Hochschule Flensburg
University of Applied Sciences

Fraunhofer IWES

Interview Task:
Offshore Decommissioning

Presented by:

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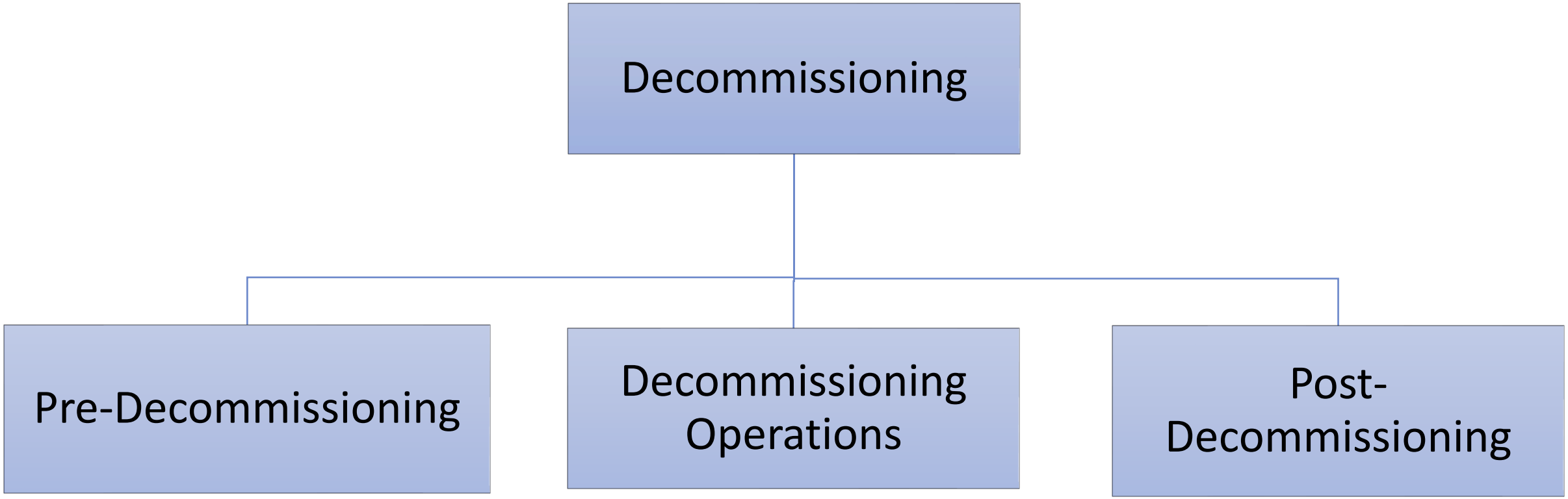
Date : 22.11.2024
Place: Flensburg

Index

1. Step involved on offshore Decommissioning



Reference: [1]

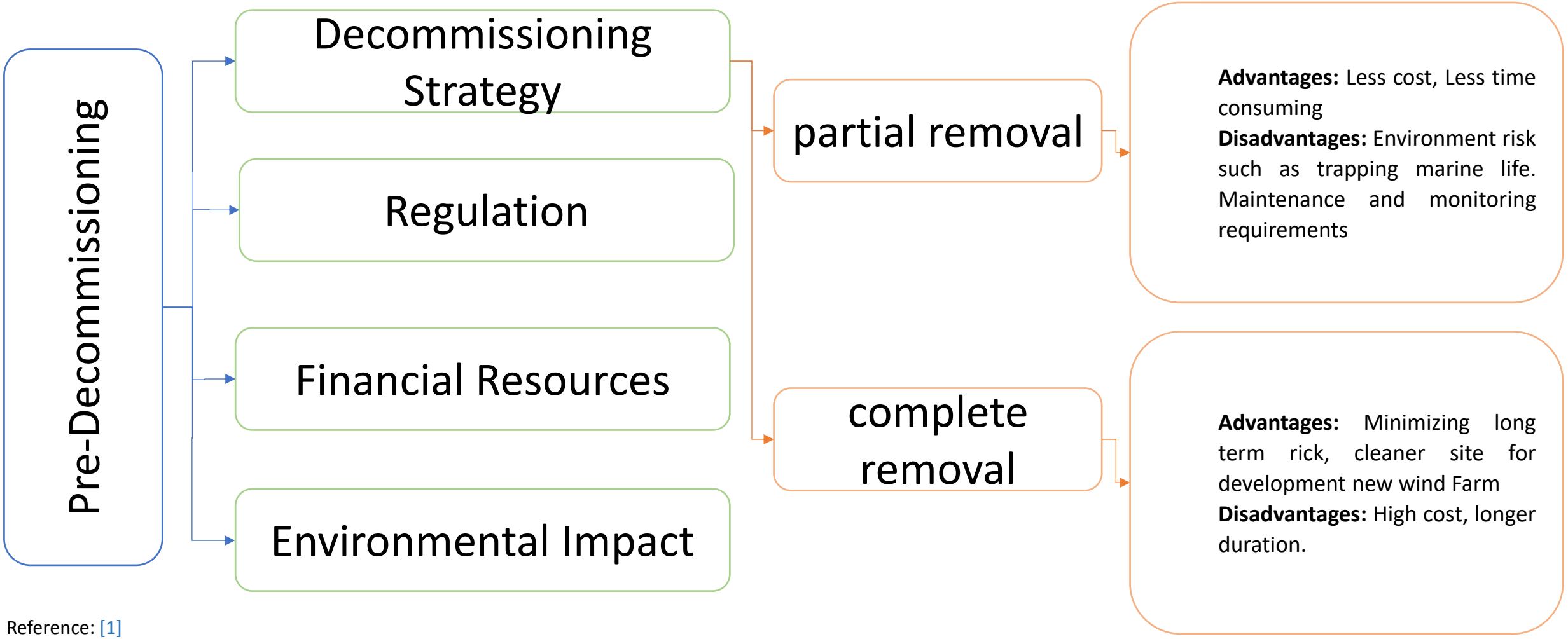
1. Steps involved in Offshore Decommissioning

