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Maturity of Circular Economy Practices in Offshore Wind Industry

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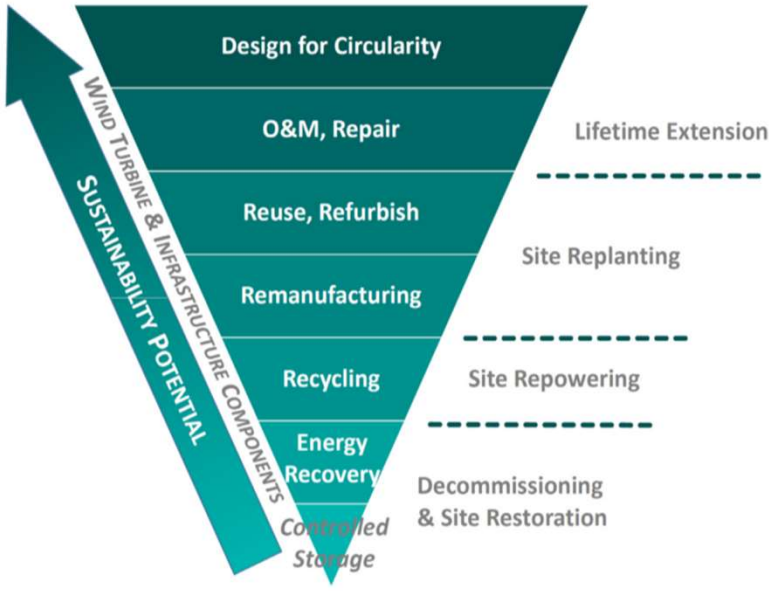
Background

- Unprecedented growth of Offshore Wind Energy (OWE)
- First generation offshore wind farms are approaching end of their expected lifespan
- Decommissioning is the default EOL, but seldomly carefully designed
- Circular Economy (CE) can be used as a solution
- CE offers economic, environmental, social benefits and several market opportunities (Spyroudi, 2021, Fonte et al. 2021)
- Theoretical Problem: Academic literature on CE in context of OWE is quite limited
- Practical Problem: Theoretical (85-90%) and actual recycling rates are different, underdeveloped sustainable waste management technologies.
- Research Question: What does the current research says about maturity of circular economy practices in the offshore wind industry?

Theory

- Ban or restricted use on landfill and energy recovery methods (Topham et al. 2019, Krauklis et al. 2021)
- Need to look for sustainable ways of managing resource use and waste generated
- Need to move to higher levels of waste management hierarchy (Jensen et al. 2020 & Velenturf, 2021)



This is where we need to be. The higher, the better!

This is where we are

Figure 1. Waste management hierarchy for wind farm components (source: Jensen et al., 2020)

