ENERGY

Dealing with innovation through standards and certification

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Renewables Certification

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Topics

- Technology Diversity and Novelty / Risk & Reliability
- Marine renewables' certification background
- Risk and risk-based Certification
- Elements of the risk-based certification
  - Technology Qualification
  - Standards, Recommended Practices and Rules

Tidal Energy Converters – different technologies

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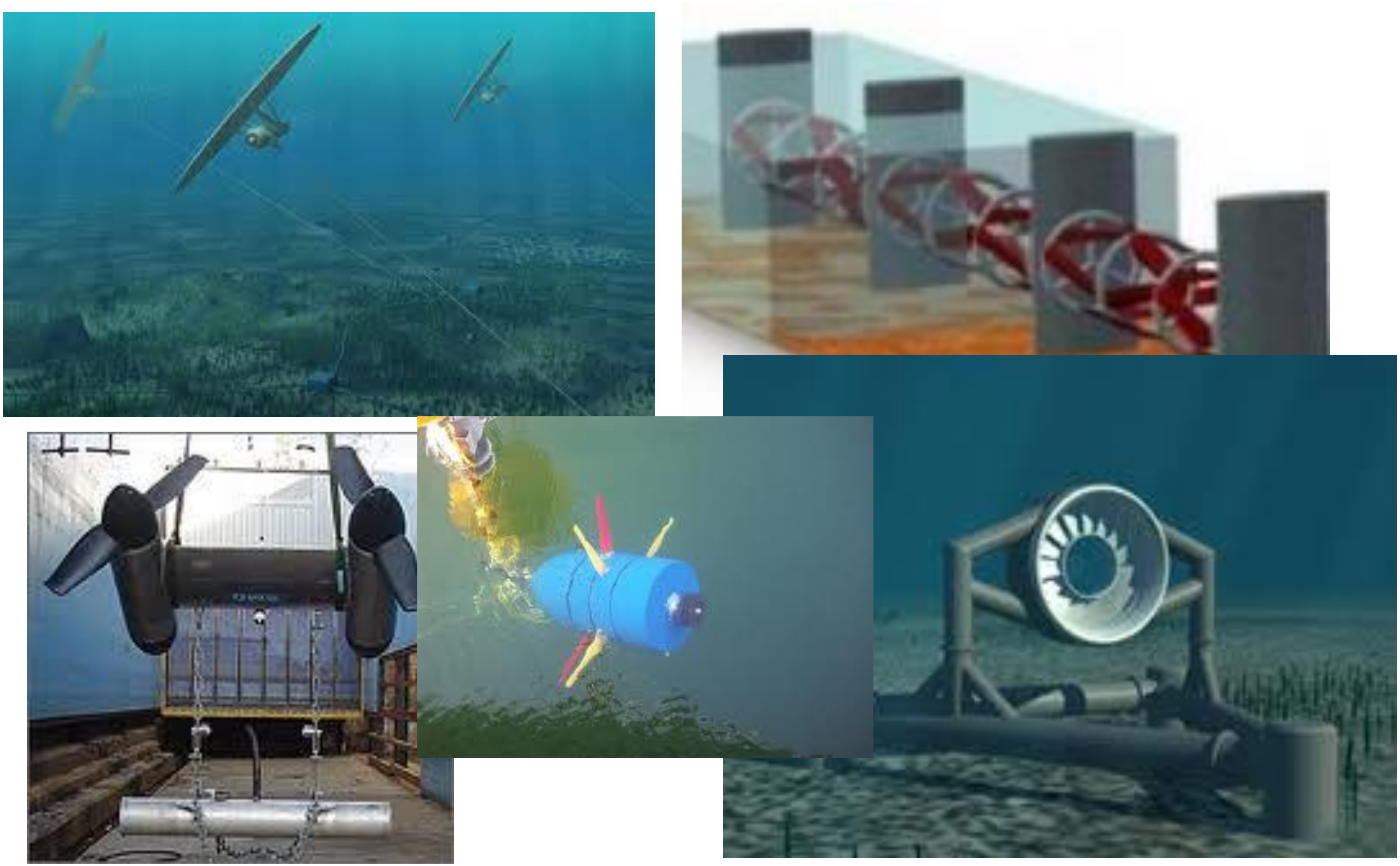


Why Risk Based Certification for Marine Renewables?

Tidal technology has a standard since 2015 (DNVGL-ST-0164 Tidal Turbines) and a certification process defined in DNVGL-SE-0163 Certification of Tidal Turbines and Arrays are risk-based.