Starting turbine composed of:	Removal options (# lifts)	Step						
		Initial Condition	Remove blade 1	Remove blade 2	Remove blade 3	Remove hub	Remove Nacelle	Remove tower to give final condition
2 tower sections:	1 (6)							
nacelle:	2 (3)							
hub:	3 (4)							
3 blades:	4 (3)							
	5 (1)							
	Felling							

Figure 1.1: Traditional offshore turbine decommissioning options [1]

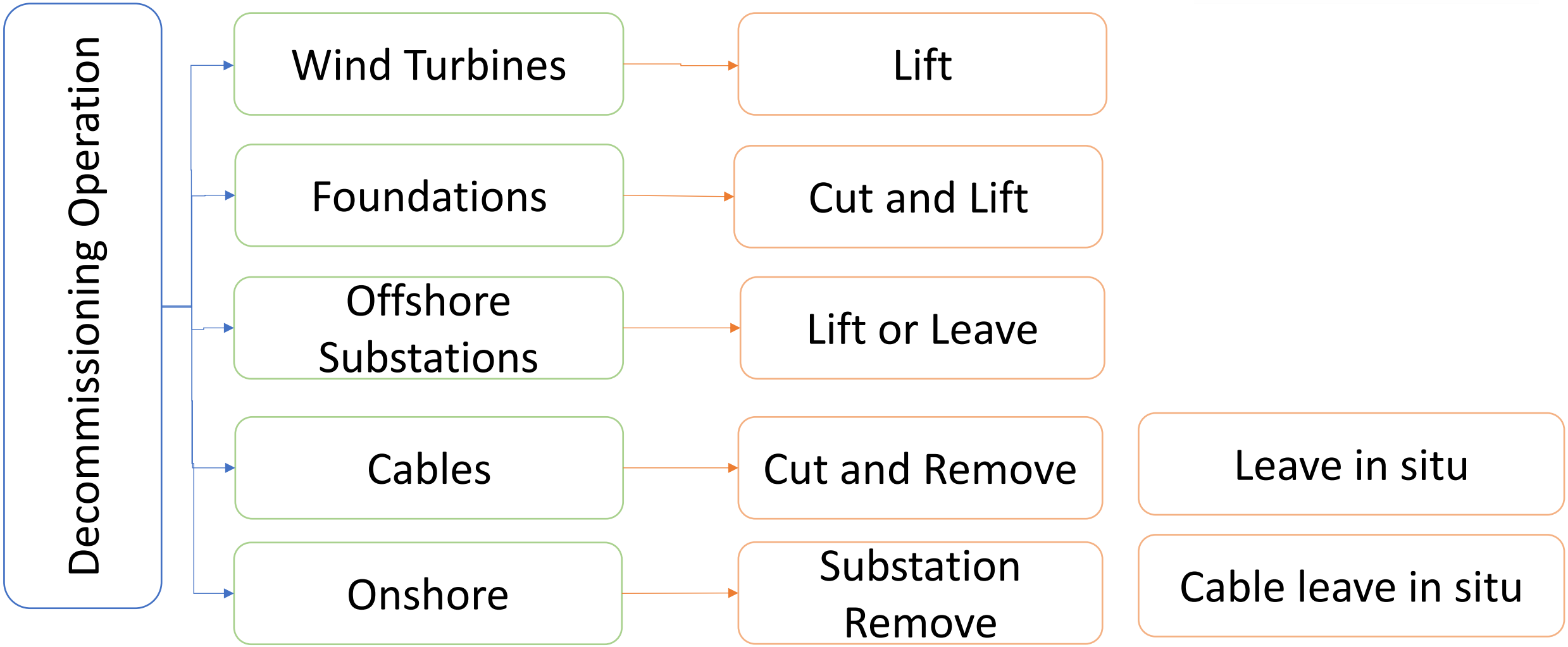
Figure 1.2: Offshore Wind turbine with Monopile Foundation [1]