Methodology

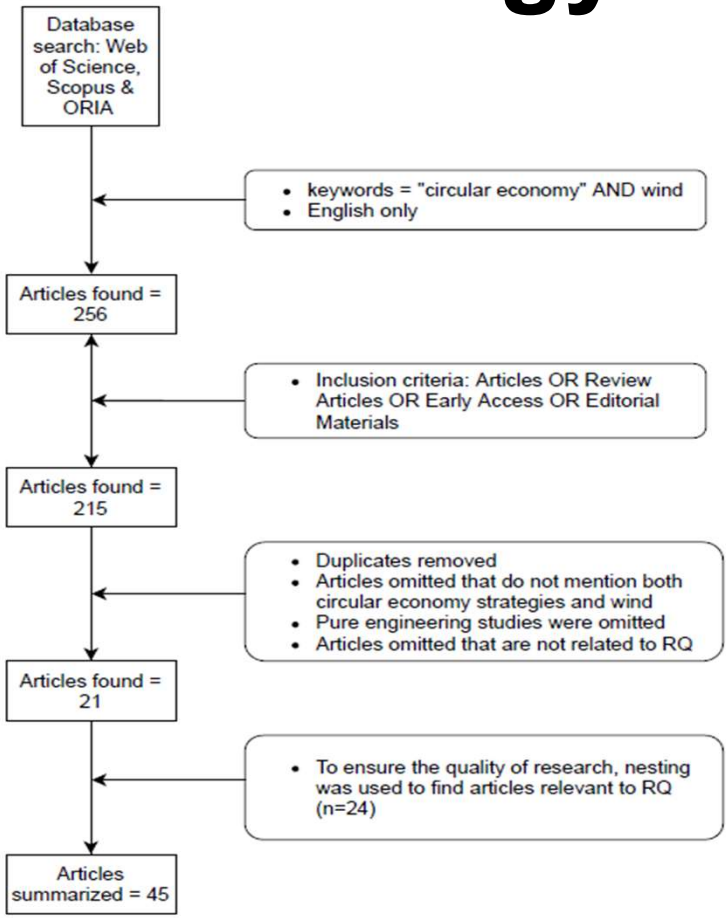
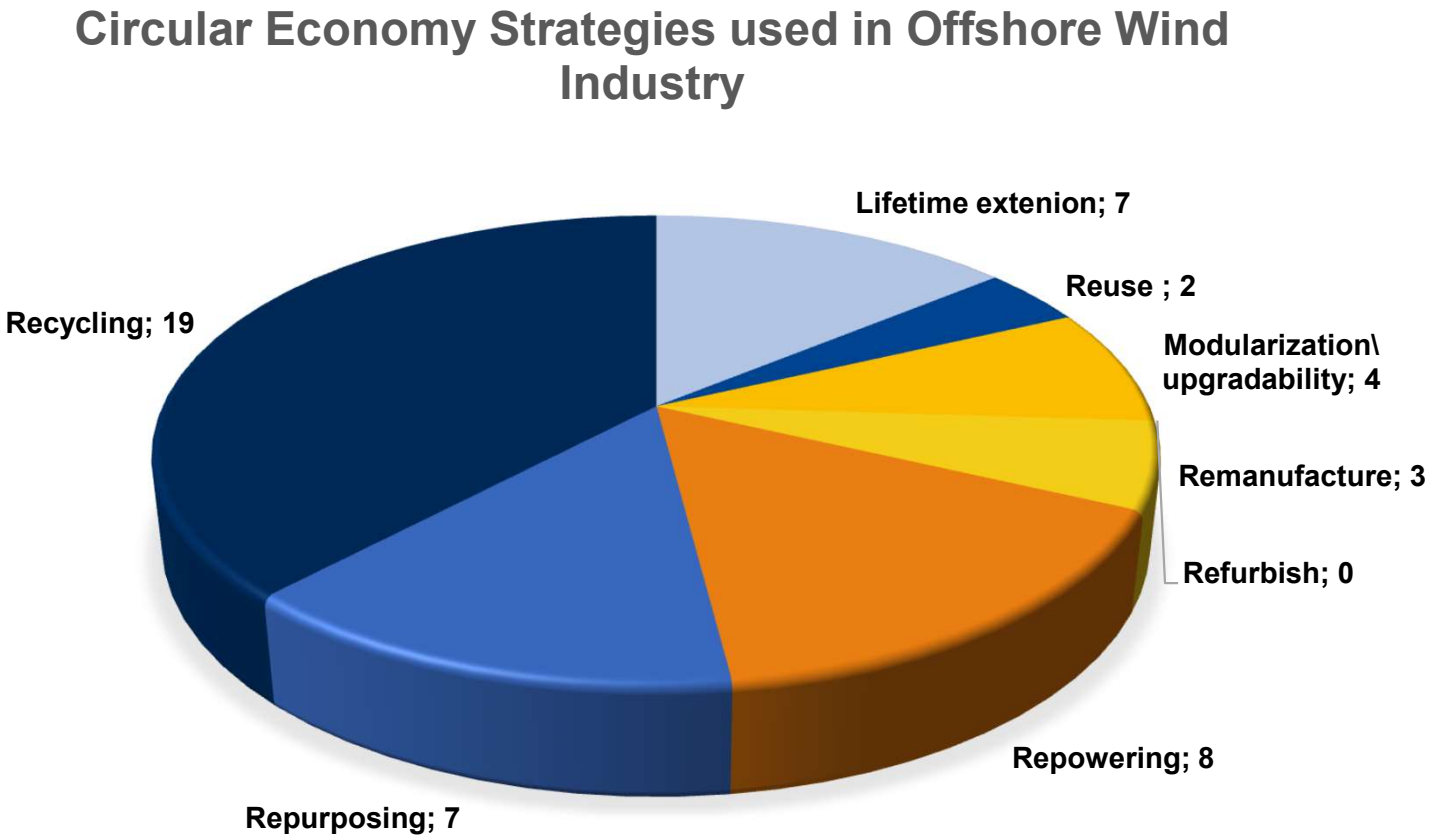


