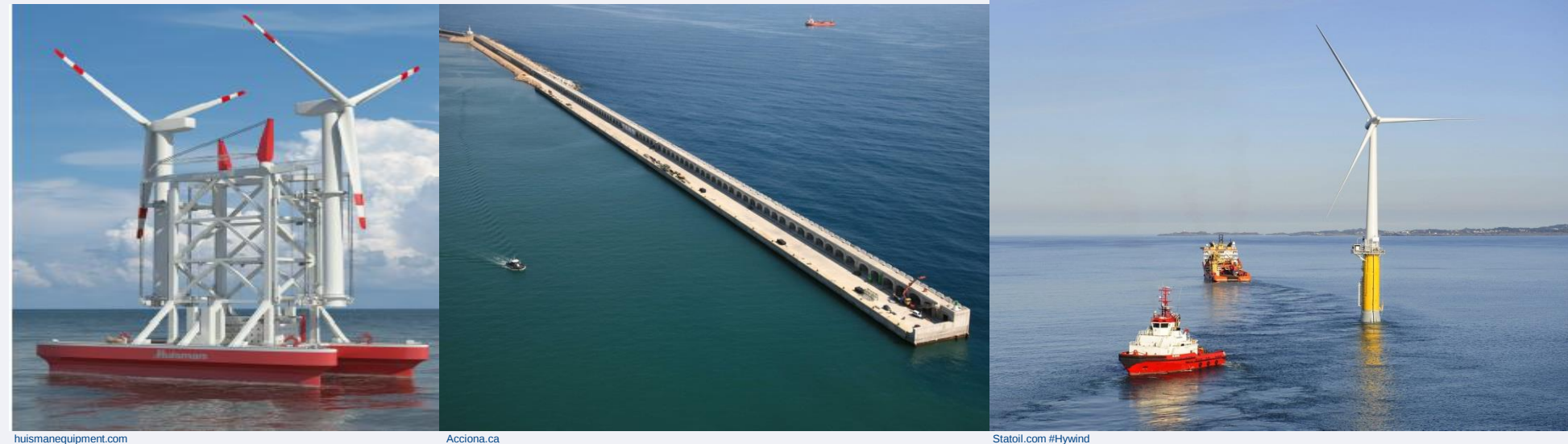


Objective

Commercial proof of 3 innovative installation concepts:

1. Breakwaters
2. Offshore assembly site
3. Floating transport

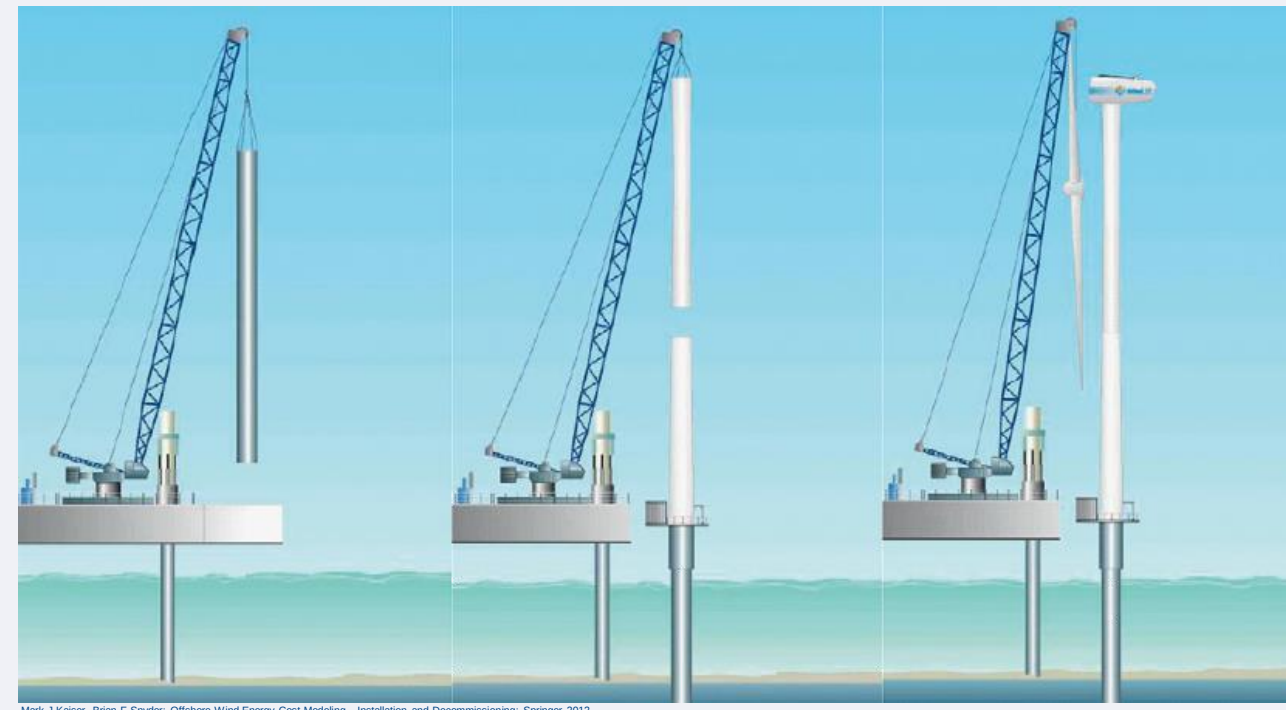


Offshore Wind Installation

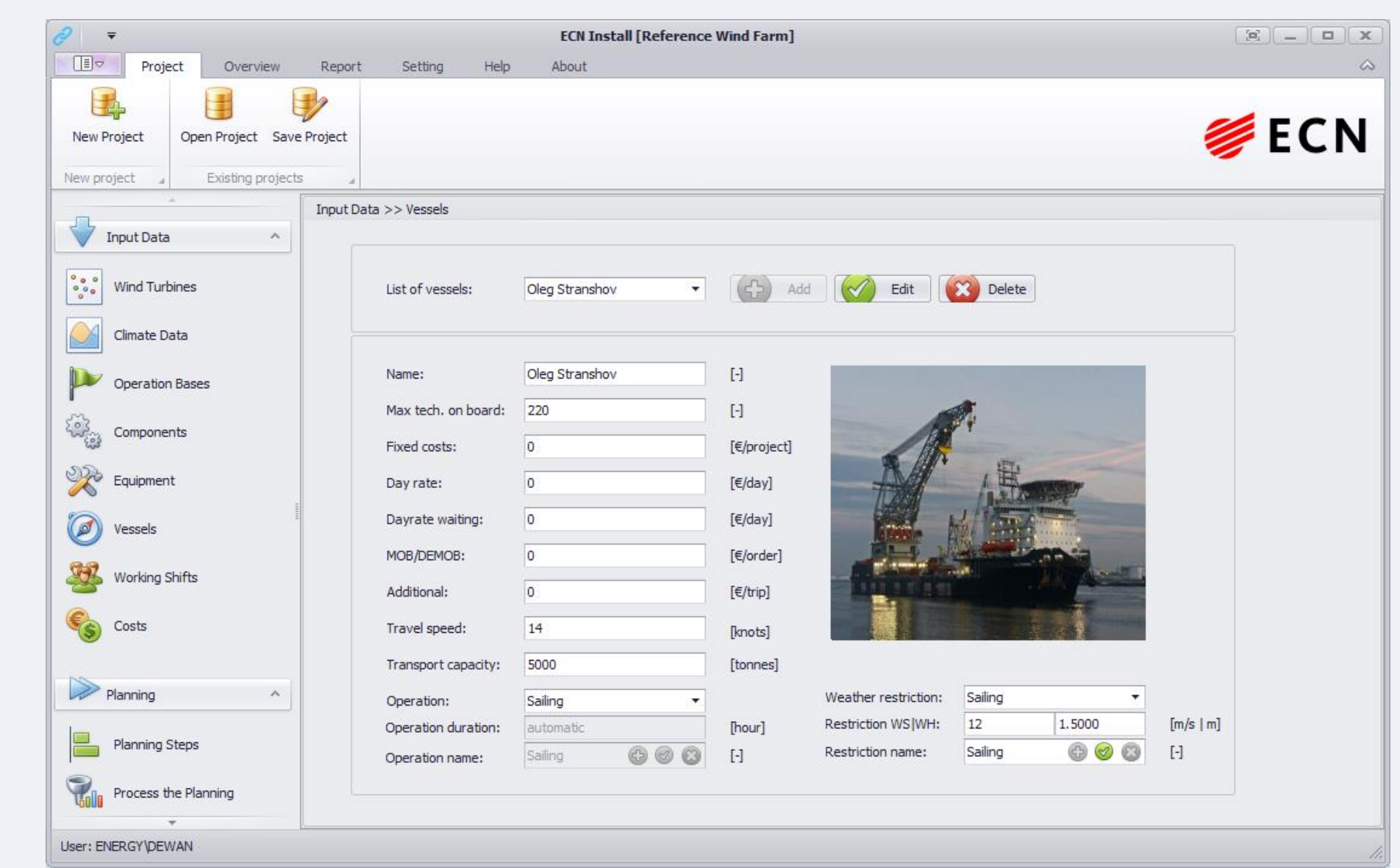
2488 offshore turbines are installed by end of 2014