- Diversity of technologies and strategies
- How to achieve success varies from technology to technology
- Limited track record and uncertainties
- Better use of resources – focused approach

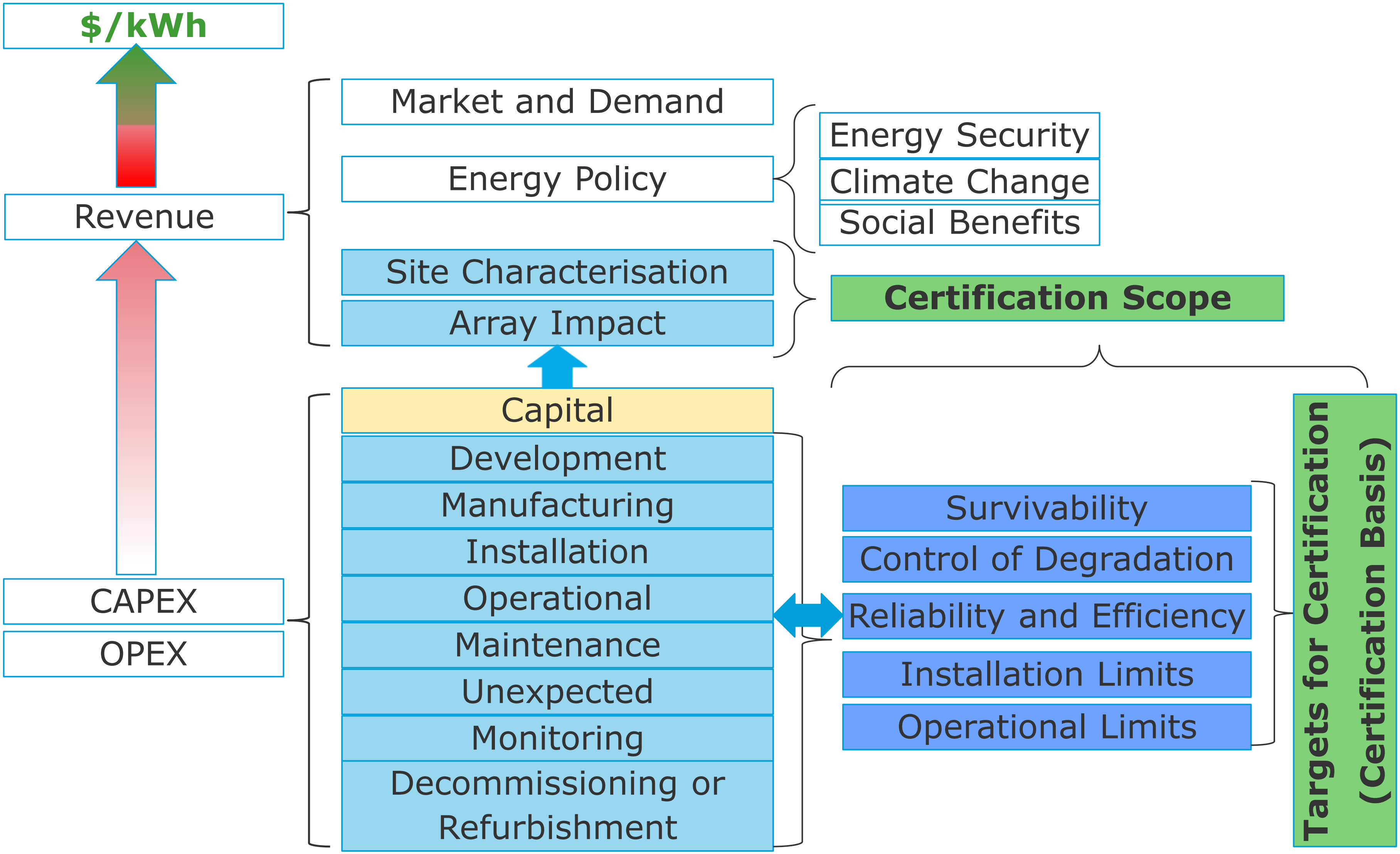
Risk-based approach

The Tidal sector requires a special approach regarding certification.

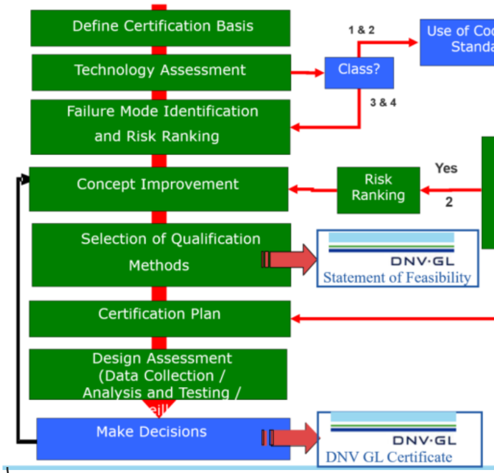
- Certification Key Aspects:
  - Handling of uncertainties, novelty, safety, environment and functional requirements
  - Risk based
  - Gradual process
  - Different success criteria
  - Use of existing technology that is compatible with marine renewables
  - Lifecycle approach

