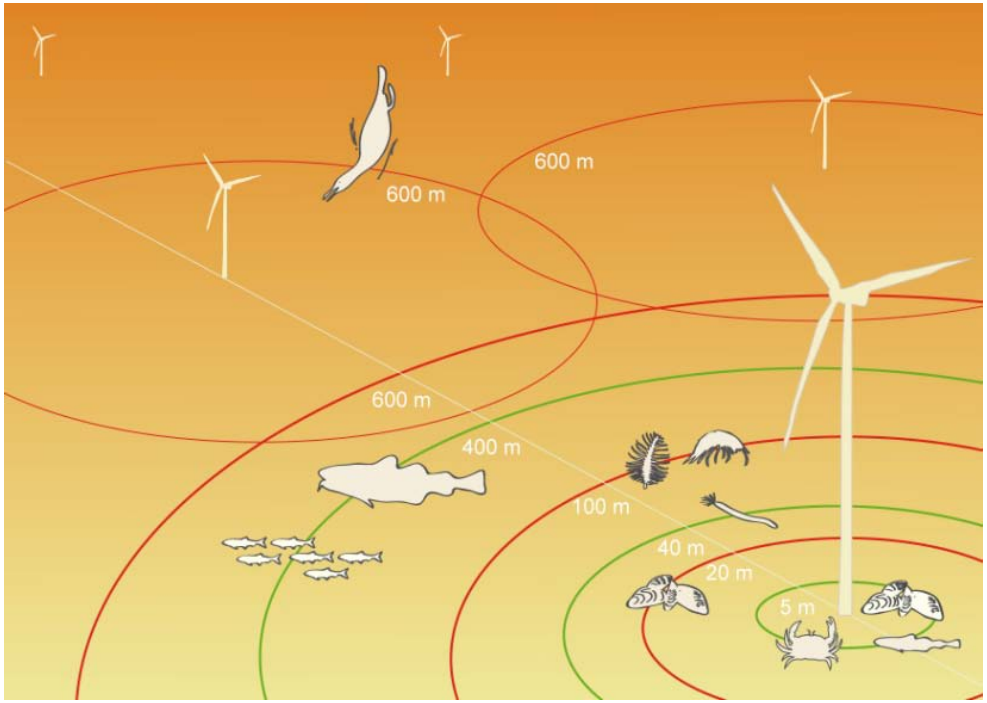
Operational phase:

- **Birds;** avoidance, collision risk, gain of feeding grounds *(e.g. Dong Energy et al. 2006, Petersen 2004, Stewart et al. 2007, Musalears et al. 2009)*

- **Fish;** noise, vibrations, electromagnetic fields, (avoidance? habituation? behavior disturbances?) (*e.g. Wahlberg & Westerberg 2005, Gill et al. 2009)*

- **Marine mammals:** noise , boat traffic *(Madsen et al. 2006, Tougaard et al . 2009*



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- **Hydrological changes**

  Up/downwelling *(Broström 2008)*

  Seabed changes

  (e.g. Martin et al. 2005 Wallingford 2005,)

Photo: Mattias Rust

- **Trawling exlusion**

  (Thrush & Dayton 2002, Kaiser et al -.2006,

  Wilhelmsson et al. 2010)

- **Artificial hard substrata**
- *(Wilhelmsson et al. 2006, 2008, 2009)*

Photo: Olivia Langhamer

Current restraints (e.g.):

- Lack of data from targeted projects
- Access to data
- Not cumulative enough
- Not ecosystem/landscape scale
- Evaluation of sources
- Application of information
- Environmental opportunities
- Low capacity in developing countries

Photo: Olivia Langhamer

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Goal:

Enhance the process of developing offshore renewable energy (e.g. wind- and wave/tidal power) in harmony with sustainable management of the marine environment

Objectives

To produce:

Review and overview of environmental aspects and research gaps

Guidance on mitigation measures, siting, spatial planning, policy, and potential cross-sectorial synergies (e.g. fisheries, aquaculture) for the benefit of the marine environment.

Implementation:

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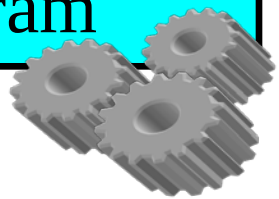

Core drafting team

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Finding the balance:

- User friendly / scientifically solid
- Global coverage / local & regional applications
- Target groups: authorities, developers, researchers, NGOs etc.
- Structure, division of topics, condensation/priorities

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- Main document (”applied”, 30 pages)
- Annex 1: Research on impacts (scientific review, 30 pages)
- Annex 2: Legislation
- Annex 3: Brief on wave, tidal and current power

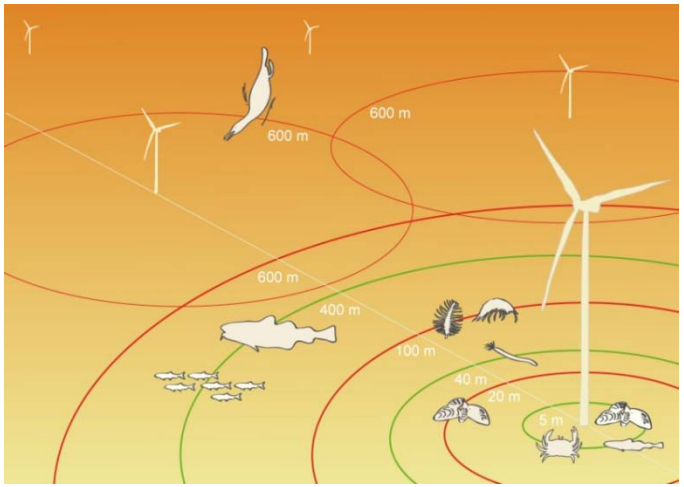
Table 3: Key environmental issues of offshore wind energy

