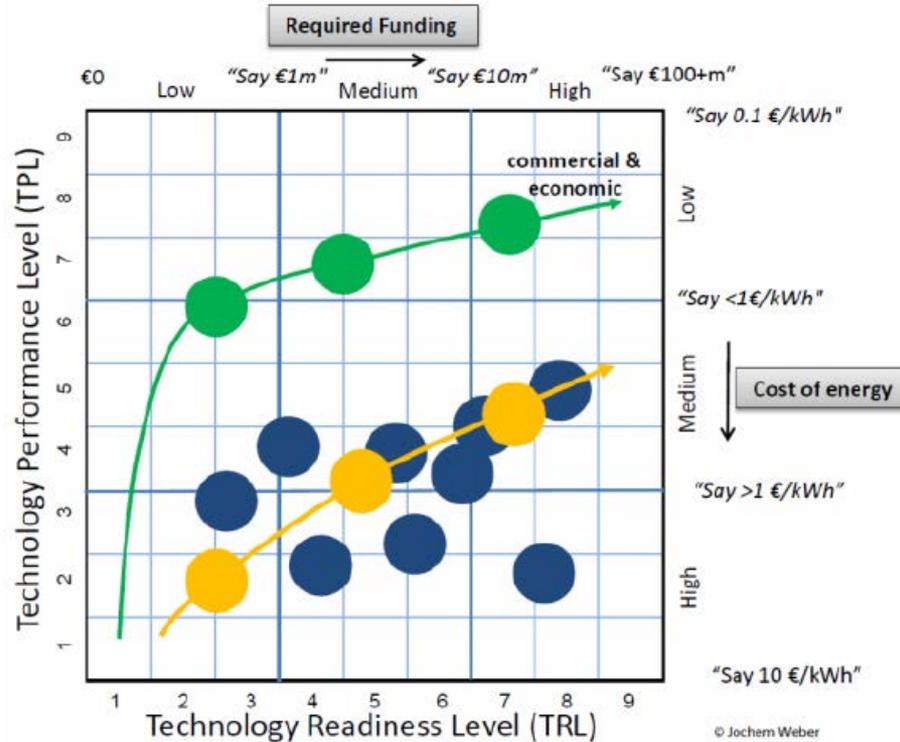


Principal Investigators:
Jochem Weber, NREL &
Jesse Roberts, SNL



Structured Innovation

Jochem Weber

NREL

Jochem.Weber@nrel.gov, 720-431-5464

February 2017

Structured Innovation

Innovation and identification of high techno-economic performing wave energy converter technology concepts to achieve competitive cost of energy from wave energy, through:

- Methodological inventive techniques,
- Early-stage technology performance assessment, and
- Implementation of the best research technology-development trajectory with respect to time, cost, and risk.

The Challenge: Invent high techno-economic performance wave energy converter technology concepts to implement the required step change improvement in economics and commercial viability.

Partners:



Increase MHK Deployment in Opportune Markets

Technology Maturity

- Test and demonstrate prototypes
- Develop cost-effective approaches for installation, grid integration, operations, and maintenance

- **Conduct R&D for Innovative MHK systems & components**

- Develop tools to optimize device and array performance and reliability

- **Develop and apply quantitative metrics to advance MHK technologies**

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- Support research focused on retiring or mitigating environmental risks and reducing costs
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

Market Development

- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain, and communicate MHK national strategy
- Support development of standards
- Expand MHK technical and research community

Crosscutting Approaches

- Enable access to testing facilities that help accelerate the pace of technology development
- Improve resource characterization to optimize technologies, reduce deployment risks, and identify promising markets
- Exchange of data, information, and expertise