- DNVGL-SE-0163 provides a suitable framework for certification activities
  - Based on **Technology Qualification** process (generic, systematic, demonstrable, risk based and traceability)
  - **Gradual** process linked to natural flow of development
  - Based on targets related to safety, environmental and **functional** requirements
  - Use of **existent knowledge** (codes and standards) addressing most of the likely design requirements
  - **Lifecycle approach**

Certification Connection with Success Criteria



Certification Phases and Communication with Stakeholders

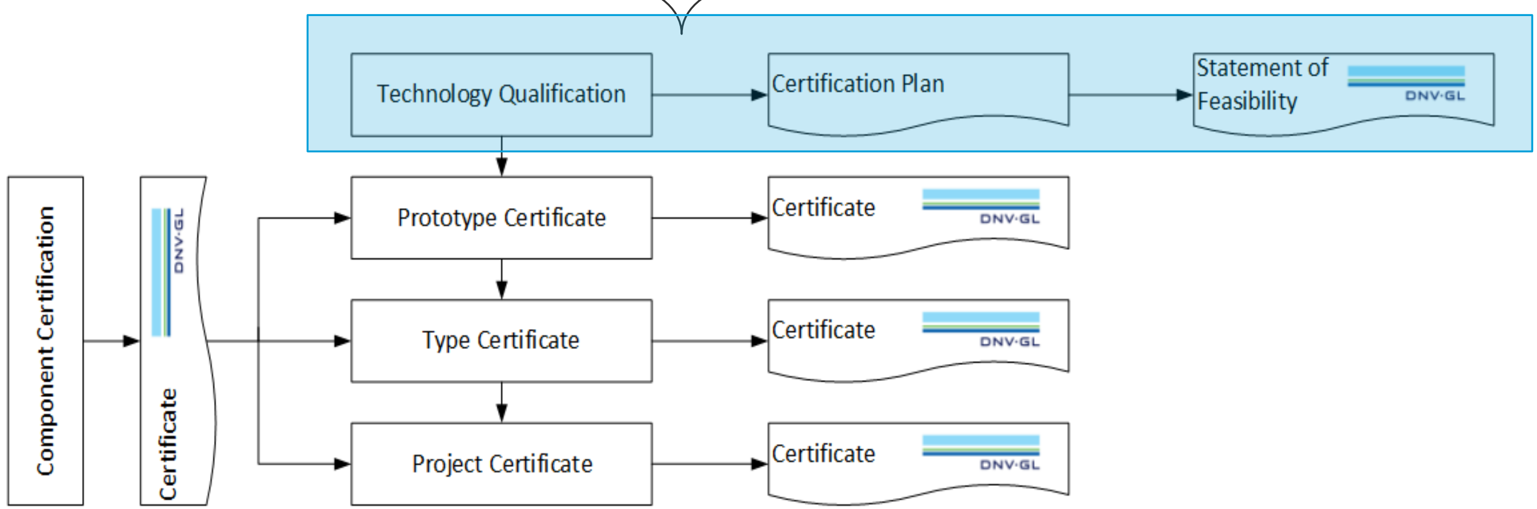


Application area	Technology		
	Proven	Limited field history	New or unproven
Known	1	2	3
New	2	3	4

