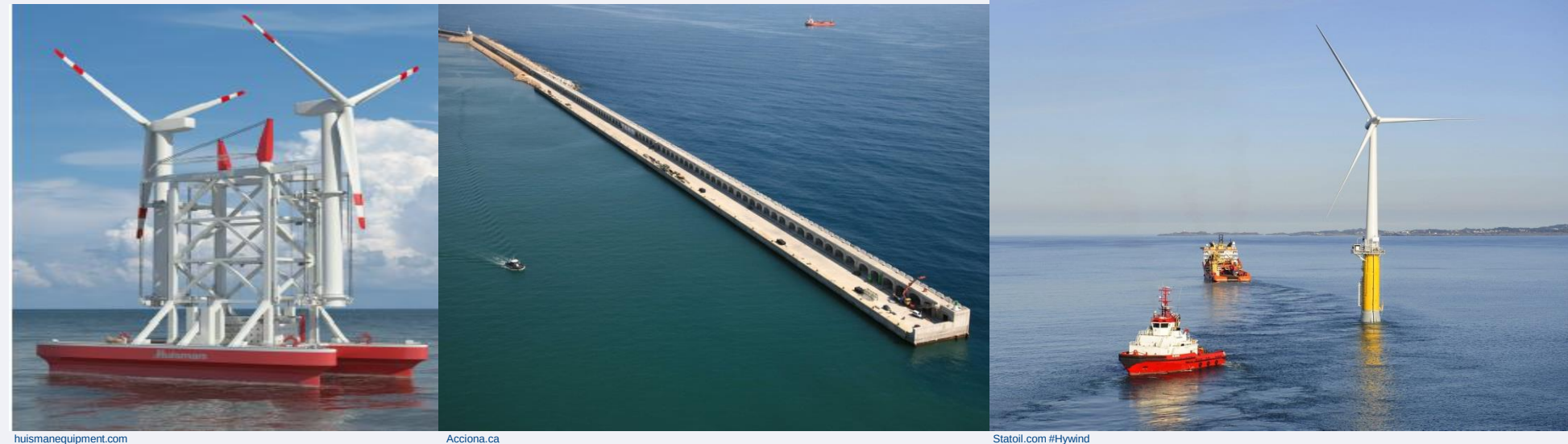


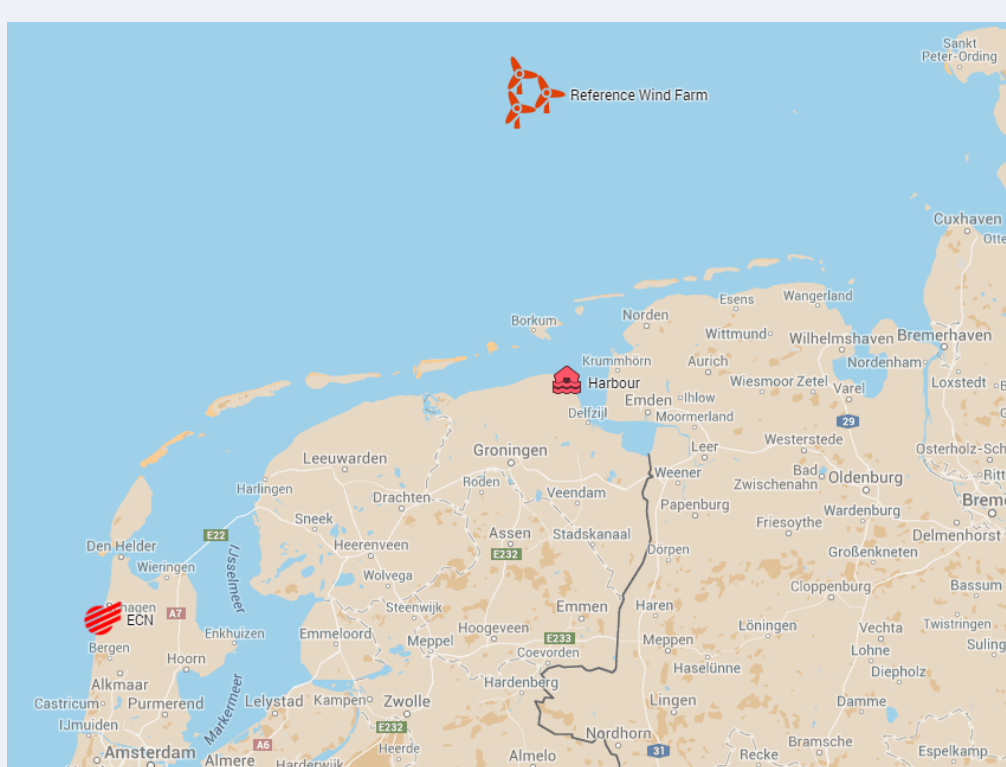
### Objective

Commercial proof of 3 innovative installation concepts:

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



### 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)

### Innovation: Breakwaters

- ❑ Breakwater to attenuate waves to an acceptable level
- ❑ Mound, monolithic & composite breakwater structure