Ambitious plan to install 30 GW more by 2020

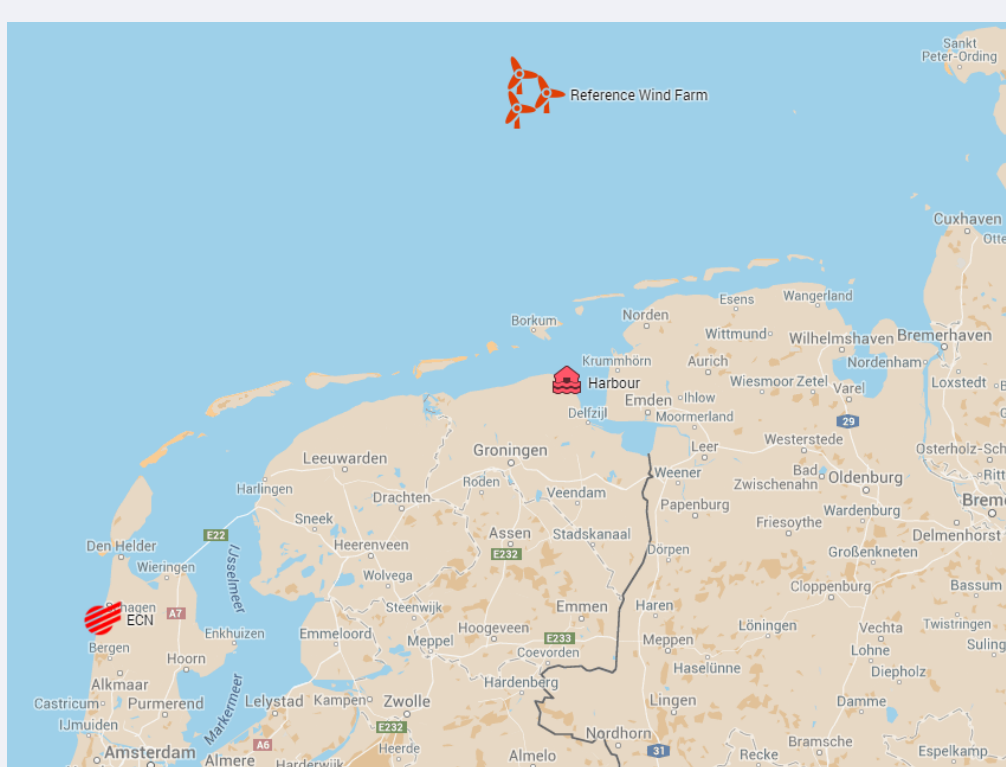
Installation, 10-15% of CAPEX due to high vessel costs