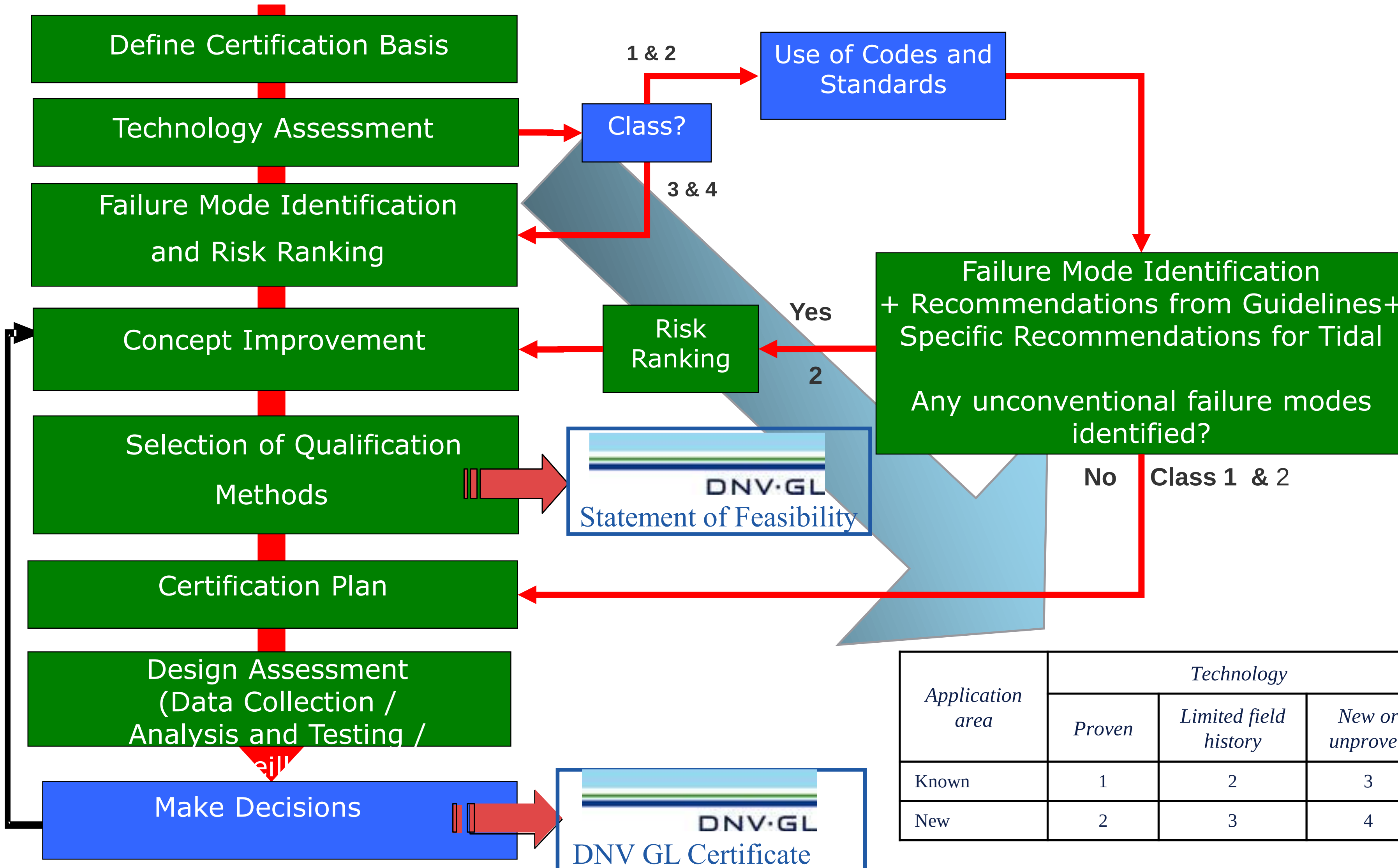
No.	Name	Description	Indicative Annual Failure Rate
1	Very Low	Negligible event frequency	10^{-4}
2	Low	Event unlikely to occur	10^{-3}
3	Medium	Event rarely expected to occur	10^{-2}
4	High	Event expected to occur once or several times during a lifetime	10^{-1}
5	Very High	Event expected to occur once or several times each year	1

Class	Safety	Environment	Operation	Assets	Cost
1	Negligible injury, effect on health	Negligible pollution or no effect on environment	Negligible effect on production	Negligible	1K
2	Minor injuries, health effects	Minor pollution, slight effect on environment	Some small loss of production, less than a month	Significant but repairable	10K
3	Significant injuries and/or health effects	Limited levels of pollution, moderate effect on environment	Loss of production up to 6 months	Localised damage, repairable in-situ	100K
		Moderate pollution with clean-up costs, serious effect on environment	Loss of production for 6 months to 1 year	Loss of main function, significant repair needed by removal of part of device	1million
		Major pollution, disastrous effect on environment	Total loss of production for more than 1 year	Loss of device, major repair needed by removal of device	10 million

PROBABILITY	CONSEQUENCES 1	2	3	4	5
5	Low	Medium	High	High	High
4	Low	Medium	Medium	High	High
3	Low	Low	Medium	Medium	High
2	Low	Low	Low	Medium	Medium
1	Low	Low	Low	Low	Medium



Handling Innovation and Uncertainties (Qualification Process)



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Handling Novelty and Uncertainties (Qualification Process)

Define Certification Basis

Certification Basis

- **Definition of concept**
  - Brief description
  - Definition of boundaries
  - Description of methods for different phases
    - Transportation
    - Installation
    - Operation / Maintenance
    - Retrieval
- **Definition of Operating Conditions**
  - Water depth
  - Metocean conditions
  - Power output
  - Design lifetime
  - Maintenance intervals
  - Installation methods
  - Any other limitations

Handling Novelty and Uncertainties (Qualification Process)

Define Certification Basis

Technology Assessment

Application area	*Technology*		
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Certification Basis