- ❑  $H_t/H_i = 0.3$  for  $L/w = 3$  &  $H_t/H_i = 0.9 - 1.0$  for  $L/w = 8$

Pros: less weather restriction, more weather window

Cons: structure costs



### 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



### 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



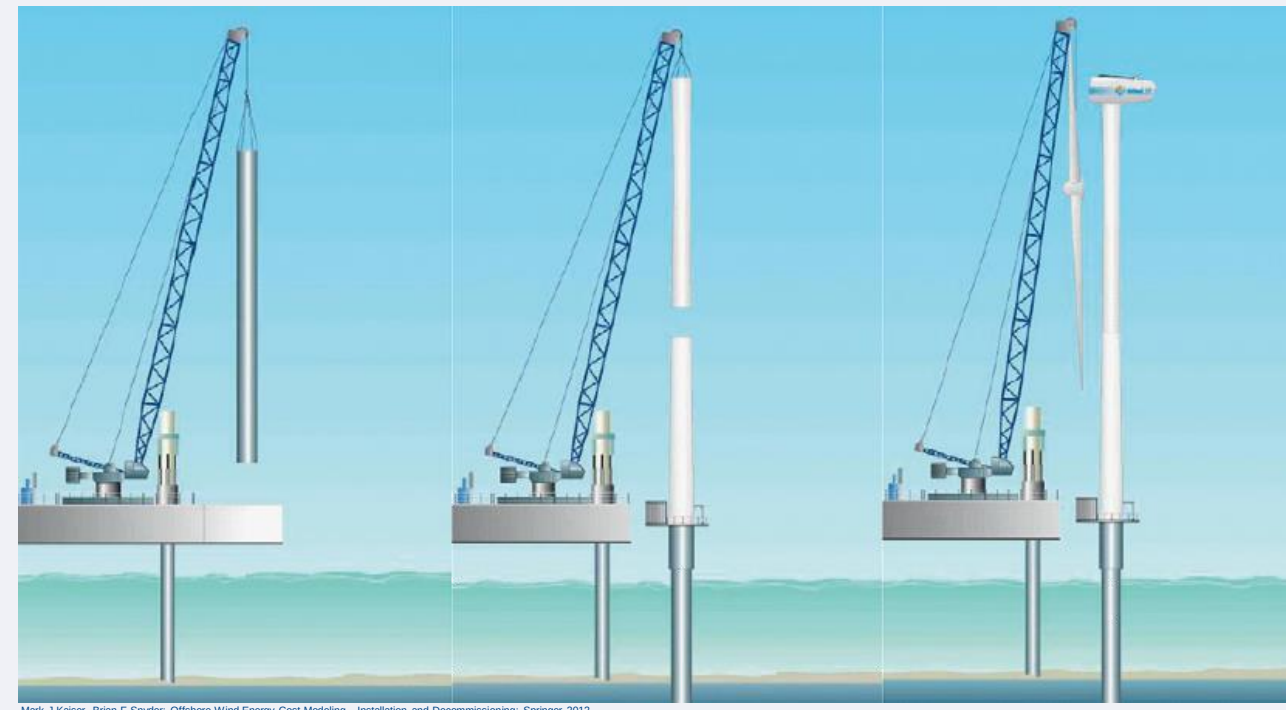
\*SS: Single Shift  
\*\*SM: Multiple Shift