ECN Install



Reference Wind Farm



300 MW, 75x4MW, 2 HVDC
North Sea, 85 km offshore
28-36 m water depth
20 years of weather data
WS: 7.64 m/s & WH:1.55m

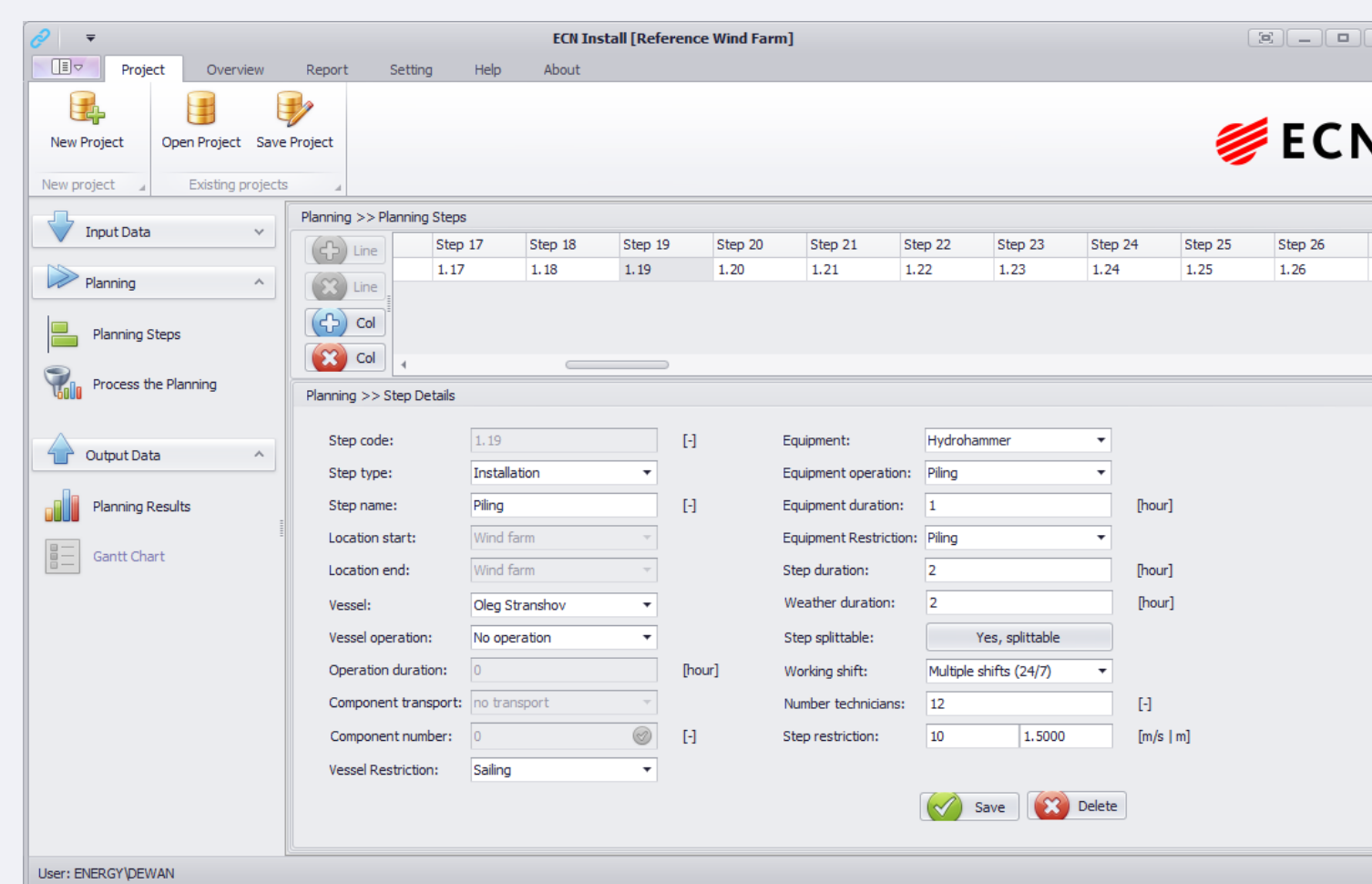