1. Step involved on offshore Decommissioning

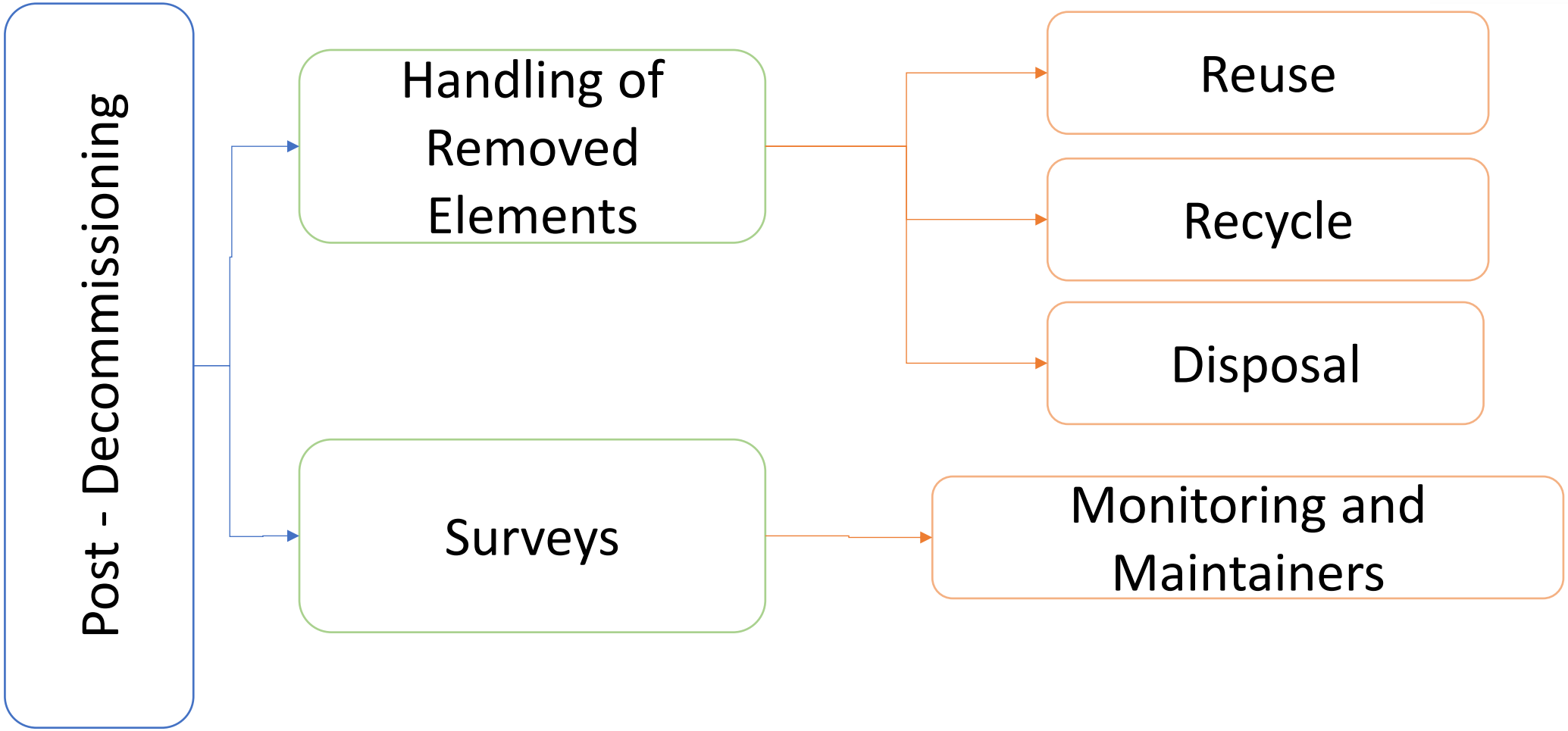


Reference: [1]

1. Step involved on offshore Decommissioning



1. Step involved on offshore Decommissioning



2. Factors Affecting Decommissioning

- Foundation type
- Vessel Availability
- Distance to port
- Water depth
- Weather conditions
- Time
- CO2 Emission
- Costs

1. Survey Vessel:

Fuel Type: HFO, Diesel, MGO, LNG, Methanol, Ammonia, Electricity
Size: Length: 80-100 m and Breadth: 15-18 m
Survey depth capacity: 2500 -3000 m [2] [3] [4] [5]