### Offshore Wind Installation

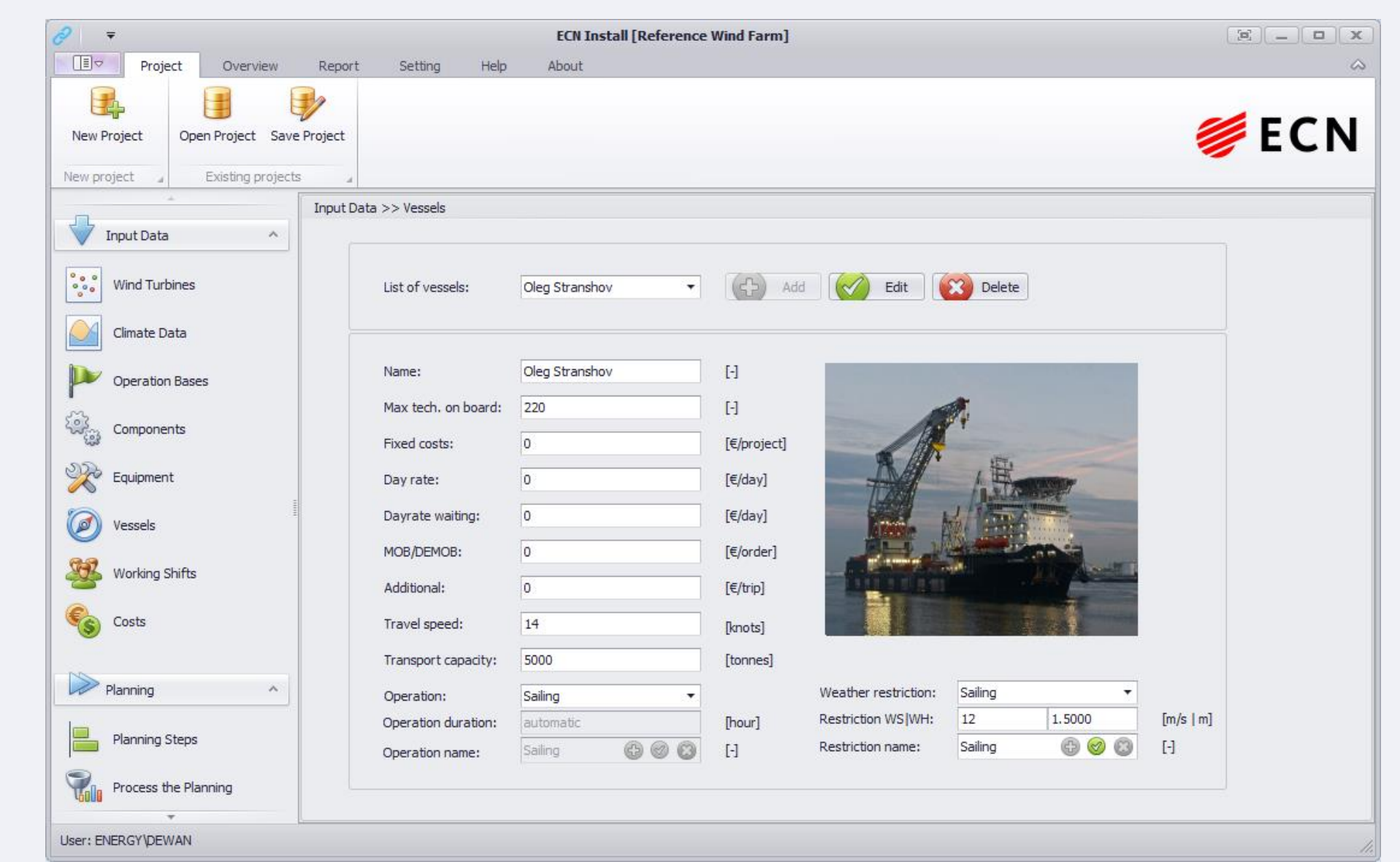
2488 offshore turbines are installed by end of 2014