Foundation: Monopile, Transition Piece, J-Tube Set

Turbine: Tower (x2), Nacelle, Blade (x3)

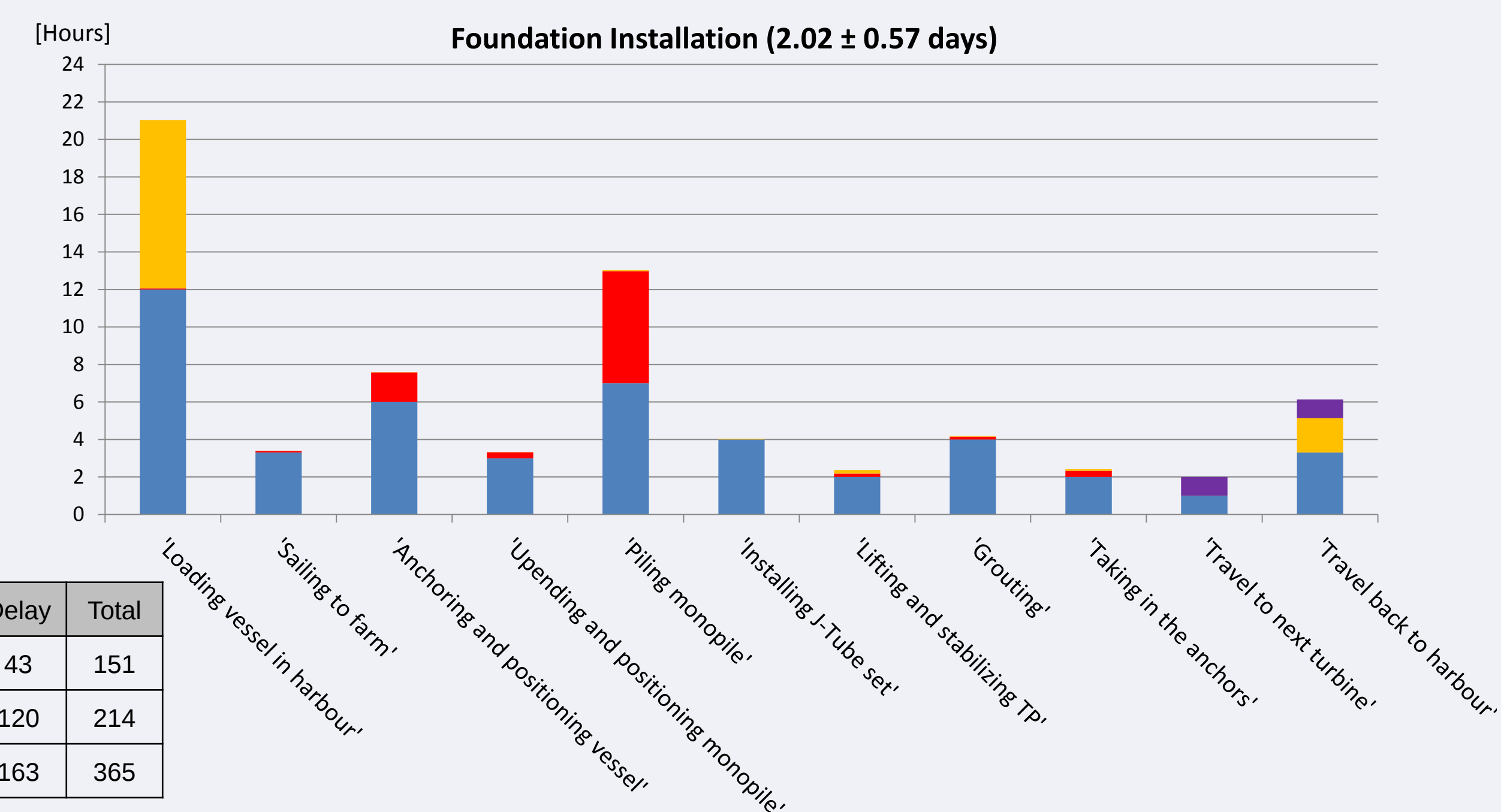
Equipment: Hydro Hammer, Jack-up Barge (x2)

