*International Symposium on*
*Life Cycle Assessment and Construction*

*LCA case studies and methods for infrastructures*

# Using Life Cycle Assessment to compare Wind Energy Infrastructures

By

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# INTRODUCTION

- Background
- Objective
- Methodology
- Results
- Conclusions
- Future work

Source: Washington Post 1922

# BACKGROUND

- EU 20-20-20
    - 40% of energy from renewable sources by 2020

•Electricity more economically & environmentally friendly

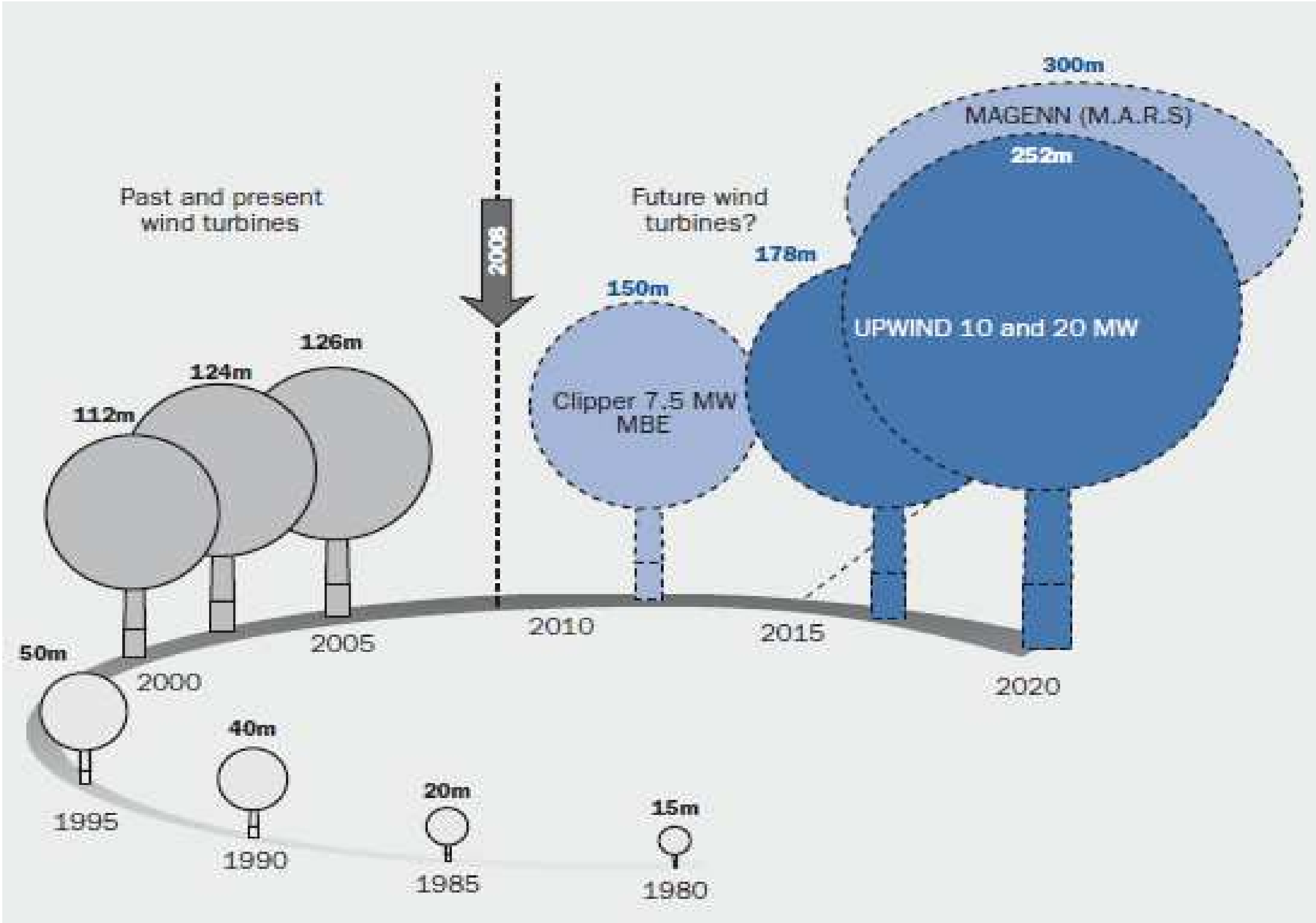
•Larger wind turbines 7 – 10MW

•Wind Turbine Towers (WTTs) need to become:
- Taller, stronger & stiffer

•Steel towers become unmanageable

•Issues with steel towers beyond 85m in height

# BACKGROUND




Source: EWEA 2009

# OBJECTIVE

- Concrete WTTs vs. Steel WTTs
  - Environmental viewpoint in terms of life cycle greenhouse gas emissions (tCO2-e)

- Identify a tower solution

vs.

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# METHODOLOGY

- Emissions life cycle assessment

- Hybrid analysis incorporating process & Input-Output (I-O)

