The international technology Catalogue experiences

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Recap of first sessions

The most important things from session 1 and 2:

- *There are many stakeholders involved*

- *The value of the technology catalogue is local conditions*

- *It takes time to develop a technology catalogue setup, which should be repeated often*

Agenda - The international experiences

- Examples of international technology catalogues
- Overview of the Indian offshore wind case
    - Guideline
    - Timeline
    - Stakeholder involvement
- Lessons learned in India so far
- Indian power technology catalogue

International examples

- Which international technology catalogues exist?
- What was the process?

Previous international technology catalogues

Technology catalogues have been developed between DEA and country partners in:

- Vietnam (power sector)
- Indonesia (power sector)
- Mexico (storage)

Currently working on new versions in:

- India (offshore+power sector)
- Ethiopia (power sector)
- Vietnam – update
- Indonesia - update

Previous international technology catalogues

In all cases the DEA is partnering with local authorities and consultants (international and/or local)

The technology catalogues feed into modelling activities in these countries

The case of Vietnam

- Partner institution: Electricity and Renewable Energy Agency of Viet Nam (EREA) as part of Ministry of Industry and trade
- Published in 2019
- Used for energy modelling in the country collaboration
- Second update is ongoing to expand to more technologies

Technology Data for the Vietnamese Power Sector

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Wind power data in Vietnam

Technology	Wind power - Offshore								
	2020	2030	2050	Uncertainty (2020)		Uncertainty (2050)		Note	Ref
Energy/technical data				Lower	Upper	Lower	Upper		
Generating capacity for one unit (MWe)	3.5	10.0	12.0	1.6	8.0	4.0	20.0		1
Generating capacity for total power plant (MWe)	105	300	360	48	240	120	600		1
Electricity efficiency. net (%). name plate								A	
Electricity efficiency. net (%). annual average								A	
Forced outage (%)	4.0	3.0	3.0	1.0	5.0	1.0	5.0		1
Planned outage (%)	0.3	0.3	0.3	0.1	0.5	0.1	0.5		1
Technical lifetime (years)	27	30	30	20	35	20	35		1
Construction time (years)	3.0	2.5	2.5	1.5	4	1.5	4		1
Space requirement (1000 m^2/MWe)	185	185	185	168	204	168	204		1
Additional data for non-thermal plants									
Capacity factor (%). theoretical	-	-	-	-	-	-	-		
Capacity factor (%). incl, outages	-	-	-	-	-	-	-		
Ramping configurations									
Ramping (% per minute)	-	-	-	-	-	-	-	B	
Minimum load (% of full load)	-	-	-	-	-	-	-	B	
Warm start-up time (hours)	-	-	-	-	-	-	-		
Cold start-up time (hours)	-	-	-	-	-	-	-		
Environment									
PM 2,5 (gram per Nm^3)	0	0	0	0	0	0	0		
SO_2 (degree of desulphuring. %)	-	-	-	-	-	-	-		
NO_X (g per GJ fuel)	0	0	0	0	0	0	0		
Financial data									
Nominal investment (M$/MWe) including grid investment	2.36	2.25	1.93	1.95	2.75	1.56	2.15	C	1
- of which equipment (%)	45	45	45	40	50	40	50	A	1
- of which installation (%)	55	55	55	50	60	50	60	A	1
Fixed O&M ($/MWe/year)	50,000	43,000	36,000	45,000	53,000	29,000	40,000		1; 2
Variable O&M ($/MWh)	3.7	3.1	2.5	3.4	3.8	1.9	2.7		1; 2
Start-up costs ($/MWe/start-up)	0	0	0						
Technology specific data									
Rotor diameter (m)	120	210	240						1
Hub height (m)	90	125	140						1
Specific power (W(m2)	309	353	332						1
Availability (%)	97	97	98	95	99	95	99		1

References:

1 Danish Energy Agency, 2018.Technology Data on Energy Plants - Generation of Electricity and District Heating, Energy Storage and Energy Carrier Generation and Conversion

2 IEA Wind Task 26, 2015, "Wind Technology, Cost, and Performance Trends in Denmark, Germany, Ireland, Norway, the EU, and the USA: 2007–2012".

