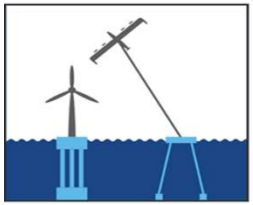
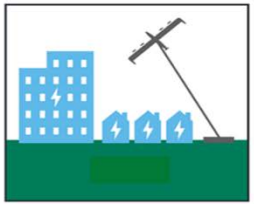
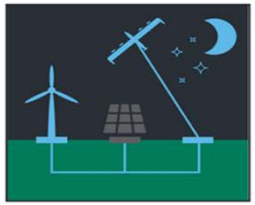
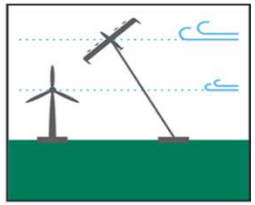
iea wind

Topical Expert Meeting TEM#102
Airborne Wind Energy

Session 4:
Functional Requirements, Metrics & Technology Assessment

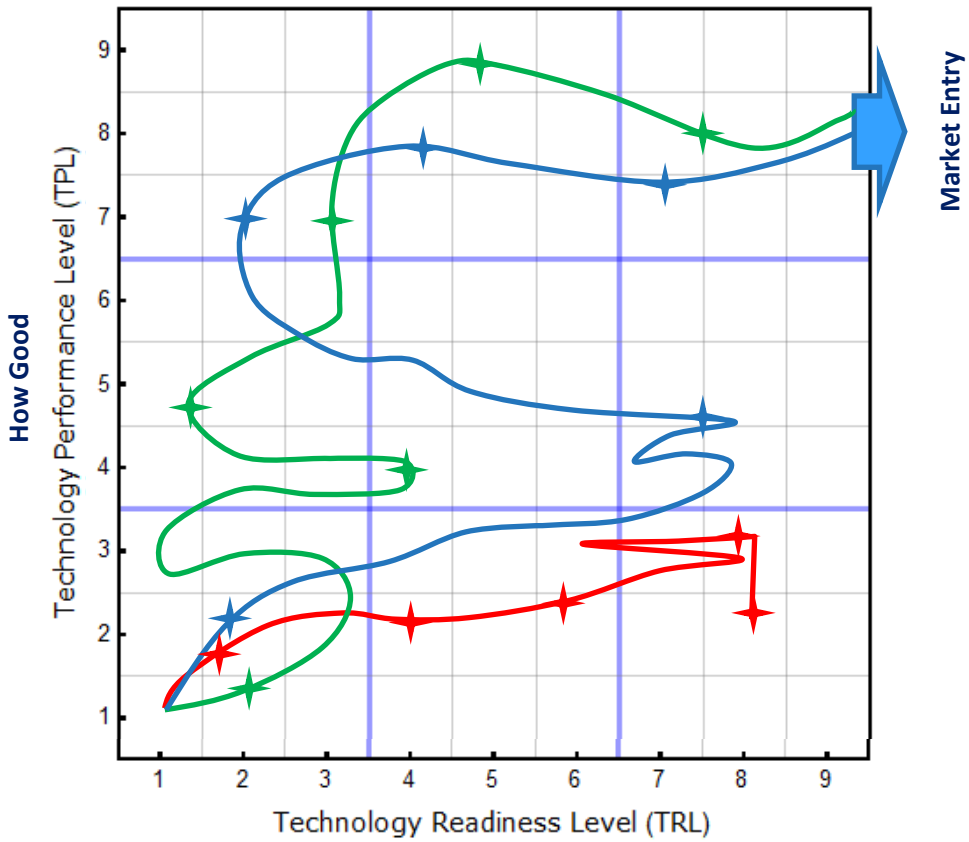
23-24 September 2020

Jochem Weber
National Renewable Energy Laboratory
Jochem.Weber@NREL.gov +1 720 431 54 64

Technology Development Trajectories

How Well

Performance Metrics:
- Energy capture
- Energy output
- Power density
- Fatigue life
- Deployment time
- Capacity factor
- Material use
- Safety
- Sound
- Installed capacity
- MW/weight
- CapEX
- OpEx
- Availability
- LCOE
- NPV
- TPL
- …