Figure 2.1: Survey Vessel [2]

2. SPIVs or Heavy Lift Vessel:

Fuel Type: HFO, Diesel, MGO, LNG, Methanol, Ammonia, Electricity
Size: Length: 220-382 meter and Breadth: 102-124 m
Lifting Capacity: 20000 -60000 tonnes [5] [6] [7]

Figure 2.2: Heavy Lift Vessel [6]

3. Support Vessel:

• **Dive support Vessel**	Offer a place to launch, supply, recover, to assist underwater
• **Crew boats**	Transferring person, environmental studies, support of shallow waters or the enforcement of safety zones
• **Workboats**	Cutting processes
• **Multicats**	Light transport, underwater support and stability handling
• **Tugs**	Normally they come with a small crane for stability handling.
• **Cargo barges**	Used for the transportation of components [1]

4. My Approach to Decommissioning Offshore Wind Farm

Pre-decommissioning

1. **Decommissioning Strategy :** Partial Remove Approach
2. **Regulation, Financial resources:** Right now, I assume, it is okay.
3. **Environment Impact:** Finding Co2 Emissions

Decommissioning Operation

4. **Wind Turbine :** 8 Wind Turbines (Assume 8MW one wind Turbine)

Turbine Type	Nacelle	Rotor blades	Tower
4 MW	165 t	20 t	300 t
8 MW	450 t	35 t	650 t

Table 4.1: Wind turbine components weight [1]

4. My Approach to Decommissioning Offshore Wind Farm

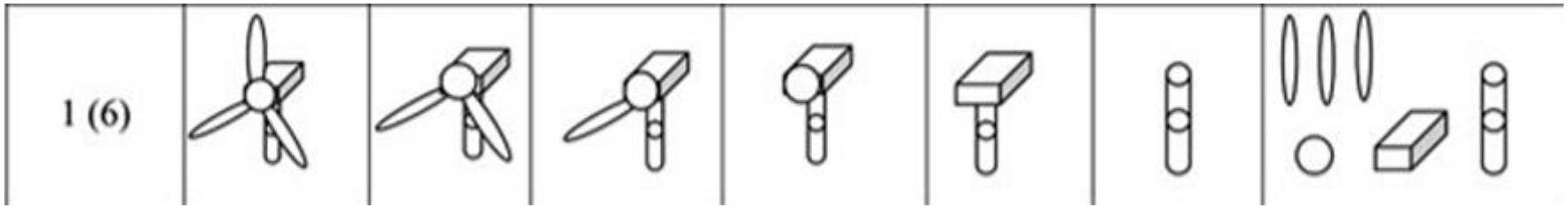


Figure 4.1: Selected Decommissioning process for Wind Turbine [1]

5. Foundation : Cut (Monopile Foundation)

6. Offshore substation, Cables Assuming Constant

Post-Decommissioning

Ignore it

4. My Approach to Decommissioning Offshore Wind Farm

• **Foundation type**	Monopile Foundation
• **availability Vessel**	Survey, SPIVs, Dive support, Crew boat, Work boat, Multicats, Cargo barges, Tugs
• **Distance to port**	80km
• **Water depth**	40 m
• **Weather conditions**	Normal
• **Time**	4 [hours] + 15 days [assuming decommissioning per wind turbine] + 4.5 [hours]

4. My Approach to Decommissioning Offshore Wind Farm

Vessel	Speed (km/h) / Travel Time = Dis./ speed	Port to Site	On Site	Site to Port
Survey	18 -28	22 (3.63 hours)	-	22
SPIVs	18 - 28	**22**	-	**18 (4.44 hours)**
Dive support	15 - 22	22	-	22
Crew boat	28 - 37	28 (2.85 hours)	-	`28
Work boat	15 - 23	22	-	22
Multicats	15 - 22	22	-	22
Cargo	18 - 27	**22**	-	**18 (4.44 hours)**

Table 4.2: Vessel, speed, travel time and case [6]

4. My Approach to Decommissioning Offshore Wind Farm

Vessel	Fuel Consumptions ranges (litres/h) for Diesel	Port to Site	On Site	Site to Port	Total Fuel Consumptions for Diesel
Survey	200 - 300	250	200	250	
SPIVs	200 - 300	**250**	200	**300**	
Dive support	300 - 500	400	300	400	
Crew boat	100 - 200	150	100	`150	
Work boat	200 -400	300	200	300	
Multicats/ Tugs	300 -500	400	300	400	
Cargo	500 - 1000	**700**	500	**1000**	

Table 4.3: Vessel, Fuel Consumptions and case [6]