Figure 1. Systematic literature review illustration

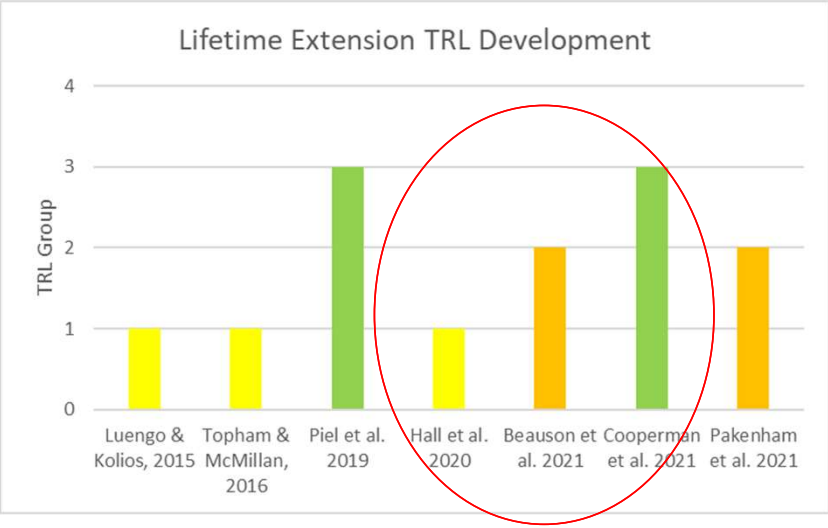
- Technology Readiness Level (source: Grow, ND)

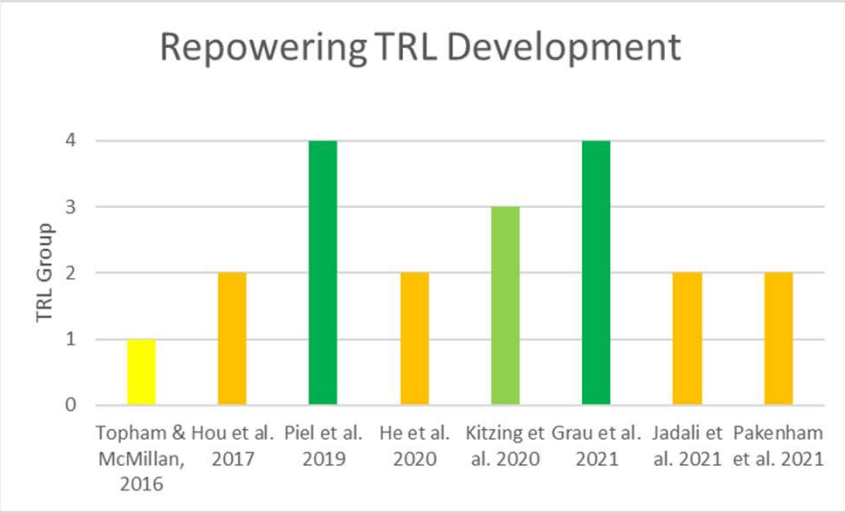
Criteria & TRL Group	TRL	Principle
Research (1)	1	Basic Principles Observed
	2	Technology concept formulated
	3	Experimental proof of concept
Technical Development (2)	4	Technology validated in lab
	5	Technology validated in relevant environment
	6	Technology demonstrated in relevant environment
Demonstration (3)	7	System prototype demonstration in operational environment
	8	System complete and qualified
Deployment (4)	9	Actual system proven in operational environment

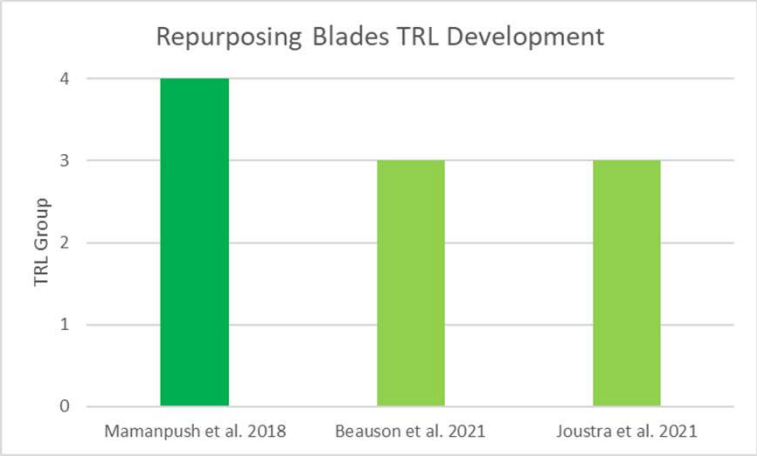
Results – wide variation in research of CE strategies