Notes:

A Equipment: Cost of turbines including transportation. Installation: Electrical infrastructure of turbine, civil works, grid connection, planning and management. The split of cost may vary considerably from project to project.

B With sufficient wind resource available (wind speed higher than 4-6 m/s and lower than 25-30 m/s) wind turbines can always provide down regulation, and in many cases also up regulation, provided the turbine is running in power-curtailed mode (i.e. with an output which is deliberately set below the possible power based on the available wind).

C The costs for offshore (not near shore) from the Danish TC (ref. 1 above) has been used as a best estimate for offshore in Vietnam.

Wind power data in Vietnam

Technology	Wind power - Onshore								
	2020	2030	2050	Uncertainty (2020)		Uncertainty (2050)		Note	Ref
Energy/technical data				Lower	Upper	Lower	Upper		
Generating capacity for one unit (MWe)	3.0	4.0	5.0						3
Generating capacity for total power plant (MWe)	30	80	100						1
Electricity efficiency. net (%). name plate								A	
Electricity efficiency. net (%). annual average									
Forced outage (%)	2.5	2.0	2.0						
Planned outage (weeks per year)	0.16	0.16	0.16	0.05	0.26	0.05	0.26		3
Technical lifetime (years)	27	30	30	25	35	25	40		3
Construction time (years)	1.5	1.5	1.5						1
Space requirement (1000 m^2/MWe)	14	14	14						1
Additional data for non-thermal plants									
Capacity factor (%). theoretical	-	-	-	-	-	-	-		
Capacity factor (%). incl, outages	-	-	-	-	-	-	-		
Ramping configurations									
Ramping (% per minute)	-	-	-	-	-	-	-	D	
Minimum load (% of full load)	-	-	-	-	-	-	-	D	
Warm start-up time (hours)	-	-	-	-	-	-	-		
Cold start-up time (hours)	-	-	-	-	-	-	-		
Environment									
PM 2,5 (gram per Nm^3)	0	0	0	0	0	0	0		
SO_2 (degree of desulphuring. %)	-	-	-	-	-	-	-		
NO_X (g per GJ fuel)	0	0	0	0	0	0	0		
Financial data									
Nominal investment (M$/MWe)	1.60	1.31	1.11	1.4	2.0	1.0	1.5	C	1
- of which equipment (%)	65	65	65					B	2; 3
- of which installation (%)	35	35	35					B	2; 3
Fixed O&M ($/MWe/year)	40,500	37,800	35,900	36,500	44,600	28,700	43,100	E	4
Variable O&M ($/MWh)	4.2	3.9	3.6	3.8	4.7	2.8	4.3	E	4
Start-up costs ($/MWe/start-up)	0	0	0						
Technology specific data									
Rotor diameter (m)	120	130	150	90	130	100	150		3
Hub height (m)	90	100	110	85	120	85	150		3
Specific power (W/m2)	309	301	283	270	350	250	350		3
Avability (%)	97	98	98	95	99	95	99		3

References:

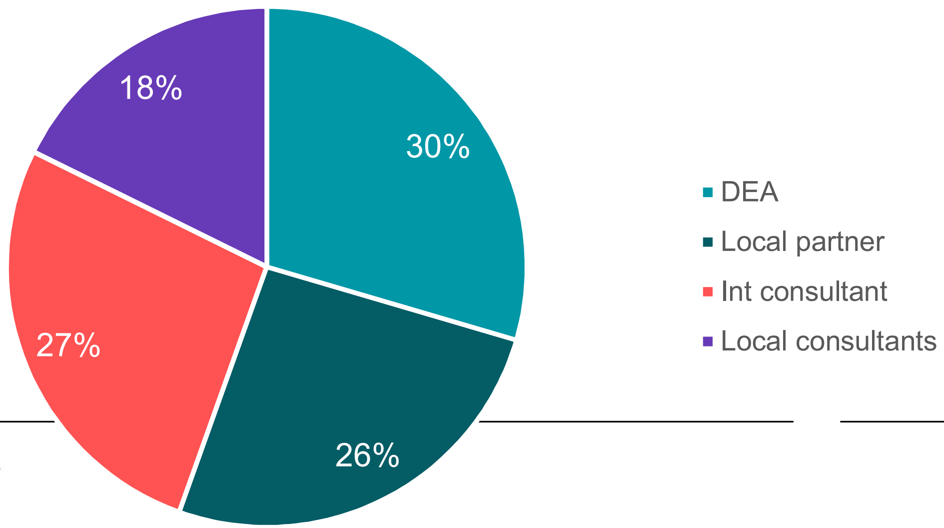
1 Ea Energy Analyses and Danish Energy Agency, 2017, "Technology Data for the Indonesian Power Sector - Catalogue for Generation and Storage of Electricity"
2 IRENA (2015). Renewable Power Generation Cost in 2014
3 Danish Energy Agency, 2012/2016.Technology Data on Energy Plants - Generation of Electricity and District Heating, Energy Storage and Energy Carrier Generation and Conversion
4 Danish Energy Agency, 2018.Technology Data on Energy Plants - Generation of Electricity and District Heating, Energy Storage and Energy Carrier Generation and Conversion
5 Vestas data provided by the Sales Division for the Asian Pacific.

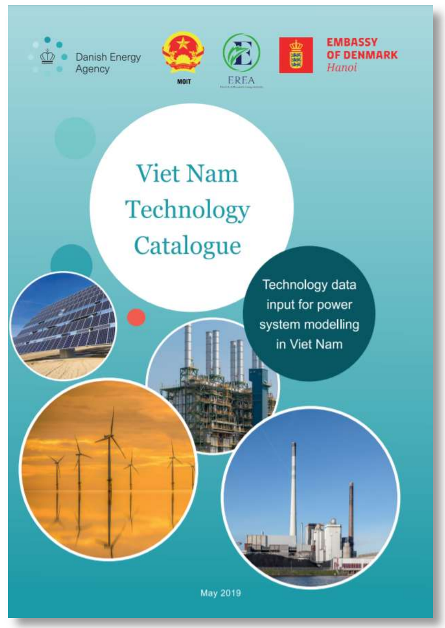
Notes:

A The efficiency is defined as 100%. The improvement in technology development is captured in capacity factor, investment cost and space requirement.
B Equipment: Cost of turbines including transportation. Installation: Electrical infrastructure of turbine, civil works, grid connection, planning and management. The split of cost may vary considerably from project to project.
C The IEA expects approximately a doubling of the accumulated wind power capacity between 2020 and 2030 and 4-5 times more by 2050 compared to 2020. Assuming a learning of 12.5 % per annum this yields a cost reduction of approx. 13 % by 2030 and approx. 25 % by 2050.
D With sufficient wind resource available (wind speed higher than 4-6 m/s and lower than 25-30 m/s) wind turbines can always provide down regulation, and in many cases also up regulation, provided the turbine is running in power-curtailed mode (i.e. with an output which is deliberately set below the possible power based on the

The process of the Vietnam case

- Local and international concultants contracted
- Timeline:
    - Phase 1: February – October 2018
    - Phase 2: November 2018 – June 2019





Lessons learned in other countries

- Access to data is an extensive process (limited sharing)
- Comparison of data
  - Immature technologies
  - Site specific conditions vs. Generalizing for entire country
  - National legislation across countries
  - Local markets and competition
  - Different plant sizes
  - Currencies and years
- Appoint one responsible person in each institution along with a team

Indian offshore wind technology catalogue

- Which activities have taken place?
- What was the process?
  - Guideline
  - Timeline
  - Stakeholder involvement

Objectives and products

To quantify the LCOE of offshore wind farms in India in Gujarat and in Tamil Nadu with two approaches:

- LCOE from a project developer perspective
- LCOE from a socio-economic perspective