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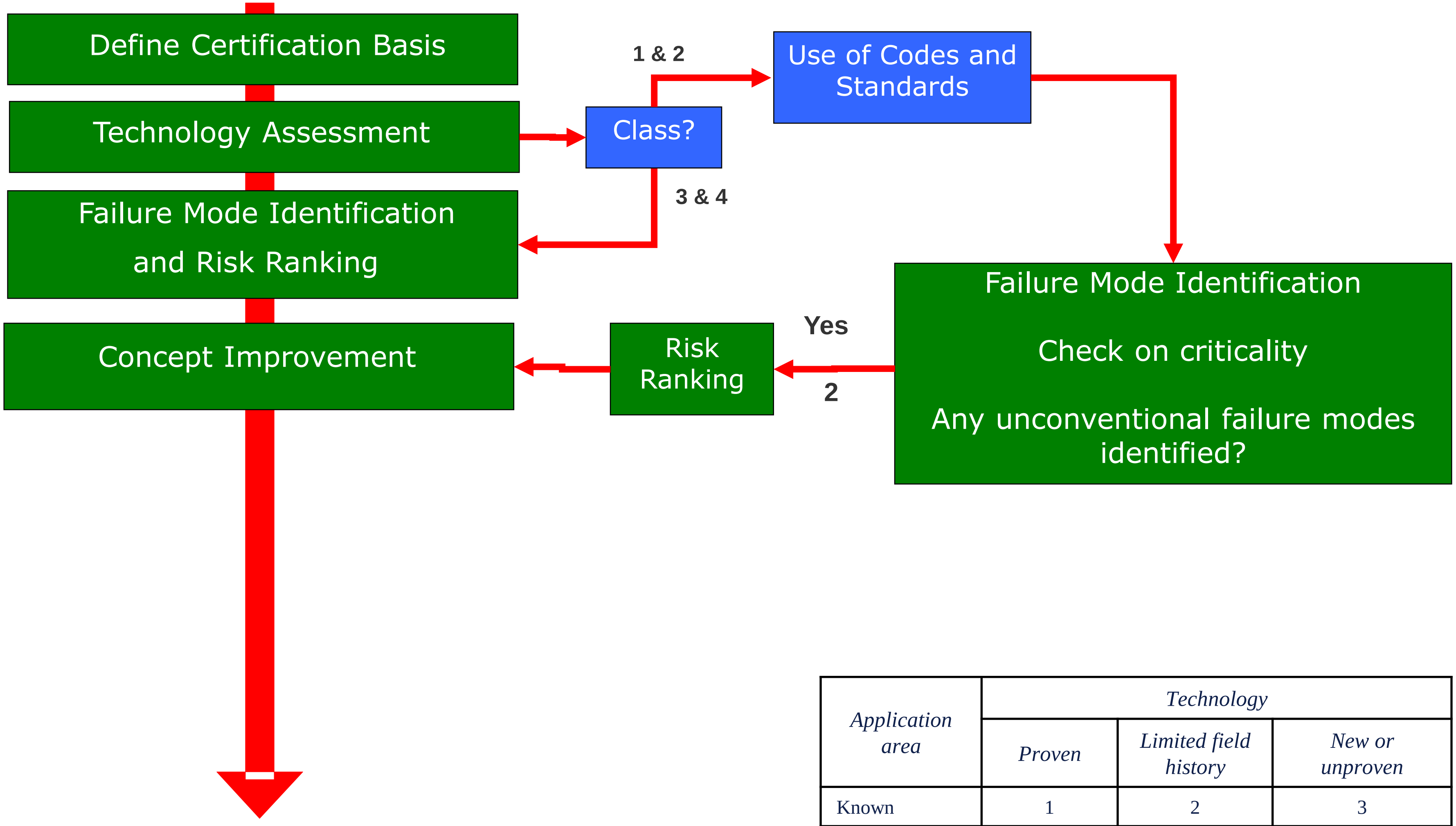

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Risk – Definition of Safety Philosophy

Safety Philosophy

- Risk to life
- Environmental impact (fluid releases, anti-fouling coatings, bilge water)
- Loss of production
- Inspection and maintenance cost, risks during removal of equipment for inspection and maintenance
- Reputation of developer, industry, concept
- Underwriter perception of risks and definition of premium value
- Financial or venture capital communities' perception of risk to the return on investment
- Expected safety level by Authorities

Safety Level Low

Safety Level Normal

Safety Level High

Separate target levels for **Personnel**, **Asset, Production** and **Environmental Safety**.