Ambitious plan to install 30 GW more by 2020

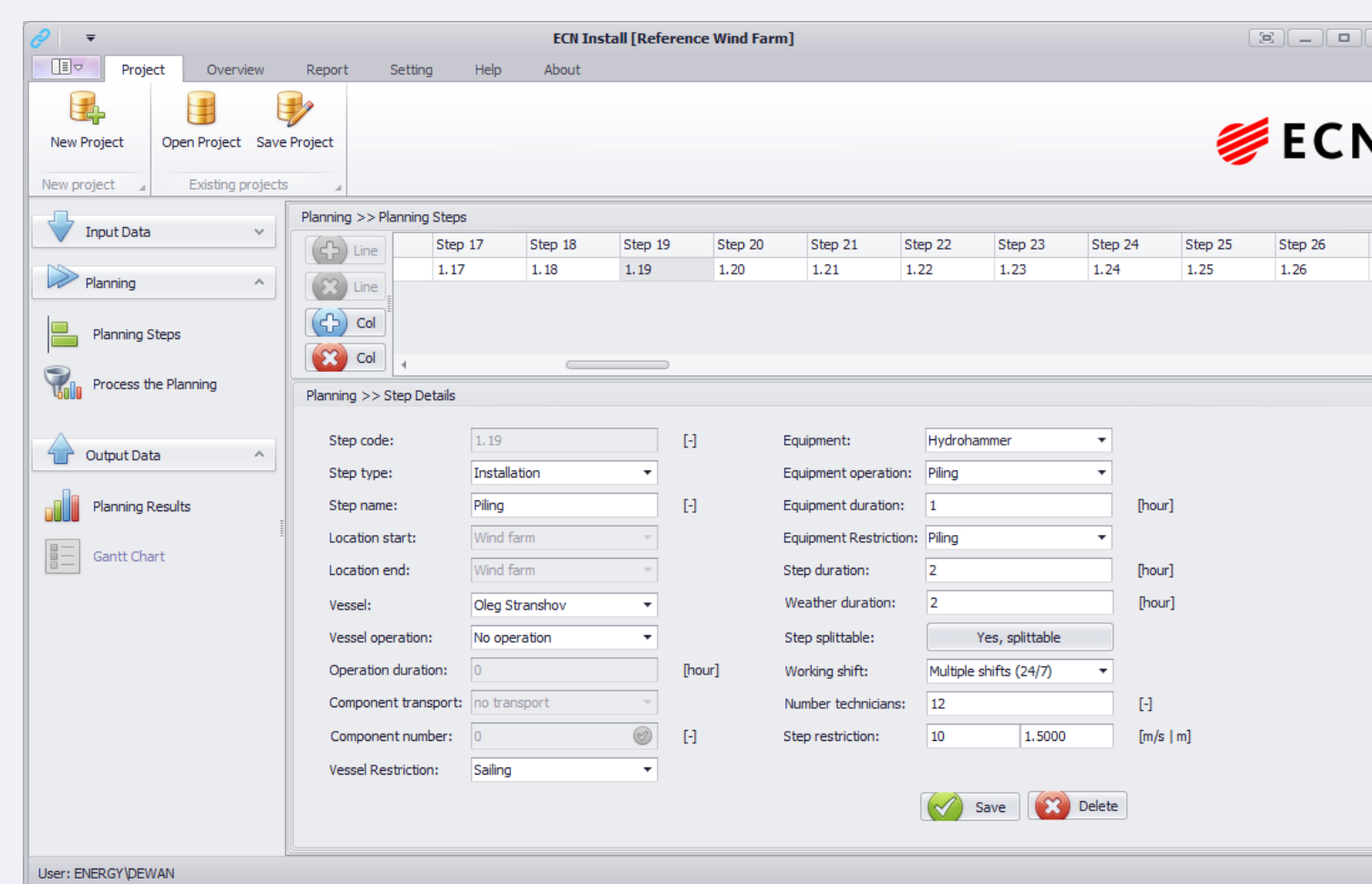
Installation, 10-15% of CAPEX due to high vessel costs