| Property | Onshore | | Offshore | |
|---|---|---|---|---|
| Height (m) | 96.55 | 96.55 | 126.5 | 126.5 |
| Top diameter (m) | 3.5 | 3 | 3.4 | 3 |
| Top thickness (m) | 0.01 | 0.4 | 0.02 | 0.4 |
| Base diameter (m) | 4.5 | 8.2 | 5.1 | 8 |
| Base thickness (m) | 0.02 | 0.6 | 0.06 | 0.6 |
| Tower material | steel | concrete | steel | concrete |
| Density (kg/m3) | 7,850 | 2,400 | 7,850 | 2,400 |
| Tower mass (kg) | 142,000 | 1,856,000 | 625,000 | 2,146,000 |
| Wind turbine rating (MW) | 2 | 2 | 3.6 | 3.6 |
| Wind turbine mass (kg) | 80,000 | 80,000 | 1,364,000 | 1,364,000 |
| Location | Castledockrell, Co.Wexford, Ireland | Castledockrell, Co.Wexford, Ireland | Arklow Bank, Co.Wicklow, Ireland | Arklow Bank, Co.Wicklow, Ireland |

# METHODOLOGY

- Lifetime
  - Wind turbines and steel tower 20 years
  - Offshore transformer, cables and concrete tower 40 years
  - Wind turbines and steel tower re-fit at year 20

- Process data from Inventory of Carbon and Energy (ICE)

- I-O data from sector emission intensities table for Ireland derived by DIT student