Failure Mode Identification and Risk Ranking

- **Define Risk Matrix**
  – Set Probability classes
  – Set Consequence classes
  – Set level of risk tolerance
- **Same system breakdown as for Technology Assessment**
- **Level of detail based on technology class:**
  – 1: Identification of criticality of component
  – 2: Investigate failure modes not covered by standards
  – 3: Investigate failure modes not covered by standards (more than class 2)
  – 4: Investigate all possible failure modes
- **Describe consequences of each failure mode**
- **Rank risk for each failure mode**

Risk Matrix – Probability of Failure Classes (DNVGL-SE-0163)

No.	Name	Description	Indicative Annual Failure Rate	Reference
1	Very Low	Negligible event frequency	10^{-4}	Accidental event
2	Low	Event unlikely to occur	10^{-3}	Strength / ULS
3	Medium	Event rarely expected to occur	10^{-2}	Fatigue / FLS
4	High	Event expected to occur once or several times during a lifetime	10^{-1}	Operation low frequency
5	Very High	Event expected to occur once or several times each year	1	Operation high frequency

Risk Matrix – Consequences Classes (device level) (DNVGL-SE-0163)

Class	Safety	Environment	Operation	Assets	Cost
1	Negligible injury, effect on health	Negligible pollution or no effect on environment	Negligible effect on production	Negligible	1K
2	Minor injuries, health effects	Minor pollution, slight effect on environment	Some small loss of production, less than a month	Significant but repairable	10K
3	Significant injuries and/or health effects	Limited levels of pollution, moderate effect on environment	Loss of production up to 6 months	Localised damage, repairable in-situ	100K
4	Serious injuries	Moderate pollution with clean-up costs, serious effect on environment	Loss of production for 6 months to 1 year	Loss of main function, significant repair needed by removal of part of device	1million
5	A fatality	Major pollution, disastrous effect on environment	Total loss of production for more than 1 year	Loss of device, major repair needed by removal of device	10 million

Risk Matrix

		CONSEQUENCES				
		1	2	3	4	5
PROBABILITY	5	Low	Medium	High	High	High
	4	Low	Medium	Medium	High	High
	3	Low	Low	Medium	Medium	High
	2	Low	Low	Low	Medium	Medium
	1	Low	Low	Low	Low	Medium

Failure Mode Identification

The system / technology is broken down to a level of detail that each failure mechanism is understood

Handling of uncertainties

Workshop format (multi-discipline, all phases during life time of device / technology)

The description of failure and its risk ranking will be used to define the qualification method (i.e. what needs to be done to deal with uncertainty)