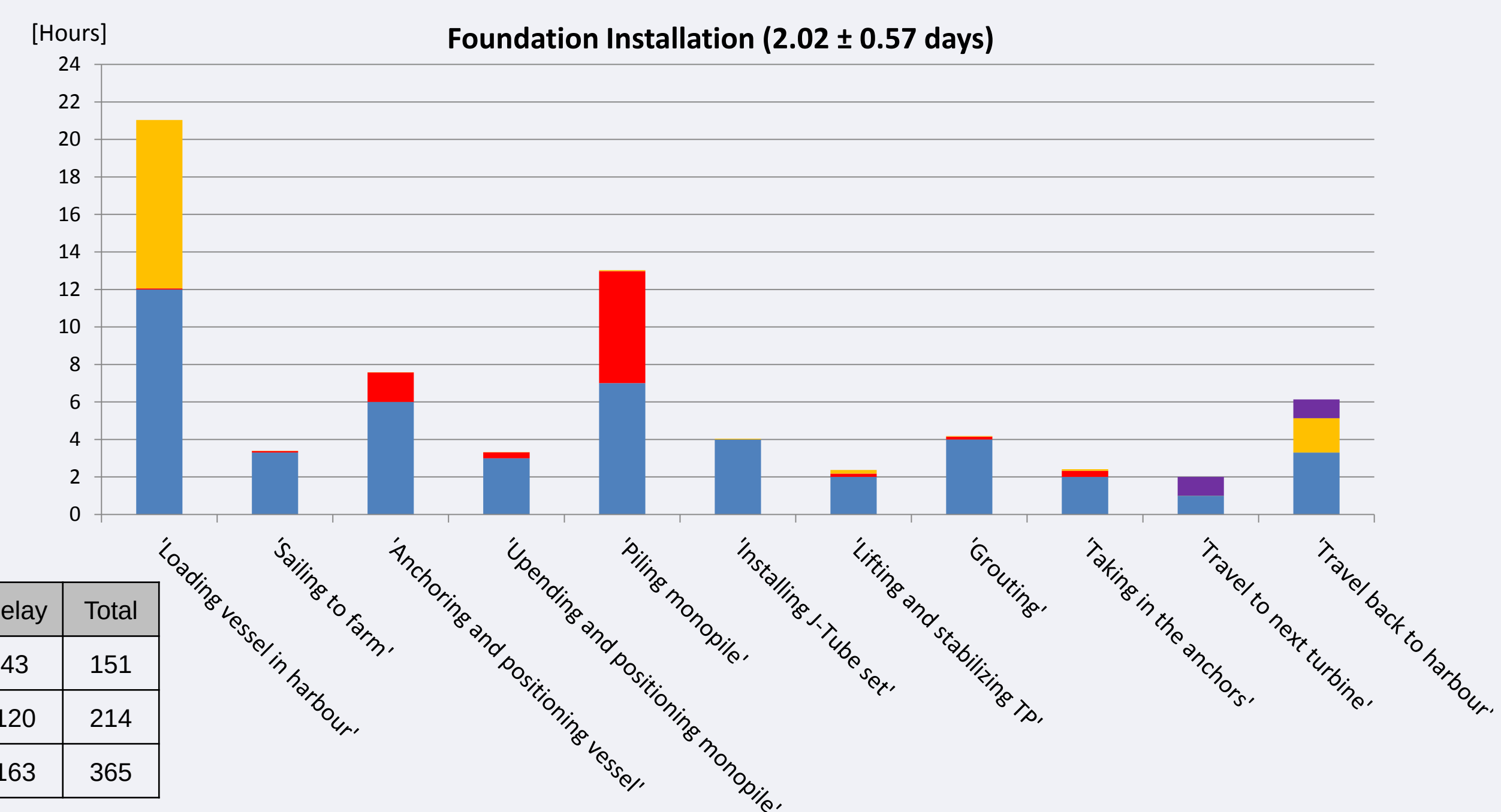
### ECN Install



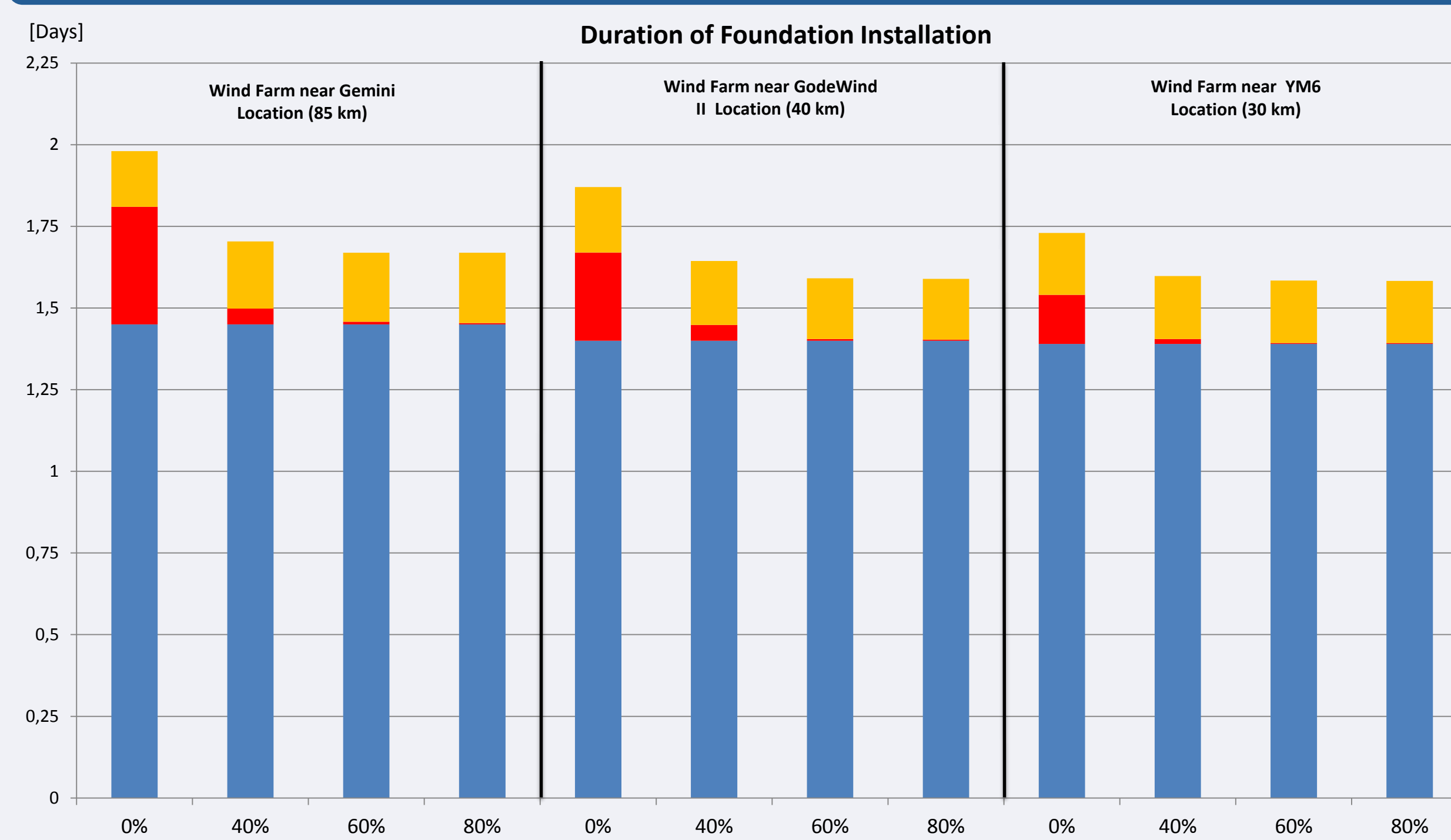
### Installation Planning Results