4. My Approach to Decommissioning Offshore Wind Farm

Case: Take to Wake

Fuel	Carbon Factor (gCo2/g Fuel)	Cost Energy [USD/kWh]	Energy Content (kWh/litres)
HFO	3.114	0.043432836	9.6
Diesel	3.206	0.06618267	10
MGO	3.206	0.066	9.8
LNG	2.750	0.0423	9
Methanol	1.375	0.055175879	6
Ammonia	0	0.123870968	4.5
Electricity	0	-	-

Table 4.4: Fuel types, carbon factor and cost [7]

5. Fuel Usage, CO2 Emissions, and Cost Analysis for Ships

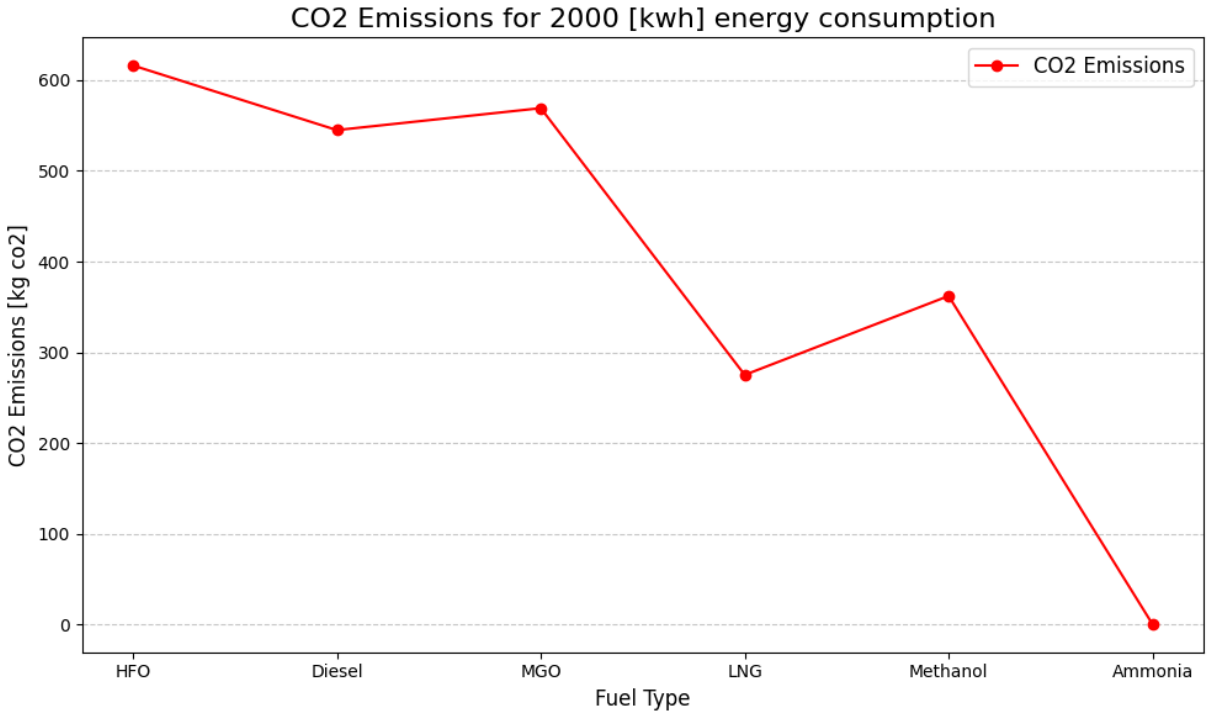


Figure 6.1: Energy Consumption Vs Co2 Emission [own drawing]