- System boundary - Cradle to Grave

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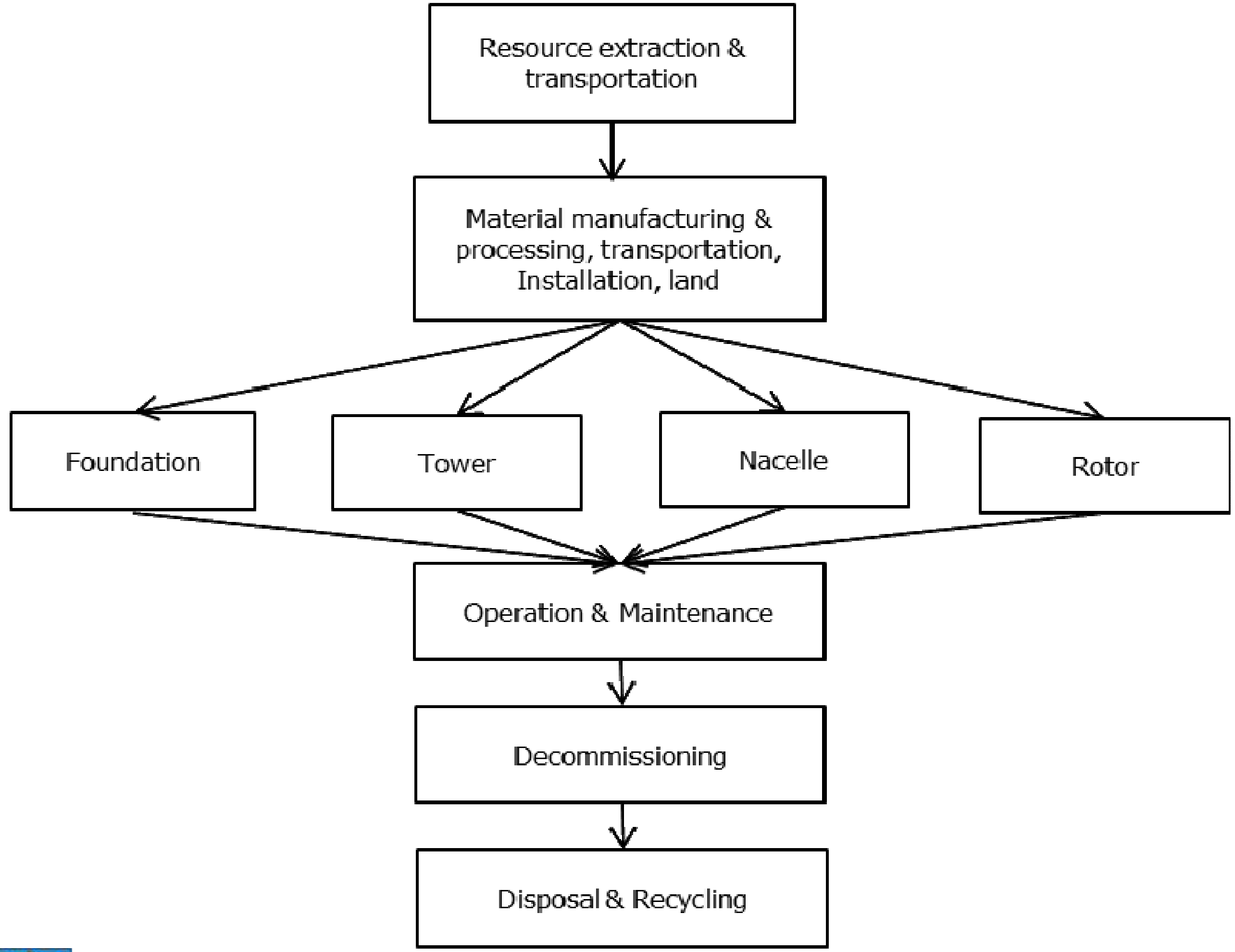
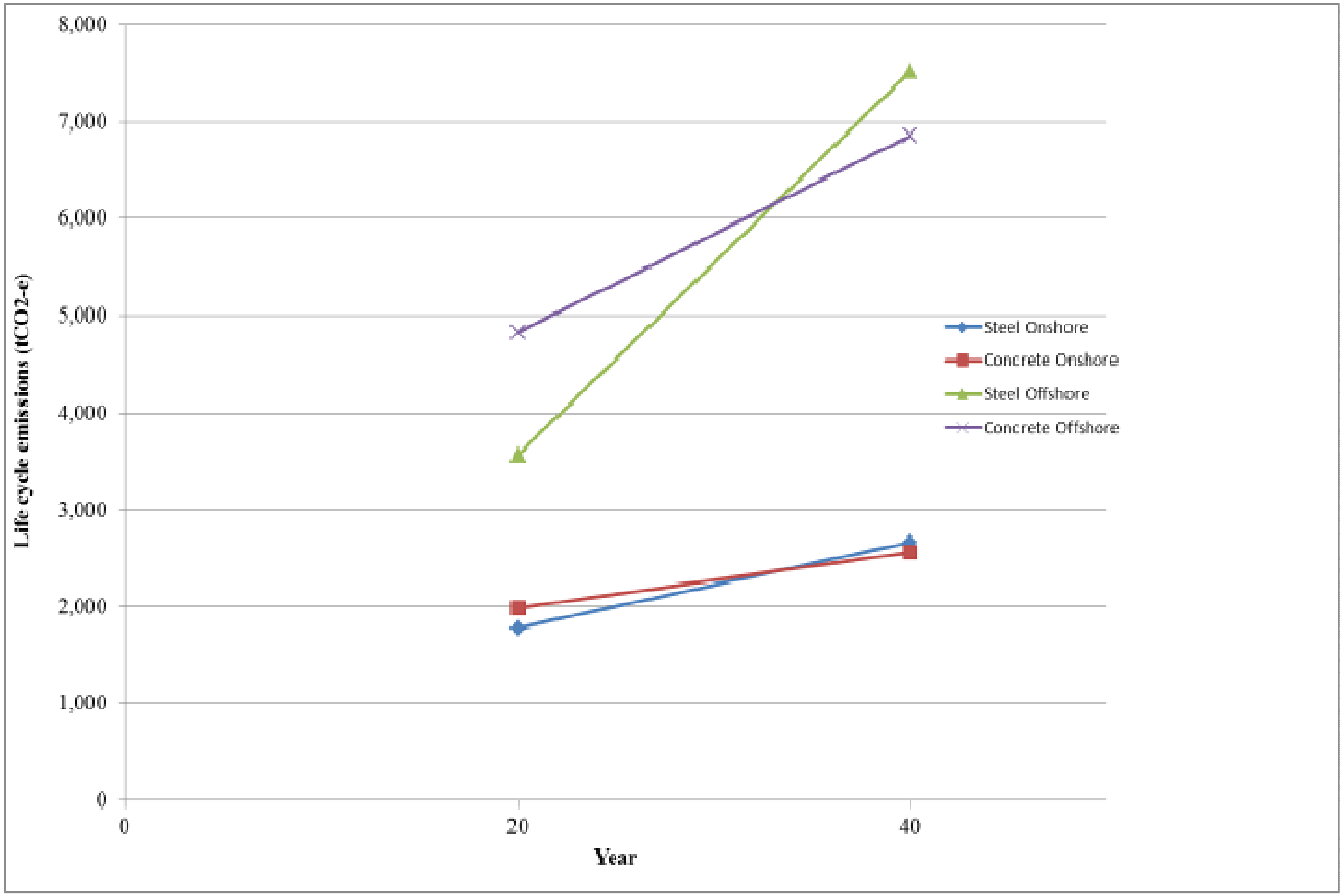
# METHODOLOGY