Working Shift: Loading (12h), Installation (24x7)

Installation Planning Results



[days]	Start Date	End Date	Total	Work	Delay	Weather Delay	Shift Delay	Harbour Delay
Found.	29-Mar	27-Aug	2.02 ± 0.57	1.45	0.57 ±0.57	0.36 ±0.51	0.17 ±0.05	0.04
Turb.	05-Aug	07-Mar	2.86 ± 2.09	1.26	1.6 ±2.09	1.41 ±2.00	0.19 ±0.09	0



Innovation: Breakwaters

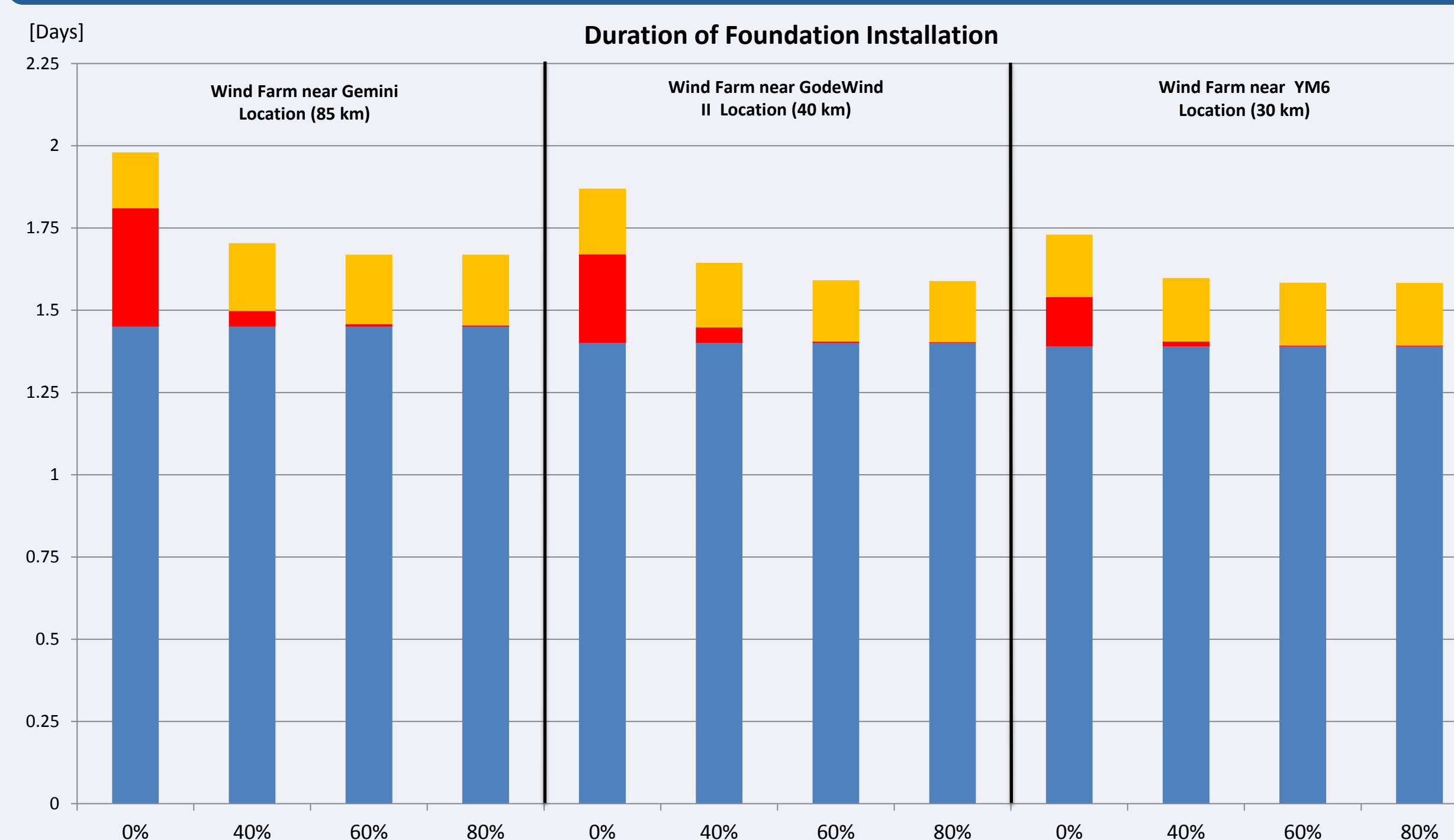
- Breakwater to attenuate waves to an acceptable level
- Mound, monolithic & composite breakwater structure
- Ht/Hi = 0.3 for L/w = 3 & Ht/Hi = 0.9 – 1.0 for L/w = 8