| [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             |

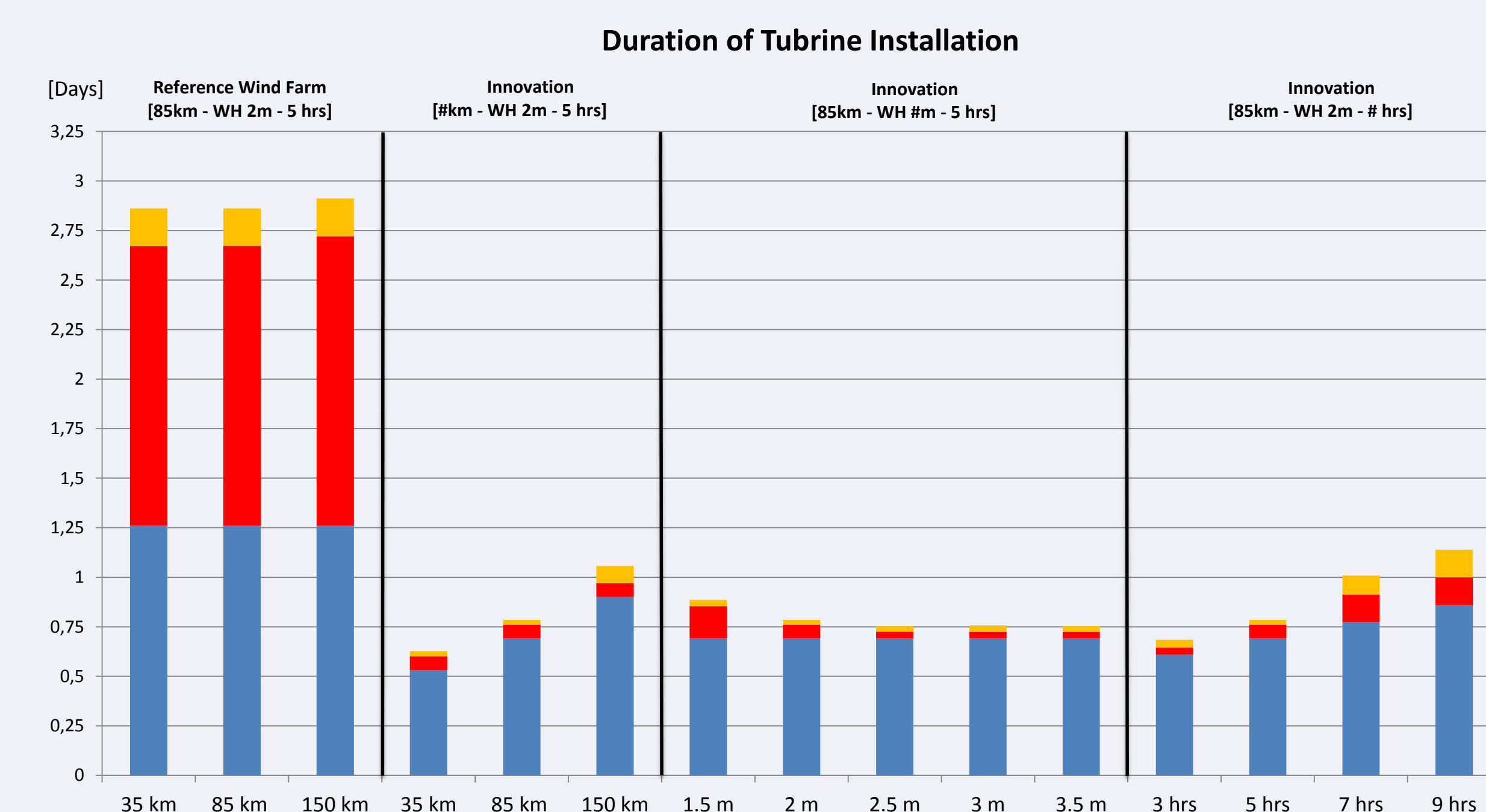


### Installation Planning Results



| 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       |

### 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       |

### Installation Planning Results

