

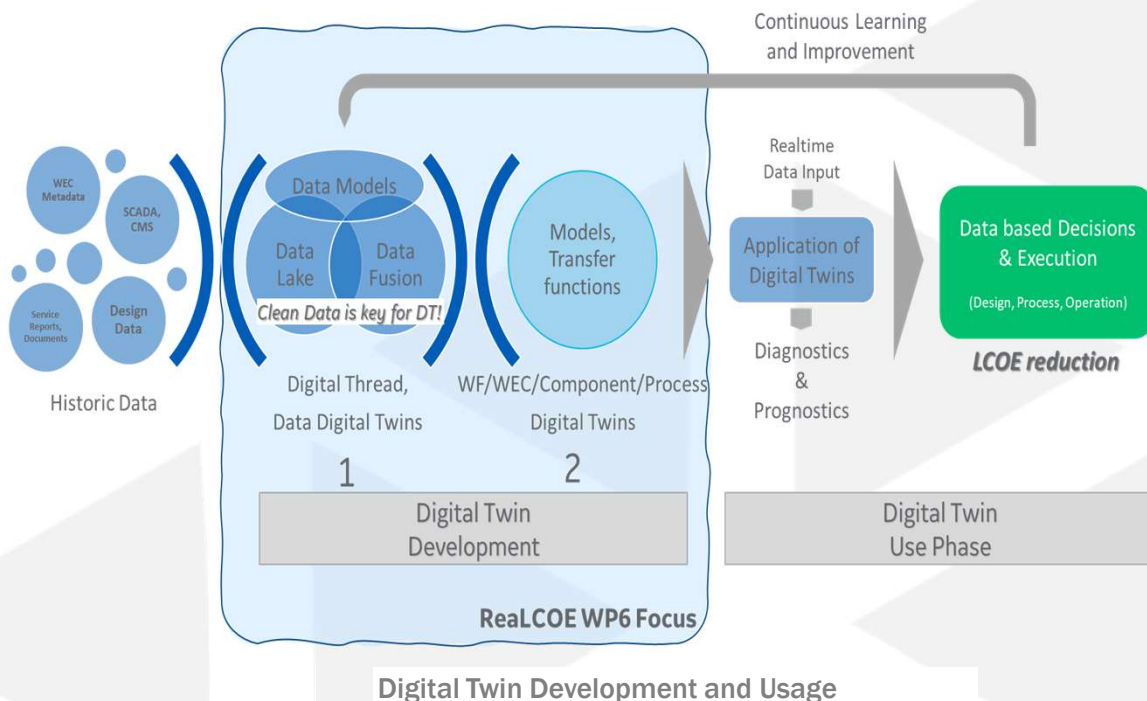
Semantic Interoperability and Integrated Data Models for Next-Generation Wind Turbine Digital Twin

Motivation and Approach

Unplanned failures and inefficient maintenance could represent major cost drivers in wind energy, especially offshore, where fragmented data and heterogeneous IT systems would hinder systematic use of operational and condition monitoring information. As a result, maintenance becomes conservative, causing unnecessary downtime, higher OPEX, and increased risk of major component failures. In this work package (WP6), the project addresses these challenges by establishing the foundations for holistic Condition Monitoring Systems (CMS) and Digital Twin applications, enabling cross-lifecycle data integration and standardized information models to support data-driven maintenance decisions. Following a use-case-driven, standards-based approach, potential CMS and Digital Twin scenarios were identified across the wind turbine lifecycle (design, manufacturing, installation, operation, and maintenance) and prioritised based on cost, risk, and feasibility impact.

Results

Functional and data requirements were defined for priority scenarios, and existing IT systems were analysed to identify gaps in data availability and interoperability. An Industry 4.0-aligned framework and data model was developed to support structured, data-driven maintenance strategies that reduce downtime, risk, and energy costs. Two high-impact use cases, big component replacement and condition-based maintenance, were selected for implementation and validation, laying the foundation for scalable Digital Twin applications that extend asset lifetime, optimise performance, and lower the levelised cost of energy (LCoE). In the subsequent task, building on this foundation, an ontology-based information model was used as middleware for interoperable Digital Twins, integrating product, SCADA, and component data into a meta-ontology based on ISO 15926-12 to enable efficient metadata management and further advance the holistic CMS approach and Digital Twin scenarios.



ReaLCoE's vision is to unleash the full potential of offshore wind energy
 €35/MWh LCoE Goal, +12MW WEC Capacity, ~32 mio € Total Budget, 42 month project duration



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