Pros: less weather restriction, more weather window

Cons: structure costs



Installation Planning Results



85km	Start Date	End Date	Total	Work	Delay	Weather Delay	Shift Delay
Ref.	29-Mar	27-Aug	1.95	1.45	0.50	0.36	0.17
40%	29-Mar	3-Aug	1.71	1.45	0.25	0.048	0.206
60%	29-Mar	1-Aug	1.67	1.45	0.22	0.008	0.211
80%	29-Mar	1-Aug	1.67	1.45	0.22	0.004	0.215

Innovation: Offshore Assembly Site

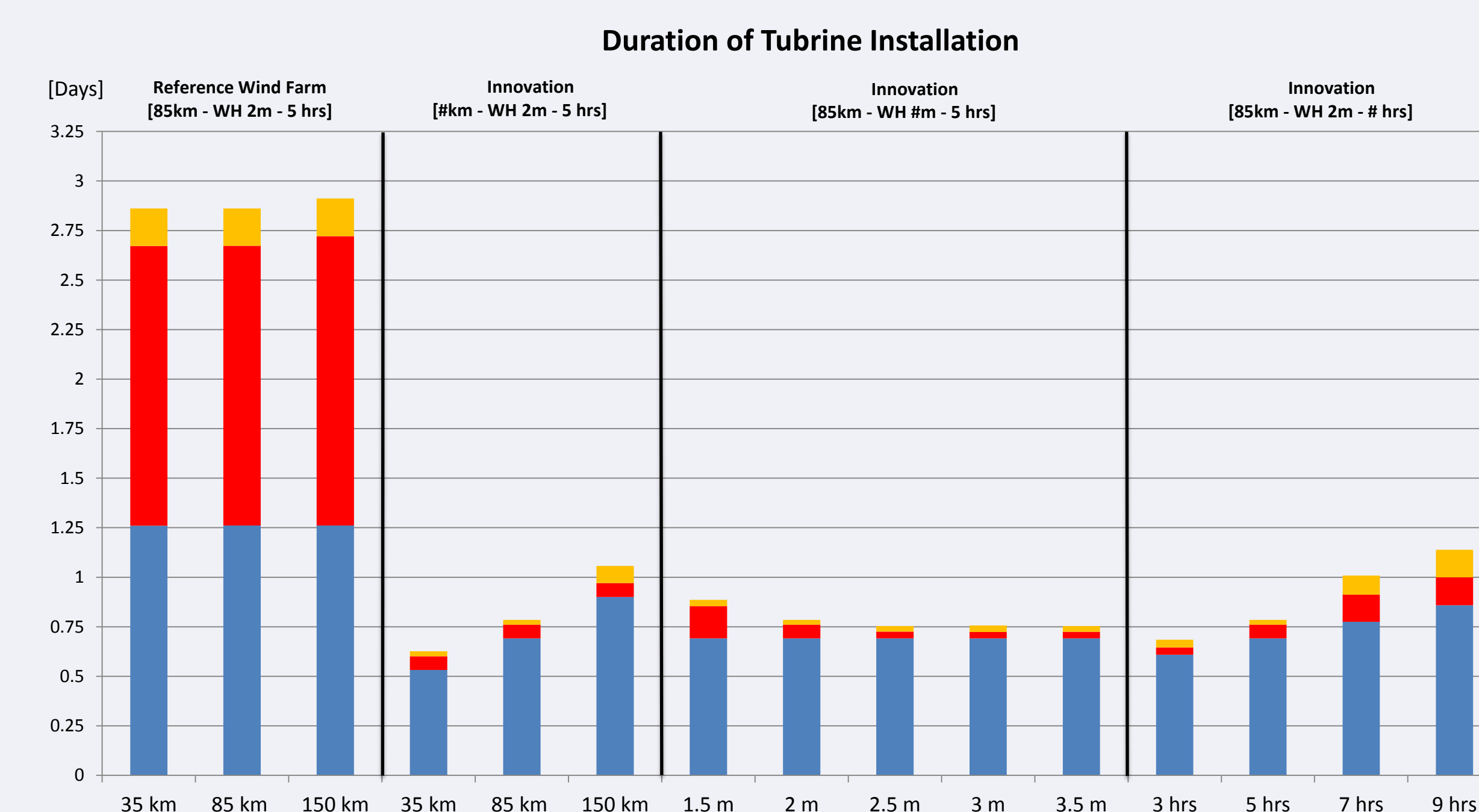
- Floating pontoon structure as offshore harbour
- Components are assembled together on the platform
- Feeder vessel feeds new components to the platform