How Ready

What & When: Development Stages

What to Do

Stakeholder Requirements:
- Over Lifecycle

Functional Requirements:
- Clear
- Complete
- Solution agnostic

Development:
- Cost
- Time
- Risk
- Success

Overview of Topics

Functional Requirements

- Lifecycle analysis
- Stakeholder Requirements
- Functional Requirements
- AWE markets specific

Performance Metrics

Identify, collate:

- Quantitative and qualitative cost and performance drivers
- Performance metrics
- Trade-Offs

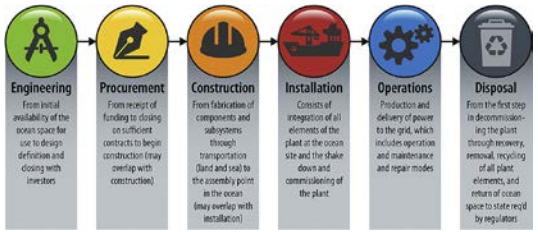
Technology Assessment

Development of:

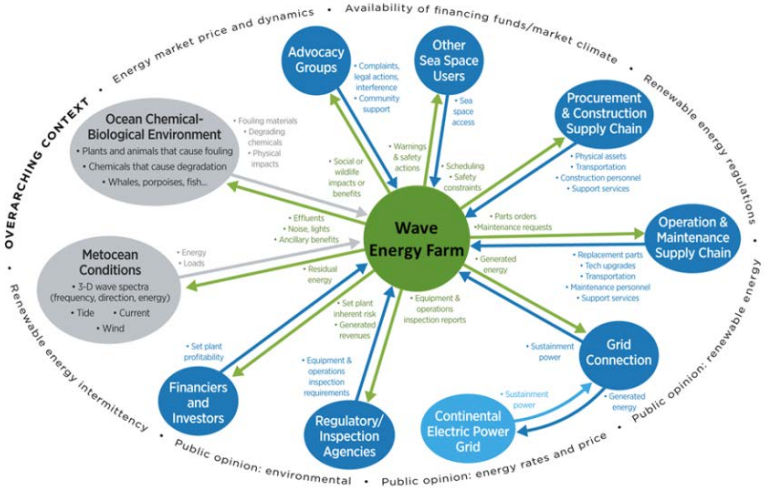
- Assessment methods
- Assessment tool
- Single criteria thresholds
- Cluster assessments
- Guided expert judgement

Functional Requirements

Lifecycle



Stakeholder Context



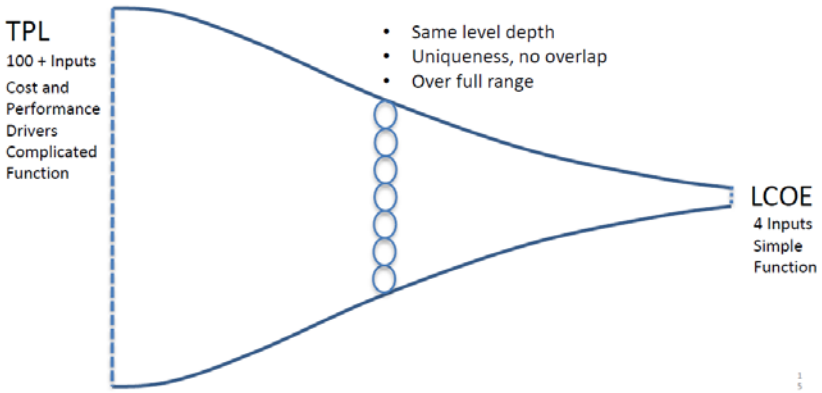
Functions

Performance Metrics

Wishlist

- *Objective – Quantitative – Specific – Measurable*
- *Certain – Precise – Repeatable – Transparent*
- *Straightforward – Simple – Meaningful – Correct*
- *Complete*, capturing all relevant aspects
- *Balanced*, reflecting the impact of diverse criteria
- *Interconnected*, reflecting all relevant trade-offs
- *Independent*, no need for subject matter experts
- *Ease of description*, low effort in providing the system description as the basis for the assessment
- *Ease of use*, low effort assessment process
- *Fast*, short duration of assessment process
- *Cheap*, low cost assessment process
- *Supported*, existing empirical & theoretical tools
- *Characterizing*, capturing qualitative features of additional system performance information
- *Flexible*, applicable at all development stages
- *Universal*, applicable across systems levels, archetypes
- *Equitable*, providing comparability across different technologies, archetypes, domains
- *Established*, globally recognized