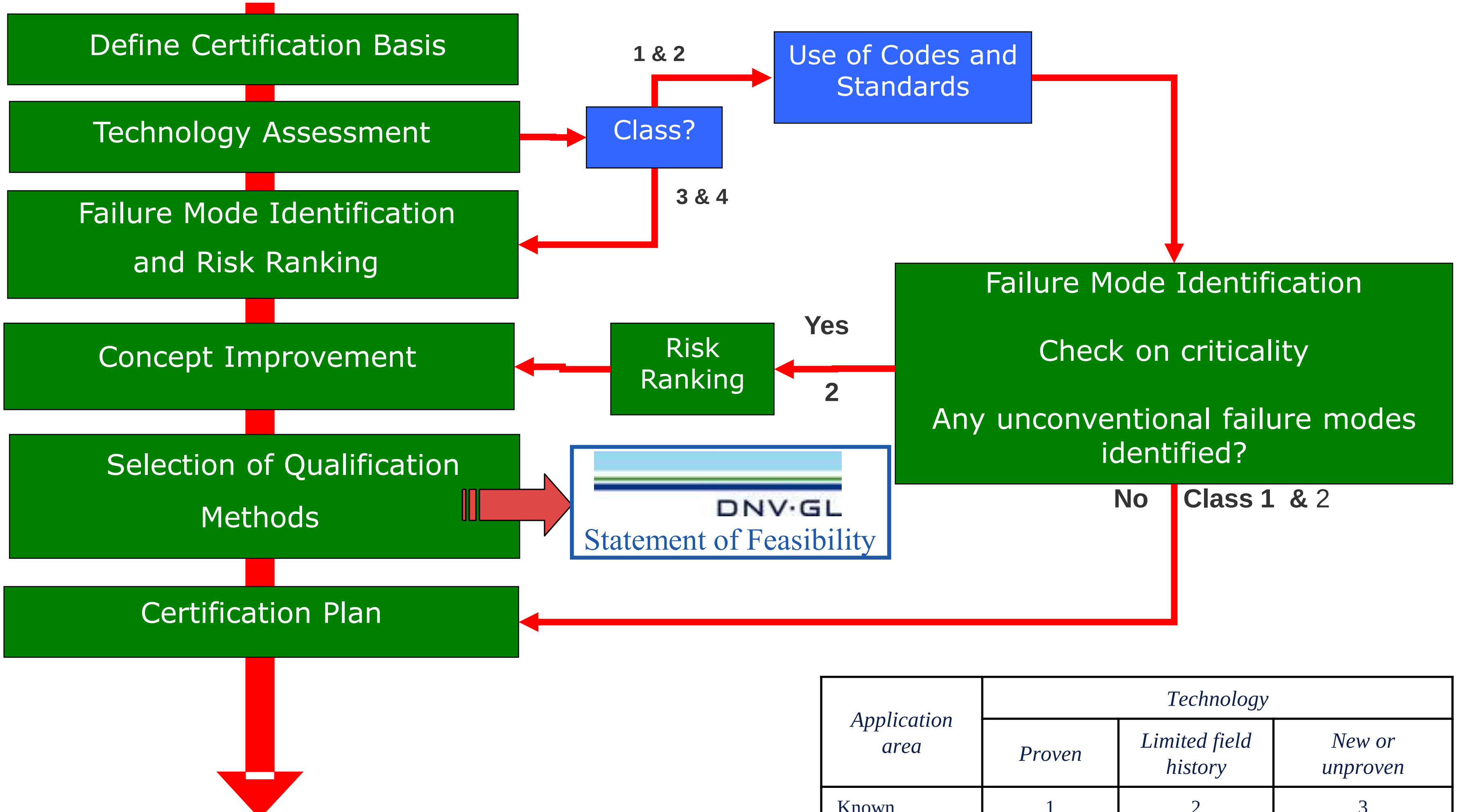
Components and functions

ID	Component	Function	Failure mode	Failure mechanism or cause	Detection	Consequence	Risk Ranking			Comments
							Cons.	Prob.	Risk	

Phases and activities

ID	Activity	Component	Failure mode	Failure mechanism or cause	Detection	Consequence	Risk Ranking			Comments
							Cons.	Prob.	Risk	
1	**Mobilisation**									
1.1	<Activity 1>	<Component X>								
		<Component Y>								

Handling Novelty and Uncertainties (Qualification Process)



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Selection of Qualification Methods and Certification Plan

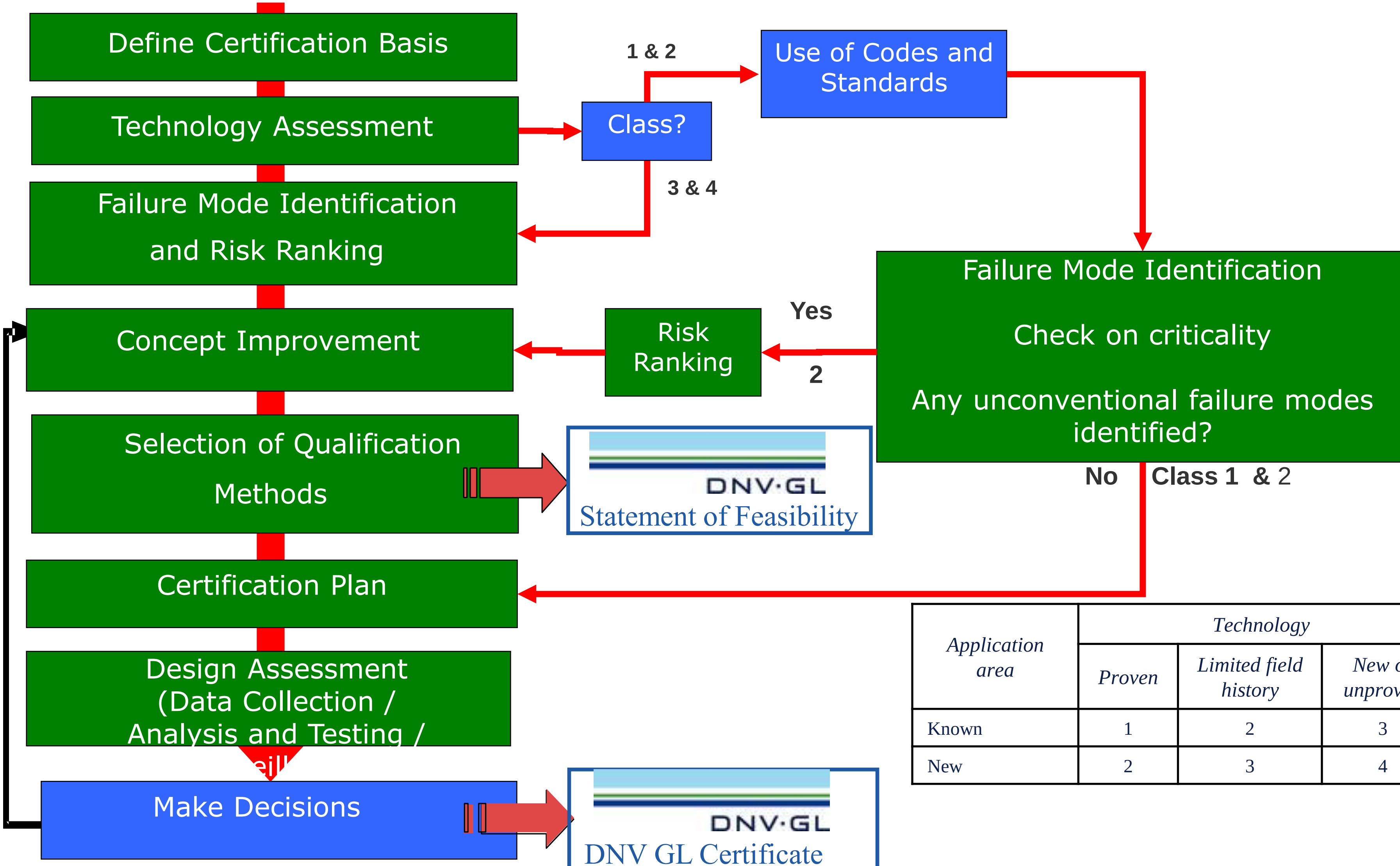
- For unacceptable risks (high or medium), mitigation to be identified
  - May be analyses, tests, use of higher safety factors
  - Should be documented to allow follow-up of risk ranking