Pros: faster turbine installation

Cons: platform costs



Installation Planning Results



Ref.	Start Date	End Date	Total	Work	Delay	Weather Delay	Shift Delay
85km	5-Aug	8-Mar	2.86	1.26	1.60	1.41	0.19
Inno.	Start Date	End Date	Total	Work	Delay	Weather Delay	Shift Delay
85km	5-Aug	4-Sep	0.78	0.69	0.09	0.069	0.024
Inno.	Start Date	End Date	Total	Work	Delay	Weather Delay	Shift Delay
WH 3m	5-Aug	1-Sep	0.74	0.69	0.05	0.031	0.033
Inno.	Start Date	End Date	Total	Work	Delay	Weather Delay	Shift Delay
3 hrs	5-Aug	26-Aug	0.67	0.61	0.06	0.038	0.038

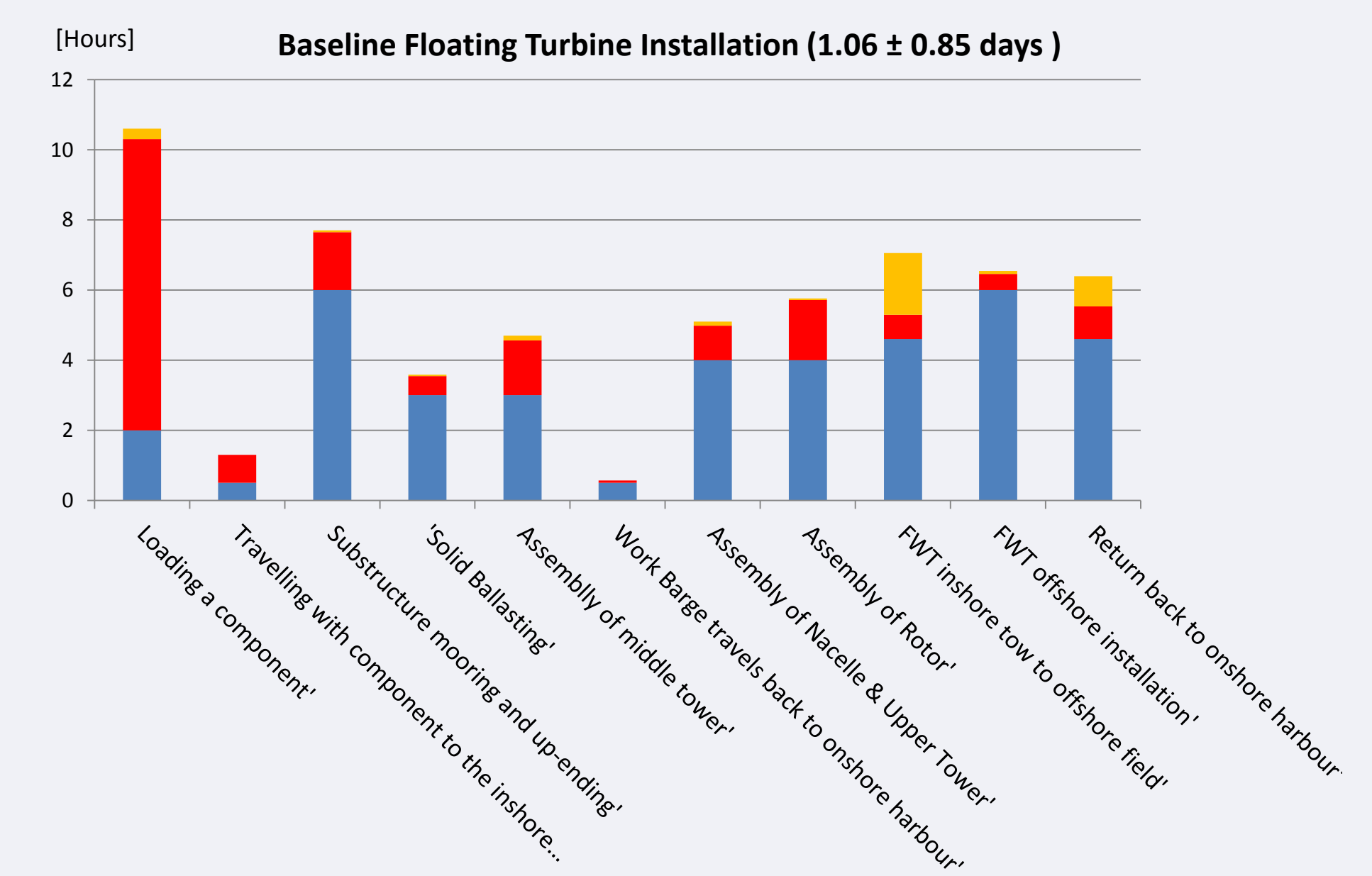
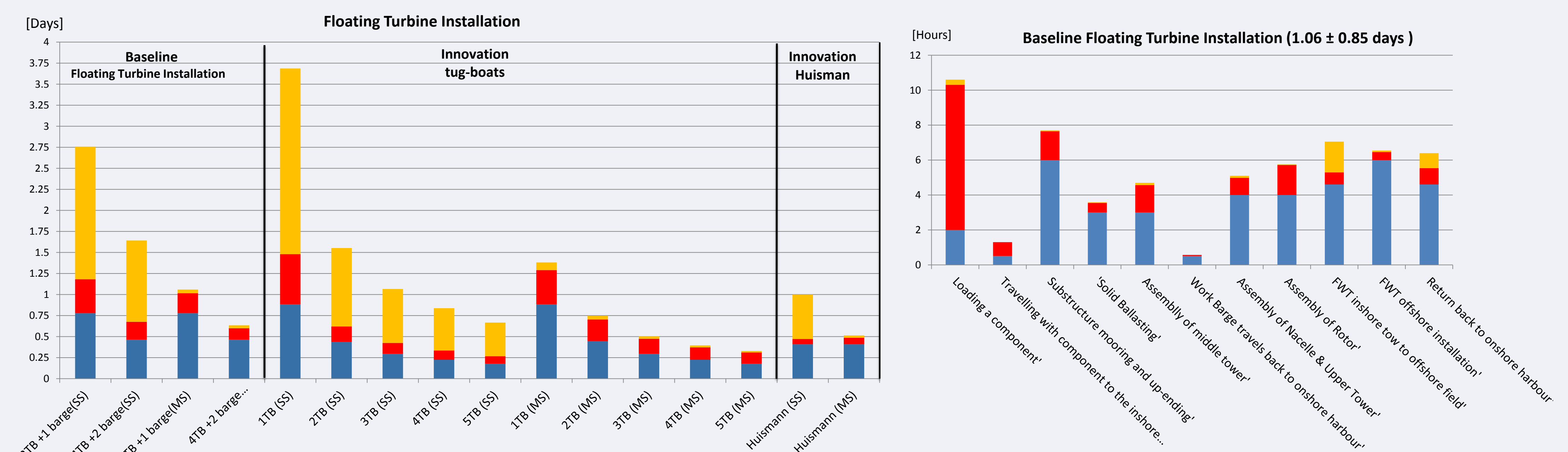
Innovation: Floating Transport

- Baseline
 - Spar buoy concept installation
 - Assembly in a fjord, towing offshore and mooring
- Use tug-boats or Huisman vessel instead

Pros: faster turbine installation



Installation Planning Results



*SS: Single Shift
**SM: Multiple Shift