Increase MHK Deployment in Opportune Markets

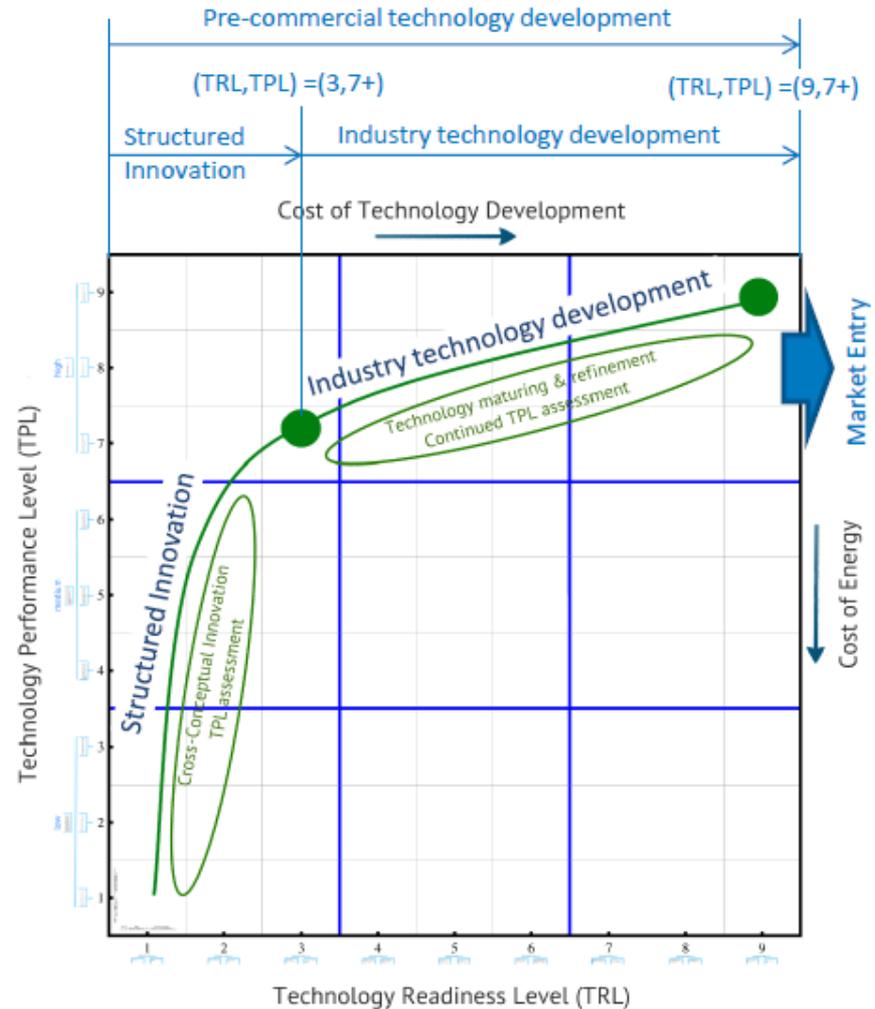
Technology Maturity

- Test and demonstrate prototypes
- Develop cost-effective approaches for installation, grid integration, operations, and maintenance
- **Conduct R&D for Innovative MHK systems & components**
- Develop tools to optimize device and array performance and reliability
- **Develop and apply quantitative metrics to advance MHK technologies**

The Impact

- This project has the potential to deliver game-changing novel wave energy converter technology concepts that will provide the required step change reduction in LCOE when fully developed and commercialized.
- These early stage high techno-economic performance wave energy converter concepts will be provided to the industry on a non-exclusive basis raising all boats and supporting technology convergence and economic viability.
- Assessment of the technologies currently under development will highlight technology-specific and common 'pain points' and support these developments towards higher techno-economic performance and economic viability.

- WEC technologies to date have not achieved commercial viability.
- Development paths have prioritized readiness over performance.
- The SI project implements the best development trajectory with respect to time, cost, and risk.
- This approach will deliver to industry, TRL3 wave energy technology concepts with high techno-economic potential, i.e. TPL7+





- Industry will be the direct beneficiary of all lab led project modules and will take over leadership from module five onwards.

3 Innovation & Identification

US Technology

- TPL assessment of WEC developers
- Identification of technology pain points and innovation needs
- Focused application of techniques of inventive problem solving (TIPS/TRIZ)

Clean Sheet

- Use of fundamental problem statement of wave energy
- System and subsystem requirements
- General application of techniques of inventive problem solving (TIPS/TRIZ)

Within the overall WEC technology development, the Structured Innovation project will deliver:

1. Standardized TPL assessment methodology,
2. WEC farm required functions,
3. Identification of US WEC industry common technology challenges, and
4. WEC technology specifications to TRL 3 and TPL 7 (or greater) through clean sheet novel WEC technology concepts

Based on the deliverables of the Structured Innovation project, the full technology development towards market entry will subsequently be completed through industry development.

- Technology Performance Levels (TPLs) as a techno-economic performance metric have been applied in the first technology gate in the Wave Energy Prize to down-select 20 WEC technology concepts from 92 entrants.
- The Structured Innovation project has attracted high caliber international collaboration of highly recognized wave energy experts.
- TPL metric used in EU projects (e.g., WETFEET).
- A substantially refined edition of the Technology Performance Levels has been completed and will be employed in the assessment of US WEC technologies under development. This improved TPL metric can be used as an evaluable tool for investors to identify technology value under development.
- Two written testimonials of TPL users were provided.

- The project started in August 2014 and will be completed in the 2018 time frame.
- The first project phase delivered the first edition of the TPL metric, assessment methodology, and supporting assessment tool in form of an Excel spreadsheet.
- FY15 and FY16 project work met all the Go/No-go decision points.
- The definition of functional requirements was delivered in FY16 and quantifying metrics for key functions will be delivered in Q2 FY17.
- Key deliverables for FY17 are: Assessment of 5+ WEC technologies, identification of pain points, innovation of key function solutions, and description of 1+ novel WEC technology concepts at TRL1.
- The industry will benefit through close collaboration and webinars

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-Share	DOE	Cost-Share	DOE	Cost-Share
\$160,000		0		\$750,000*	

* \$122,500 of funding was transferred to this project in FY 2016.

- Funds allocated at the end of FY 2014 (\$160,000) were spent in FY 2015.
- 75% of project funding has been spent to date.

Partners, Subcontractors, and Collaborators

Project lead by NREL and SNL. Four highly recognized international experts as subcontractors:

- Dr. Aurelien Babarit, Ecole Central de Nantes, Fr.
- Dr. Claudio Bittencourt Ferreira, DNV-GL, UK
- Dr. Ronan Costello, WaveVentures, UK
- Dr. Kim Nielson, Ramboll, DK



Communications and Technology Transfer

This work has been presented at the most relevant international conferences, including ICOE 2014, EWTEC 2015, IMREC 2015, ICOE 2016, METS 2016, OWET 2016; workshops were held in the United States and in Europe. Very positive feedback has been received on these occasions from industry and wider community.

FY17 / Current Research

FY17 concentrates on:

- TPL assessments of US WEC technologies under development with strong industry involvement leading to identification of common pain points and innovation needs, and
- Application of techniques of inventive problem solving (TIPS/TRIZ) to fundamental wave energy problem statement in form of full set of functional requirements.

Proposed Future Research

The outcome the project will be provided to the wave energy industry for full development of these technology concepts and to satisfy techno-economic performance requirements to kick start the commercialization. Laboratories will be supporting these development activities in the normal FOA framework.