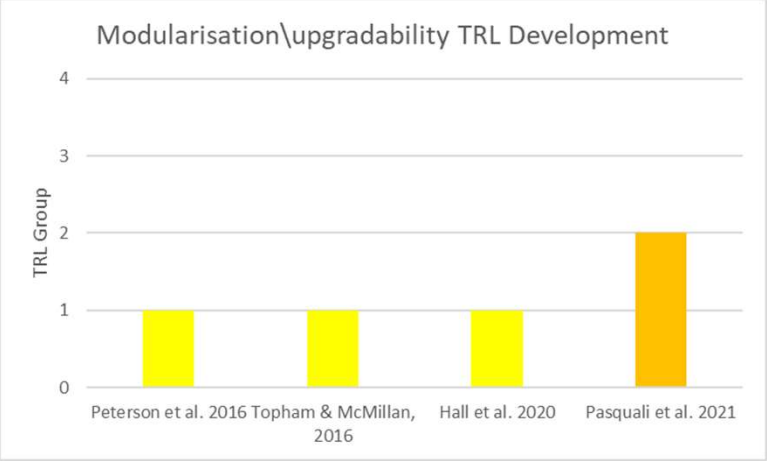


Wide variation in TRL development of CE strategies

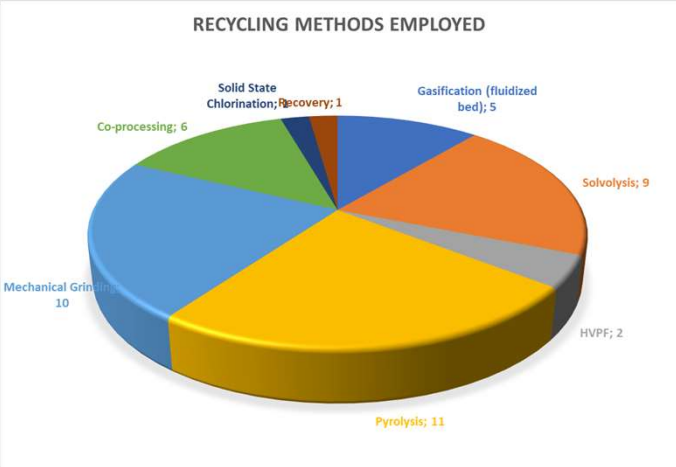


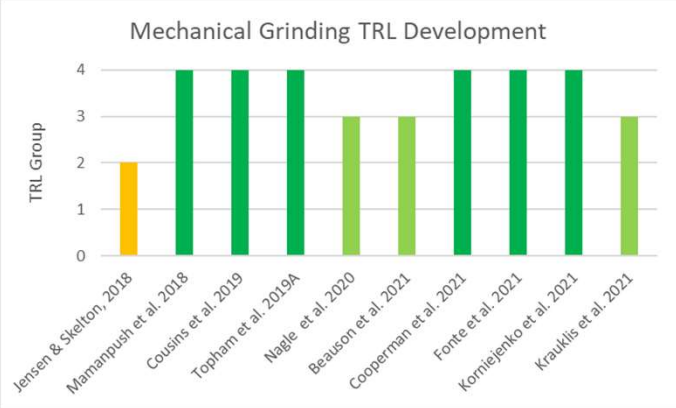


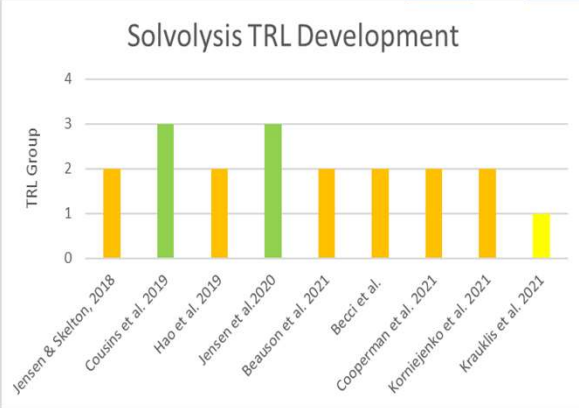


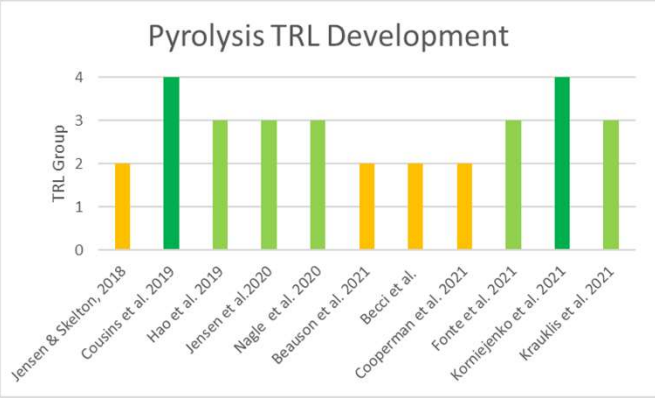


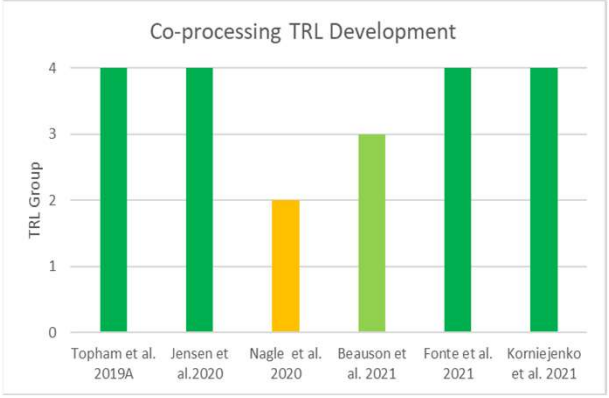
Wide variation in TRL development of recycling