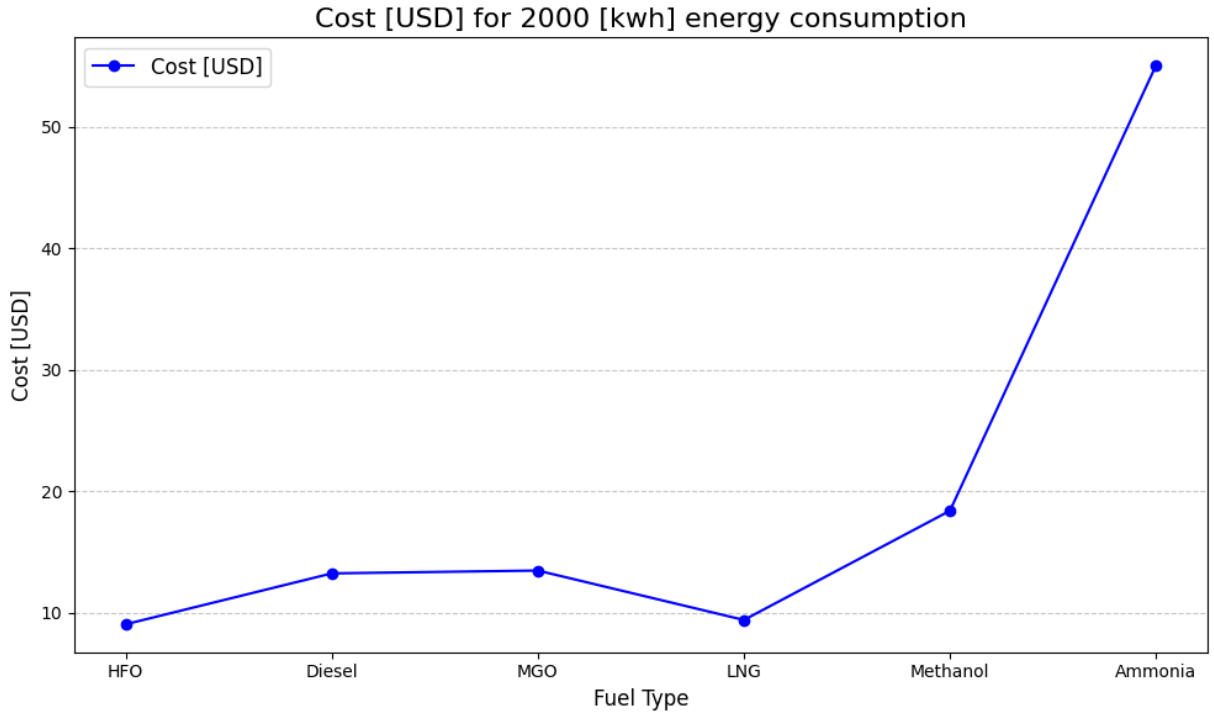
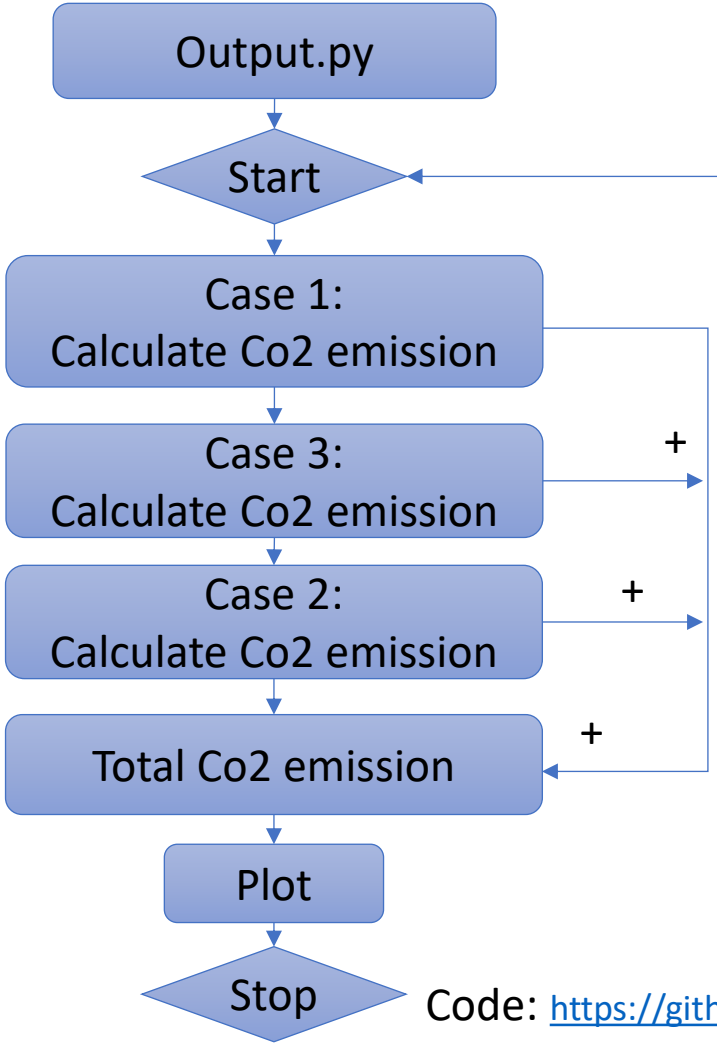


Figure 6.2: Energy Consumption Vs Cost [own drawing]