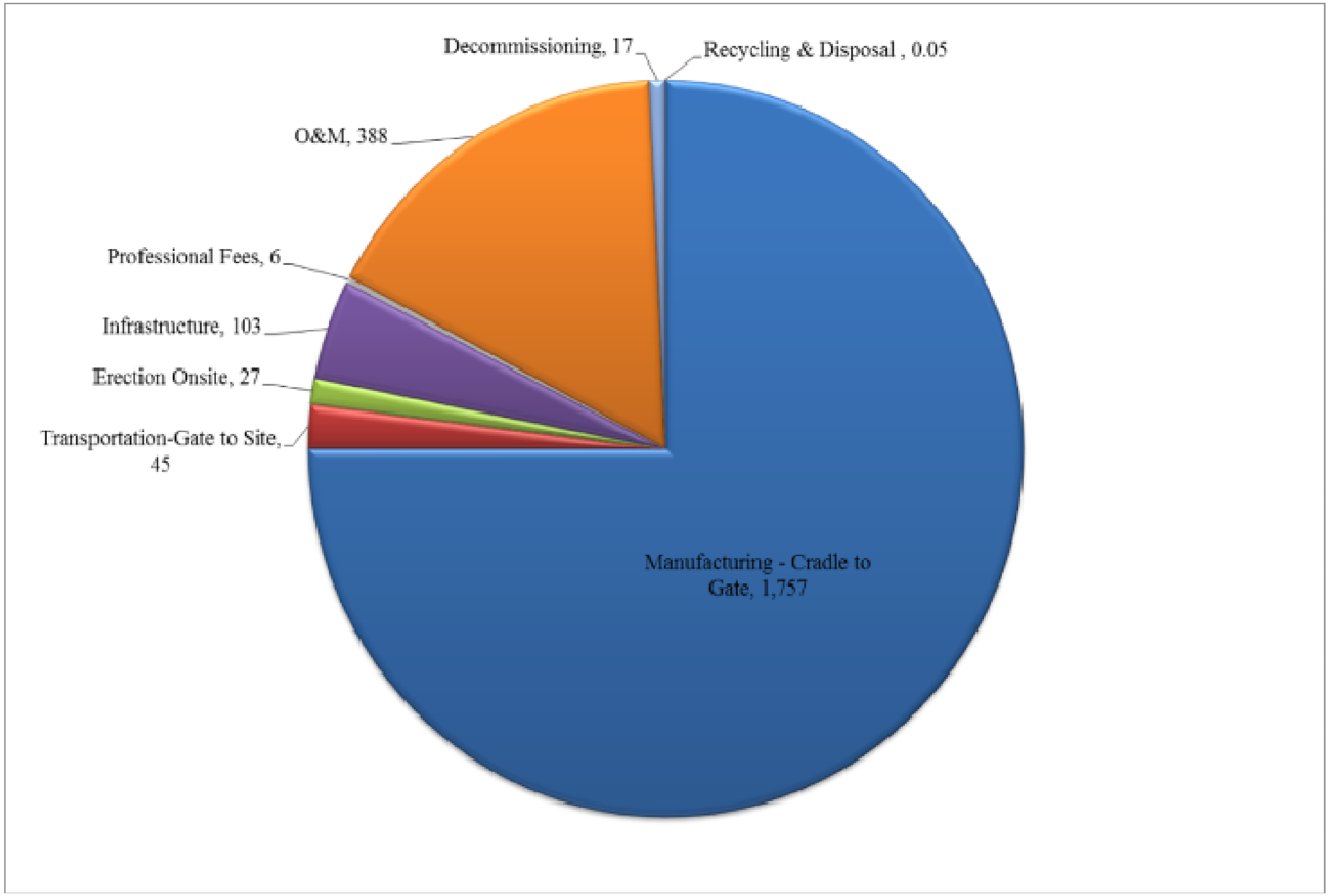
# RESULTS

Life cycle emissions for onshore and offshore WTTs



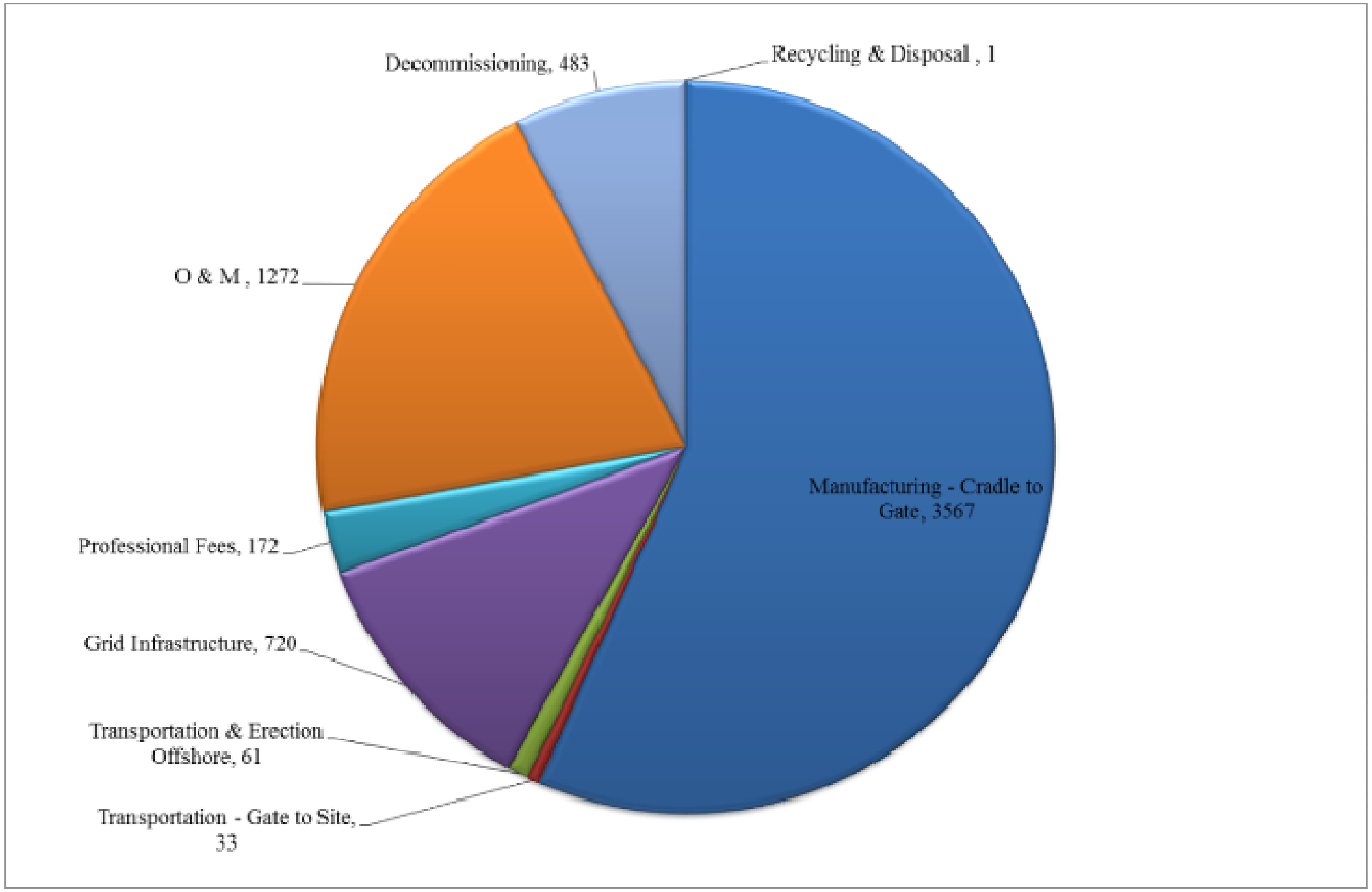
# RESULTS

Life cycle greenhouse gas emissions share for onshore concrete WTT



# RESULTS

Life cycle greenhouse gas emissions share for offshore concrete WTT



# RESULTS

Effect of % of GGBS addition on concrete WTT LCE at year 20

| WTT type | WTT height (m) | GGBS (%) | LCE ($tCO_{2}$-e) | LCE % decrease |
|---|---|---|---|---|
| Onshore | 96.55 | 0 (using CEM 1) | 1,984 | 0% |
| Onshore | 96.55 | 50 | 1,805 | 9% |
| Onshore | 96.55 | 70 | 1,706 | 14% |
| Offshore | 126.5 | 0 (using CEM 1) | 4,829 | 0% |
| Offshore | 126.5 | 50 | 4,394 | 9% |
| Offshore | 126.5 | 70 | 4,249 | 12% |

# CONCLUSIONS

- At year 40, LCE are 4% and 9% lower for concrete WTTs for both onshore and offshore facilities respectively
- Reduction in LCE and increase in durability with GGBS
- Concrete WTTs provide an alternative to steel WTTs for larger wind turbines
- Reduction of LCE = reduction in energy consumption and materials = reduction of costs
- Investigate the LCE of wind farm developments to win the argument that wind energy is the way forward

# FUTURE WORK

- In discussions with an offshore wind developer
- Determine the LCE of their concrete foundation solution
- Develop a life cycle multi-objective optimisation model for wind energy coupled with energy storage
- Determine the marginal abatement cost (€/t$CO_2$-e) associated with wind/storage system

# QUESTIONS

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