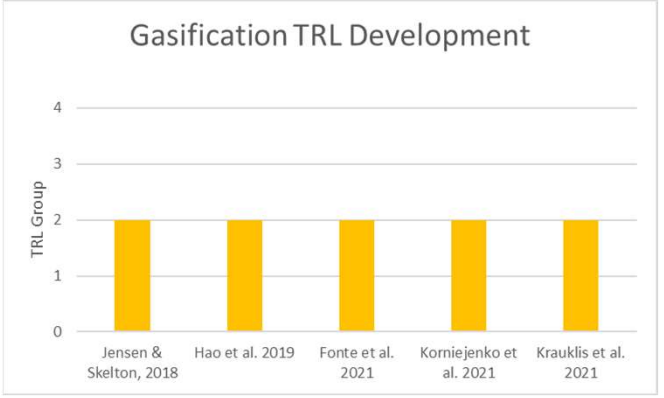






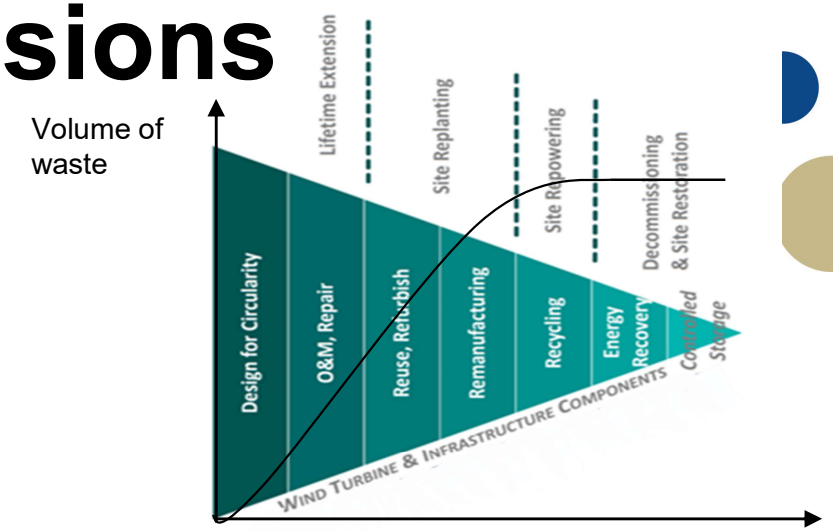




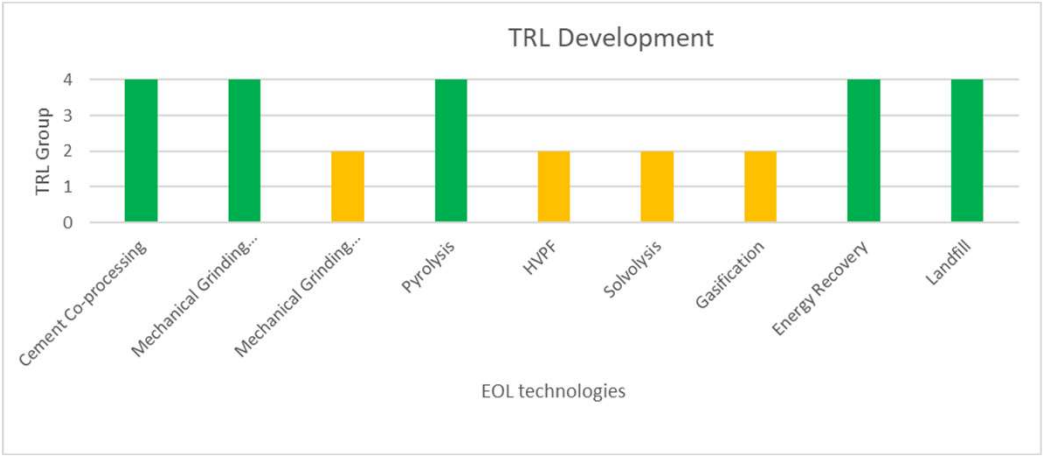


Findings and Discussions

- No one size fits all – highly site specific EOL solutions (Topham & McMillan, 2017, Jensen & Skelton, 2018, Piel et al. 2019, Packenham et al. 2021)
- Recycling is most researched strategy, despite its low priority
- Inverse correlation between volume of waste generated and waste management hierarchy
- Underdeveloped CE strategies (Velenturf, 2021)
- TRL claimed by industry are different than our findings
- TRL is region-specific and is affected by logistical, regulatory and geopolitcial issues



Waste management strategies



TRL levels claimed by wind industry (adapted from ETIPWind, 2020)

Conclusion

- More emphasis should be placed on higher levels of waste management hierarchy
- Important to consider CE strategies in early design stage
- TRL should not be used as sole means to justify technology development and its applicabilty
- Need of cross-border trade-off of information, along with setting proper standards, regulations and guidelines for EOL of future wind farms

References

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- Spyroudi, A. (2021). End-of-life planning in offshore wind
- Velenturf, A. P. (2021). "A Framework and Baseline for the Integration of a Sustainable Circular Economy in Offshore Wind." Energies 14(17): 5540.

Questions?

Extra slide – not part of main presentation

Criteria	TRL	Principle	Description
Research	1	Basic Principles Observed	This phase is characterised by fundamental research. The basic principles of the technology have been observed and there are assumptions about the working principles of this technology. However, no experimental evidence for this is yet available.
	2	Technology concept formulated	The technological concept and the possible field(s) of application have been formulated.
	3	Experimental proof of concept	The first laboratory tests or analytical studies have been completed with a "proof of concept" as a result.
Technical Development	4	Technology validated in lab	The proof of concept has been validated in a laboratory environment, often using raw (low-fidelity) small-scale prototypes: basic components are integrated to evaluate how they work together.
	5	Technology validated in relevant environment	The technology has been tested and validated in a relevant environment. Functional and refined (high-fidelity) prototypes are often used for this.
	6	Technology demonstrated in relevant environment	The operation of the technology has been demonstrated in a relevant environment. The prototype's performance has not yet been optimised for the operational environment.
Demonstration	7	System prototype demonstration in operational environment	The technology is integrated into the final operational environment. The prototype is (near) an actual operating system. The focus is now on improving production design, certification, et cetera.
	8	System complete and qualified	The technology is performing properly and the latest production problems have been solved.
Deployment	9	Actual system proven in operational environment	The technology is technically and commercially ready. The next steps are production and market introduction.