6. Flowchart of the code

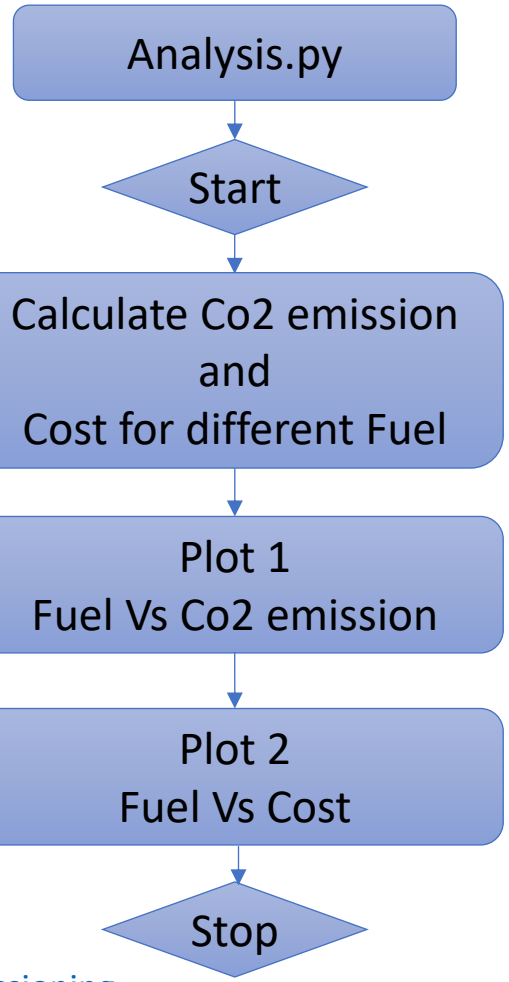


Variable_Parameter.py

Case 1:
- Consuming Fuel
- Travelling time
- Co2 Emission factor
- Fuel density
- Energy content
- Energy Cost

Case 3:
- Consuming Fuel
- Travelling time

Case 2:
- Consuming Fuel
- Working time per day
- Decommissioning wind turbine days
- No of Wind turbine



Code: https://github.com/KSoni1505/Fraunhofer_IWES_Interview_Task_Offshore-Decommissioning

6. Flowchart of the code

Fuel Usage, CO2 Emissions, and Cost Analysis for Ships :

Co_2 Emission = Amount of fuel [litres] * Density [g /litres] * Co_2 Emission factor [g Co_2 /g Fuel]

Fuel Cost [USD]= Amount of fuel [litres] * Energy content [kwh/litres] * Energy costs[USD/kwh]

Case 1 and Case 3:

$$Co_2\ Emission[kgCo_2] = \frac{Vessel\ Fuel\ consumption\ [\frac{liters}{hour}] * \text{Travelling times [h]} * \text{Density } [\frac{gram}{liters}] * Co_2\ Emission\ \text{Factor } [\frac{gCo2}{g\ fuel}]}{1000}$$

Case 2:

$$Co_2\ Emission[kgCo_2] = \frac{Vessel\ Fuel\ consumption\ [\frac{liters}{hour}] * \text{working times [hours]} * \text{Decomissoning wind turbine days } [\frac{days}{wind\ turbine}] * \text{Density } [\frac{gram}{liters}] * \text{No of Wind turbine } * Co_2\ Emission\ \text{Factor } [\frac{gCo2}{g\ fuel}]}{1000}$$