This approach has not been applied elsewhere

- To specify the uncertainties in the LCOE and the impact for financial modelling analyses
- To create transparency regarding the data used for LCOE calculations
- To evaluate whether the methods used in a Danish context also may apply to an Indian context

Products:

- Offshore wind technology catalogue (incl. excel sheets)
- LCOE report and calculations → next week's seminar

Organization

WP1 Planning phase:

- Aug 2019-Jan 2020
- Introduction seminar (Aug 2019)
- Kick-off seminar (Nov 2019)

WP2 Data collection, Processing and analysis:

- Nov 2019-June 2020

WP3 LCOE calculation:

- Jan-August 2020
- Midway seminar (Feb 2020)
- Online publication (August 2020)

WP4 Sensitivity analysis of LCOE:

- Aug 2020-Feb 2021

WP5 Technology catalogue and cost trajectory:

- Aug 2020-Jul 2021

WP6 Capacity development:

- Aug 2019-Jul 2021

Organization

WP1 Planning phase:

- Aug 2019-Jan 2020
- Introduction seminar (Aug 2019)
- Kick-off seminar (Nov 2019)

WP2 Data collection, Processing and analysis:

- **Nov 2019-June 2020**

WP3 LCOE calculation:

- **Jan-August 2020**
- Midway seminar (Feb 2020)
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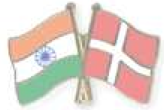
- Aug 2019-Jul 2021

The guideline (concept note)



Project agreement between NIWE and DEA

NIWE and DEA as project owners

Decision to recruit consultants

- COWI (offshore wind experience in India)
- DTU (wind ressource assessments)
- EA Energy Analysis

(technology catalogue experience)

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The contractual arrangements

Delive-rables	**WP2:** D.1: Data collection sheets (Tasks 1 and 2) D.2: Technology catalogue including qualitative descriptions and data sheets (Task 3) **WP3:** D.3: LCOE assessment report and results from LCOE tool calculations (Task 6) D.4: Midway workshop findings (Task 7) D.5: Dissemination workshop findings (Task 8) **WP4:** D.6: Sensitivity and cost reduction report (Task 11) D.7: Dissemination workshop findings (Task 12) **WP5:** To be defined in a later stage **WP6:** To be defined in a later stage

Organisation

The activities under each task are specified for the project partners in the table below.

Activity	DEA	NIWE	COWI	DTU	EA
General tasks	Co-own the project Manage international consultants contracts Quality assurance of deliverables Disseminate project results to DK stakeholders	Co-own the project Disseminate project results to IN stakeholders			
0. Kick-off workshop	Co-host and organize Present project to external stakeholders	Co-host and organize Present project to external stakeholders			
1. Data collection - societal	Quality assurance Support in methodology and scope Assist in engaging with international partners	Support COWI with data Assist in engaging with Indian partners	Responsible for data collection according to level of detail agreed with DEA/NIWE		
2. Data collection - developer	Quality assurance	Support COWI with data	Responsible for data collection according to level of detail		

The offshore wind technology catalogue

Guideline for the technology catalogue

First draft of qualitative part is currently under review (~20 pages + appendix)

Data estimates are being validated

Final version will be published in Aug/Sep 2020

Task 3: Creation of an Indian offshore technology catalogue (TC).
The international consultant shall draft a qualitative chapter for the TC for review and commenting by the Indian stakeholders who participate in the midway workshop. The existing methodologies available from the Danish TC will be adjusted to fit an Indian context. The TC will provide a brief (5-6 pages) qualitative description. For the qualitative part the existing descriptions from the Danish TC might be used and adjusted to fit the Indian context:

- Technology description (for non-engineers, explaining how the technology works and for which purpose)
- Input and output
- Typical capacities
- Wind resources
- Regulation ability
- R&D perspectives
- Best available technology
- Prediction of performance and cost
- Uncertainties
- Floating foundations

- Quantitative section similar to the format used in Denmark in the format of data sheets with data for 2020, 2022, 2025 and 2030. The following data categories shall be covered, but not necessarily limited to:

Energy/technical data
- Generating capacity for one unit (MWe)
- Average annual full-load hours
- Forced outage (%)
- Planned outage (%)
- Technical lifetime (years)
- Construction time (years)
- Space requirement (1000m2/MWt)

Financial data
- Nominal investment (M€/MW) and (M₹/MW)

Resources

The project owners (NIWE and DEA) has delivered resources as necessary

The active role of the local partner is crucial for ensuring progress and success of the project

International consultant resources

- Data collection and management, incl. technology catalogue: ~200 hours
- LCOE calculations: ~220 hours

Next work packages to begin in September 2020 with additional resources

Stakeholder involvement

Various methods have been used for stakeholder involvement:

- Workshops
- Email consultation
- Direct consultation

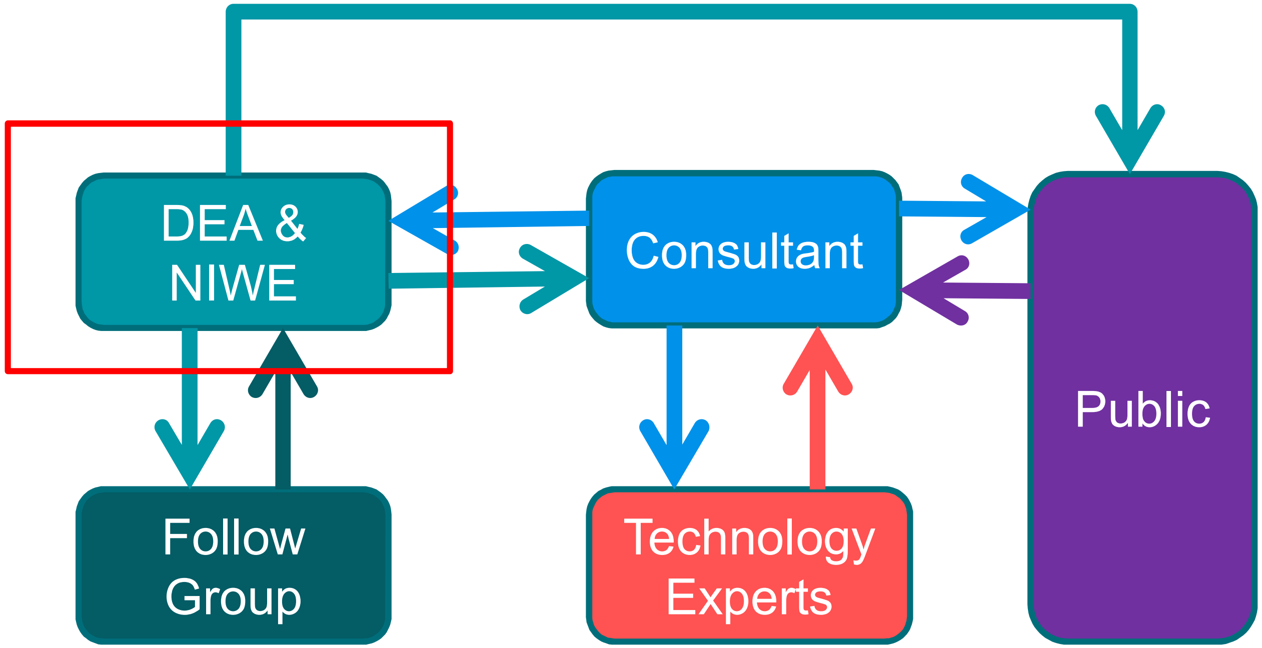
Stakeholders have been involved:

- As they have unique knowledge
- To create ownership to the process and products
- To create common assumptions across the sector
- To build trust

Stakeholder involvement

The stakeholder types:

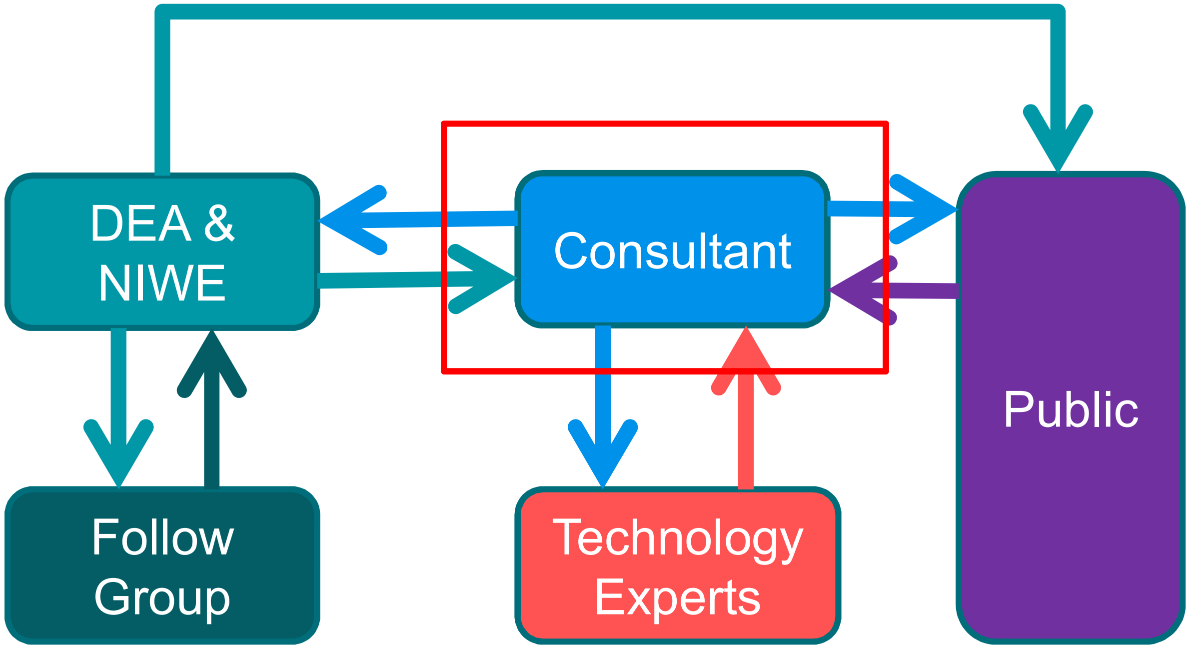
- The project owners



Stakeholder involvement

The stakeholder types:

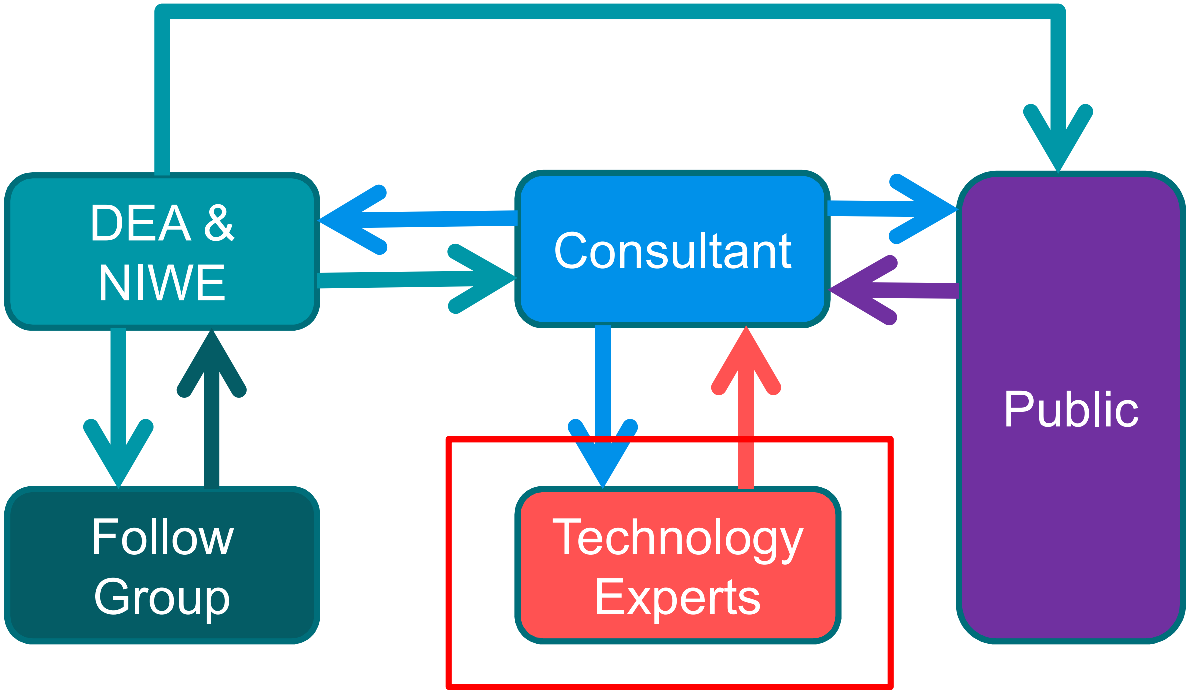
- The project owners
- Consultants



Stakeholder involvement

The stakeholder types:

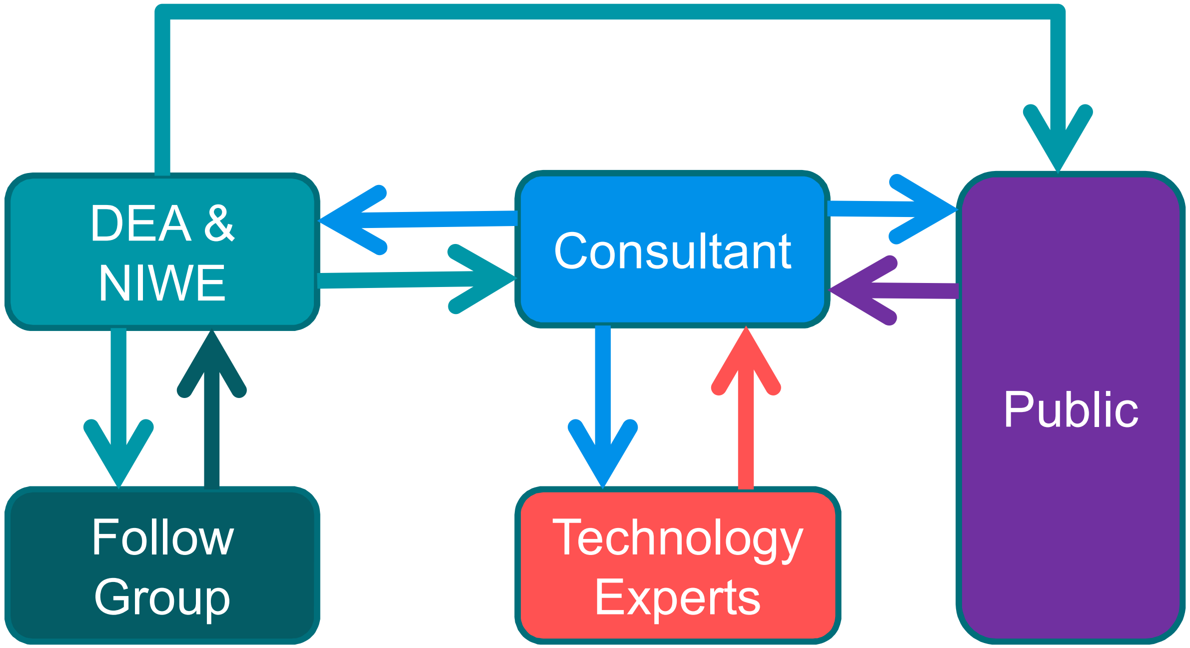
- The project owners
- Consultants
- Technology experts



Stakeholder involvement

The stakeholder types:

- The project owners
- Consultants
- Technology experts



No follow group since only one technology

Public will be involved later in the process

Kick-off workshop in Delhi

Kick-off of the FIMOI project at the Danish Embassy, November 2019

Participation by Indian and Danish authorities and several Indian and international companies