Key environmental issues		Level of certainty for predictions/ estimates (1 low to 5 high)	Estimated scale of impact n.a. = Not assessed			Discussed in section in Annexe 1
			Spatial	Temporal	Estimated degree of severity (-) or benefit (+) of impacts for species assemblages within the wind farm area	
FISH	Injuries from sound pulses (construction)	3	Local	n.a.	Small (-)	7.1
	Displacement/habitat loss (construction)	3	Very broad	Short term	(-) *see* 4.2.2	7.3
	Sediment dispersion (construction)	4	Broad	Short term	Small (-)	4
	Disturbance from operational noise	4	Very local	Long term	Small (-)	7.6
	Trawling exclusion	5	Broad	Long term	Large (+) *see* 4.2.3	3.3
	Artificial reef effects	3	Local	Long term	Moderate (+) *see* 4.2.3	3.3
	Electromagnetic fields	2	Local (but *see* migrating fish)	Long term	Small (-) (but *note* level of certainty and *see* migrating fish)	8.1
	Collisions with turbines	2	n.a.	n.a.	Small (-)	3.4
	Noise masking bioacoustics	2	Local	Long term	Small (-) (but *note* level of certainty)	7.9
MARINE MAMMALS	Injuries from sound pulses (construction)	3	Local	n.a.	Small (-) but *see* 4.2.2	7.1
	Displacement/habitat loss (construction)	3	Very broad	Short term	(-) *see* 4.2.2	7.2
	Displacement, disturbance (operation)	3	Very local	Long term	Small (-)	7.7
	Habitat enhancement	1	Broad	Long term	Small (+) (but *note* level of certainty)	3.3
	Migration barriers	2	n.a.	Long term	Small (-) (but *note* level of certainty and extra caution for whales), and *see* 4.2.3	7.9
	Collisions with turbines	2	n.a.	n.a.	Small (-)	3.4
	Noise masking bioacoustics	2	Local	Long term	Small (-) (but *note* level of certainty)	7.9

Key environmental issues		Level of certainty for predictions/ estimates (1 low to 5 high)	Estimated scale of impact n.a. = Not assessed			Discussed in section in Annexe 1
			Spatial	Temporal	Estimated degree of severity (-) or benefit (+) of impacts for species assemblages within the wind farm area	
IRDS	Displacement/habitat loss (construction)	5	Very broad	Short term	(-) *see* 4.2.2	9.3
	Displacement/habitat loss for seabirds (i.e. sea ducks and divers) (operation)	4	Very broad	Long term	(-) *see* 4.2.3	9.3
	Migration barriers (operation) 1. long distance migrators 2. daily commuters	3	n.a.	Long term	1. Small (-) 2. Moderate (-) *see* 4.2.3	9.2
	Collisions with turbines	3	n.a.	Long term	Small (-) but *see* 4.2.3	9.1
ENTHOS	Sediment dispersion (construction)	3	Broad	Short term	Small (-)	4
	Acoustic disturbance (construction)	2	Local	Short term	Small (-) (but *note* level of certainty)	7.4
	Changes in community structure directly due to turbines	4	Local	Long term	Small to Moderate (-) *see* 4.2.3	3.1 & 5
	Electromagnetic fields	2	Very local	Long term	Small (-) (but *note* level of certainty)	8.2
	Anoxia created	4	Very local	Long term	Small (-)	5
	Habitat enhancement (not considering trawling exclusion)	4	Very local	Long term	n.a.	3.1
	Entry point for invasive species	2	Very broad	Long term	n.a.	3.2
	Effects of trawling exclusion	5	Broad	Long term	Large (+) *see* 4.2.3	3.1
YDROLOGY	Depletion of phytoplankton	4	Local	Long term	Small (-)	5
	Upwelling or downwelling at the perimeter of wind farm	1	Local	Long term	Small (+/-) (but *note* level of certainty)	5
	Toxic substances	4	Local	n.a.	Small (-)	6
	Oil spills (e.g. ship accidents)	-	n.a.	n.a.	(-) *see* 4.2.3	
EA URTLES	Displacement/habitat loss (construction)	2	Very broad	Short term	(-) *see* 4.2.2	7.1 & 7.8
	Displacement/habitat loss (operation)	2	Very local	Long term	Small (-) (but *note* level of certainty) *see* 4.2.3	7.8

Issues that require special attention:

- Piling noise/construction activities (threat)
- Trawling exclusion (opportunity)
- Habitat enhancement (opportunity)
- Habitat loss for sea ducks and divers (threat)
- Migration barriers for birds, sea turtles, whales (threat)
- Bird collisions (threat)
- Seabed changes (threat)
- Navigational hazards/oil spills (threat)



Some general management implications for offshore wind power development:

- Location/Spatial planning.
- Techniques applied
- Timing of construction/decommissioning
- Monitoring of impacts
- Cumulative effects

Strategic and governance issues:

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- Quality control of EIAs
- Closing research gaps
- Enhanced coordination

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THANK YOU!