- **Certification Plan** is a consolidation of all qualification methods actions required including:
  - Design according to standards
  - Tests according to standards
  - Extra actions identified during Failure Mode Identification
- Plan should provide full visibility of outcomes from process

Codes and Standards - Transference of Technology

- Knowledge is consolidated under standards, recommended practices and guidelines.
- This knowledge can be transferred to marine renewables once screened (by the Technology Qualification) for relevance / suitability and gaps.
- The transference of technology has the benefit to make use of existing supply chains, services and methods, making the development of the marine renewables more effective and efficient.
- Example of range of standards and rules available:
  - https://www.dnvgl.com/rules-standards/index.html
- Example of how existing standards from other industries can be applied in the tidal sector:
  - https://rules.dnvgl.com/docs/pdf/DNVGL/ST/2015-10/DNVGL-ST-0164.pdf

Handling Novelty and Uncertainties (Qualification Process)



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DNV GL Certification - Tidal

DNV GL Service Specifications for Certification of Tidal and Arrays (DNVGL-SE-0163)

DNV GL Standard for Tidal Turbines (DNVGL-ST-0164)

Other DNV GL Standards

International Codes and Standards

EquiMar Protocols

DNV GL Recommended Practices

IEC 62600 Series

DNV GL Guidelines and Notes

IEC Technical Specifications

62600-1	- Terminology
62600-2	- Design Requirements
62600-10	- Assessment of Mooring
62600-30	- Power Quality
62600-40	- Acoustic Characterisation
62600-103	- Tank Testing WEC
62600-200	- Power Performance – TEC
62600-201	- Resource Assessment – Tidal
62600-202	- Tank Testing

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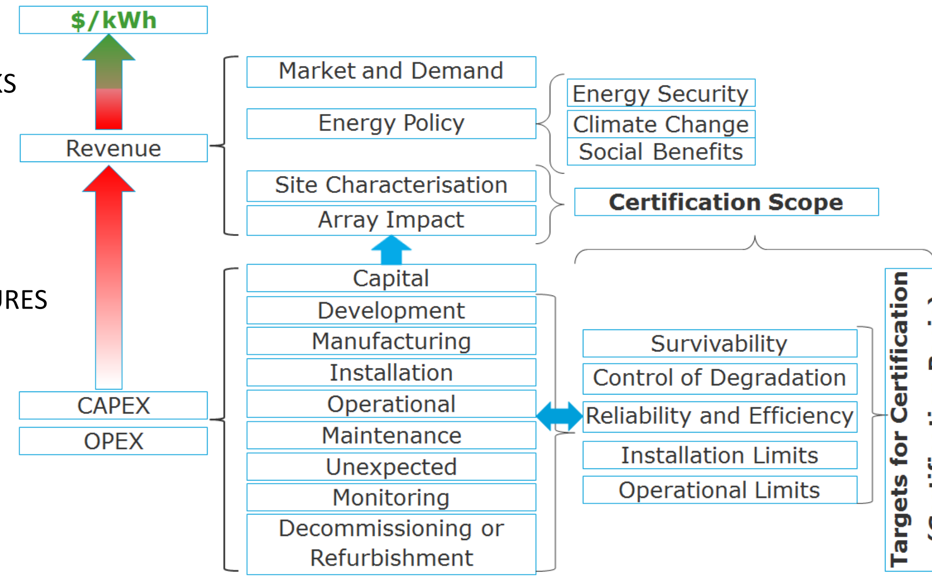

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