Construct



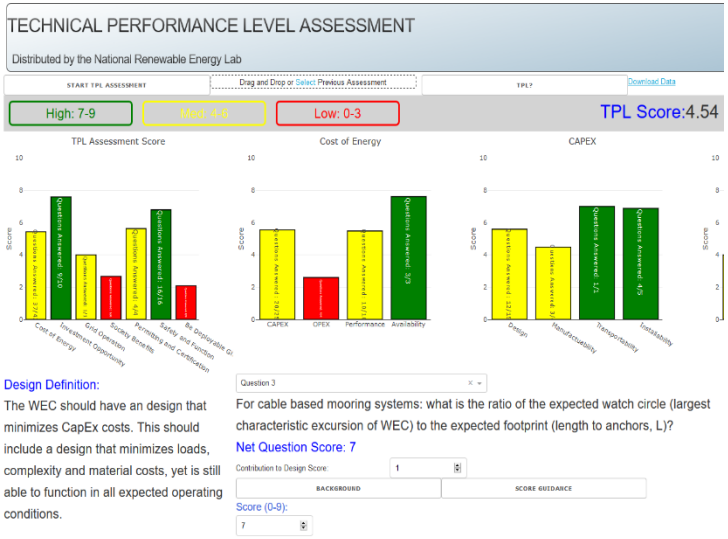
Technology Assessment

Information Base

- First principles
- Simulation
- Measurement
- Validation
- Standards
- Guidelines
- Guides expert judgement
- Certainty
- Known Unknowns
- Unknown Unknowns
- Neglected Known Unknowns

Tools

Category	Criterion	TPL_i	TPL_j
Acceptability:			7.3
	Lifecycle Environmental Acceptability	7	
	Social Acceptability and Socio-Economic Impact or Benefit	8	
	Legal, Regulatory and Certification Acceptability	8	
	Safety	7	
	Risks and Risk Mitigation	6	
	Insurability	6	
	Market Acceptability by Investor, Financier, Operator, Utility	7	
Power:			4.4
	Hydrodynamic Wave Power Absorption	3	
	Internal Power Conversion	5	
	Power Output and Delivery	6	
	Controllability - Fast - Wave to Wave	3	
	Controllability and Adaptability - Slow - Sea State to Sea State	4	
	Short-Term Energy Storage Capability	5	
Availability:			5.1
	Survivability	5	
	Reliability	6	
	Durability	7	
	Redundancy	2	
	Force, Power and Information Flow	4	
	System Adaptability Supporting Availability	3	
	Forced Shutdown	4	
Capital Expenditure (CapEx):			6.0
	Supply Chain	9	
	Material Types	7	
	Mass and Required Material Quantity	4	
	Manufacturability	5	
	Transportability	3	
	Wave Farm Infrastructure (non-WEC Device)	8	
	Device Deployment, Installation and Commissioning	5	
	Maintainability - CapEx Requirements	6	
	Modularity - CapEx Requirements	9	
	Redundancy - CapEx Requirements	9	
	Loading and Load Bearing - CapEx Requirements	4	
	Acceptability - CapEx Requirements	7	
Operational Expenditure (OpEx):			4.9
	Ability and Ease of Monitoring	5	
	Accessibility	5	
	Maintainability	4	
	Modularity and Ease of Subsystem and Component Exchange	3	
	Ease of Partial Operation and Graceful Degradation	4	
	Insurability Cost	5	
	Planned Maintenance Effort	7	
	Unplanned Maintenance Effort	5	
	Acceptability - OpEx Requirements	8	
TPL_Eco = TPL_Pow x TPL_Ava x (0.7 TPL_CapEx + 0.3_TPL_OpEx)			2.4
TPL_System = 0.2 TPL_Acc + 0.8 TPL_Eco			3.4



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Thank you for your attention!

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Chief Engineer
National Renewable Energy Laboratory
Jochem.Weber@NREL.gov
+1 720 431 54 64