7. Results

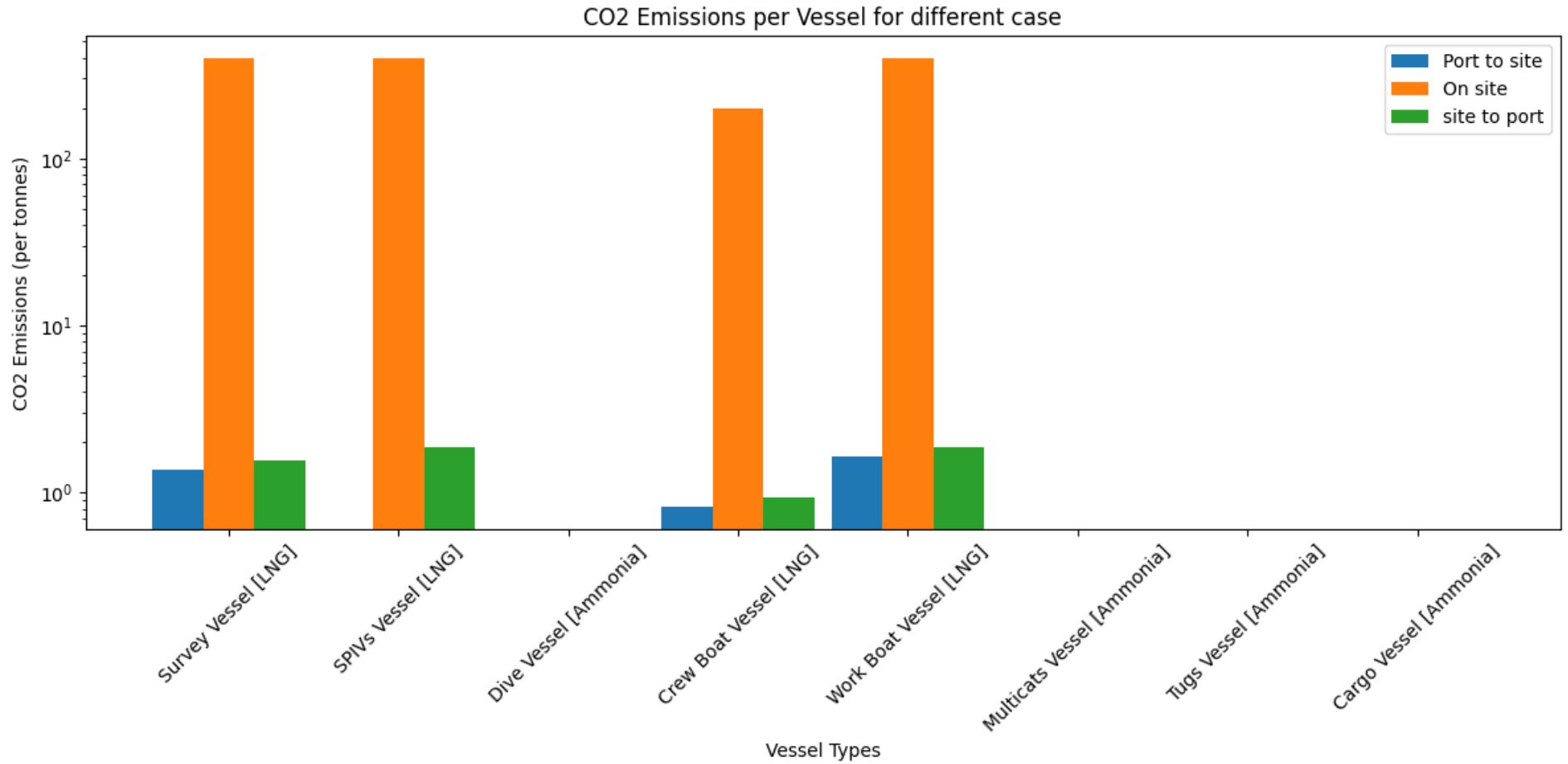


Figure 7.1: Vessel Types Vs Co2 emissions for different case [own drawing]

```
CASE 1: Co2 Emission
CO2 Emission of Survey Vessel: 1375.0000 kg CO2
CO2 Emission of SPIVs Vessel: 0.0000 kg CO2
CO2 Emission of Dive Vessel: 0.0000 kg CO2
CO2 Emission of Crew boat Vessel: 825.0000 kg CO2
CO2 Emission of work boat Vessel: 1650.0000 kg CO2
CO2 Emission of multicats Vessel: 0.0000 kg CO2
CO2 Emission of tugs Vessel: 0.0000 kg CO2
CO2 Emission of cargo Vessel: 0.0000 kg CO2
Total CO2 Emission in Case 1 : 3850.0000 kg CO2
```

```
Case 2: Co2 Emission
CO2 Emission of Survey Vessel: 396000.0000 kg CO2
CO2 Emission of SPIVs Vessel: 396000.0000 kg CO2
CO2 Emission of Dive Vessel: 0.0000 kg CO2
CO2 Emission of Crew boat Vessel: 198000.0000 kg CO2
CO2 Emission of work boat Vessel: 396000.0000 kg CO2
CO2 Emission of multicats Vessel: 0.0000 kg CO2
CO2 Emission of tugs Vessel: 0.0000 kg CO2
CO2 Emission of cargo Vessel: 0.0000 kg CO2
Total CO2 Emission in Case 2 : 1386000.0000 kg CO2
```

```
Case 3: Co2 Emission
CO2 Emission of Survey Vessel: 1546.8750 kg CO2
CO2 Emission of SPIVs Vessel: 1856.2500 kg CO2
CO2 Emission of Dive Vessel: 0.0000 kg CO2
CO2 Emission of Crew boat Vessel: 928.1250 kg CO2
CO2 Emission of work boat Vessel: 1856.2500 kg CO2
CO2 Emission of multicats Vessel: 0.0000 kg CO2
CO2 Emission of tugs Vessel: 0.0000 kg CO2
CO2 Emission of cargo Vessel: 0.0000 kg CO2
Total CO2 Emission in Case 3 : 6187.5000 kg CO2
```

```
Total CO2 Emission: 1396037.5000 kg CO2

Total CO2 Emission: 1396.0375 tonnes CO2
```

Figure 7.2: Script output [own Script]

7. References

[1] Clara Ruiz,25.01.2019. “Decommissioning of offshore Wind turbine” Escola de Camins. TFG_Decommissioning_Clara Ruiz.pdf, 15.11.2024.
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[7] Briefing, March,2021. https://theicct.org/wp-content/uploads/2021/06/Well-to-wake-co2-mar2021-2.pdf 15.11.2024.