Ambition to create awareness and commitment to project in India

Midway workshop in Delhi

Midway workshop of the FIMOI project at the Danish Embassy, February 2020

Participation by Indian and Danish authorities and several Indian and international companies

Focus on initial results and data validation

Dissemination workshop

Online dissemination workshop of the FIMOI project, August/September 2020

Participation by Indian and Danish authorities and Indian and international key stakeholders

Focus on presenting the final results to be used in India

- Offshore wind data
- LCOE estimations

Email consultation and database

Database with information about stakeholders in the Indian offshore wind sector developed from:

- Expression of interest
- Participation in workshops
- International organisations in the Danish technology catalogue database
- Other contacts

80+ contacts, 50 organisations and everyone interested is welcome!

Emails sent out for invitations to workshops, and data validation

Dear Sir/Madam,

The National Institute of Wind Energy (NIWE) in collaboration with the Danish Energy Agency (DEA) work on developing a technology catalogue with key data for offshore wind power in India, for which we would like your comments.

If you do not wish to receive future invitations for this work, or if we should add more names, please let us know.

NIWE and the Danish Energy Agency has initiated a collaboration to develop a so-called technology catalogue for offshore wind power in India and we wish to include you in this process as we believe you have valuable contributions. We would appreciate any inputs and comments you might have which are specifically relevant for the rising Indian offshore wind sector. This contributes to the process for data collection among Indian and international stakeholders in the offshore industry. The purpose of developing the technology catalogue is to support decision-making in the Indian government to assess necessary subsidies, promote cost-efficiency and benchmark against other technologies. Experience show that the higher quality of the data, the better the support for decision making.

Please confirm that you have received this email and that you intent to contribute to the data collection, if this applies to your organization.

The material attached to this email contains:

- A brief introduction to the project and how the data will be used
- An overview of the assumptions for the first wind farms in India
- A data table for the state of Gujarat where the first offshore wind tender is planned
- A data table for the state of Tamil Nadu where offshore wind power has great potential

The collected information will be used for developing a technology catalogue for offshore wind power in India based on similar methods from Denmark, Vietnam, Indonesia, China and Mexico. The information will provide support and insight for decision making in the Indian government for the development of the offshore wind sector in a cost-competitive manner. The data products and cost estimations will subsequently be made publicly available.

Direct consultation

Calling and setting up meetings with key stakeholders for data inputs and validation

Direct consultations with several international offshore wind developers and financial institutions

Currently, process ongoing to organize consultations with Indian organizations

Lessons learned from stakeholder involvement in FIMOI project

Engagement of potential users and data providers has shown to be long and extensive

Data collection can be difficult, e.g. because data is not available

Simplification of the technology description is necessary but unpopular

More **interactions** and validation when using direct consultations and workshops – provide data to comment on rather than blank sheets

Both the technology and the technology catalogue are **new in India** and will take time before they reach a similar level as in Denmark

→ Many of the same lessons learned as in Denmark, but also some differences

Indian power sector technology catalogue

- What is planned to take place?

Indian power technology catalogue

Ambition is to develop a technology catalogue for the main technologies in the Indian power sector (e.g. thermal plants, hydropower, onshore, PV, etc.)

The power sector technology catalogue will be developed in collaboration with CEA and MOP

Currently, discussions are ongoing about the various activities, timelines and so on

The technology data will feed into activities under CEA with power modelling

Q&A Session on Monday, June 8

Live online Q&A session discussing:

- Possible questions from presentations and the project
- The exercises
- Brief evaluation

If you have any questions or points that are worth discussing, please send the questions in advance to keha@ens.dk

They will be aggregated and answered by the DEA!

Exercise

Question 1:

Suggest the 3 main things seen from your perspective we have learned from developing the offshore wind technology catalogue in India that can be useful while developing technology catalogues for other technologies

Question 2:

How can the offshore technology catalogue be replicated for onshore wind power?

Thank you for listening!

Kenneth Hansen (keha@ens.dk)
Danish Energy Agency