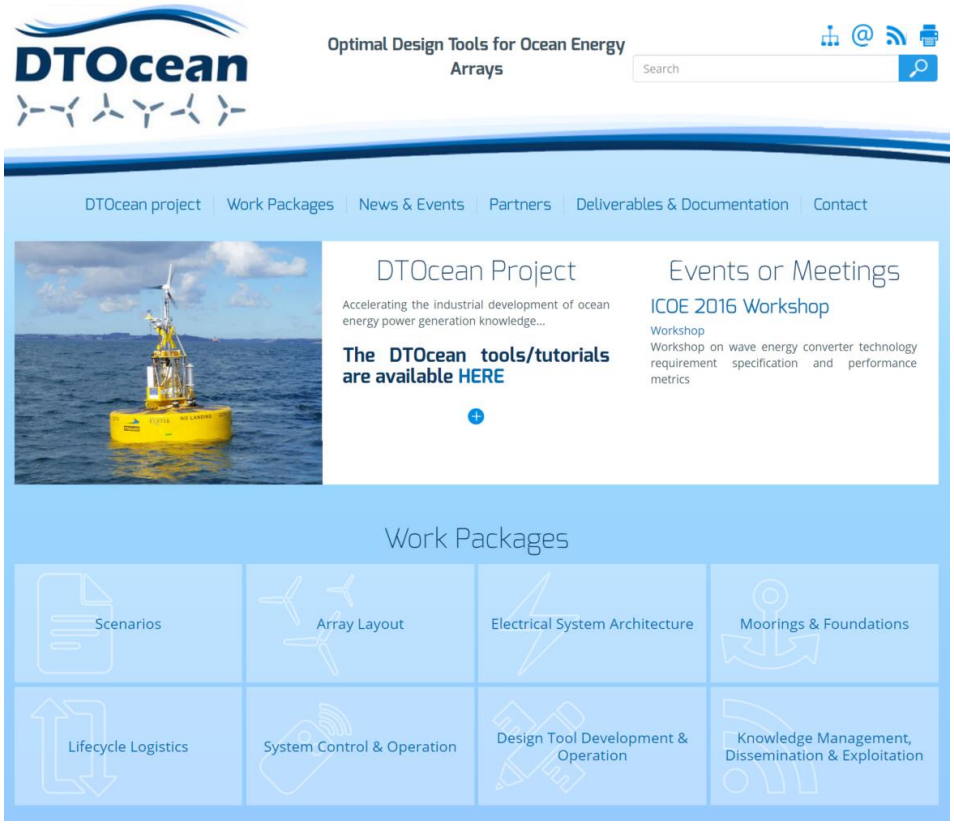

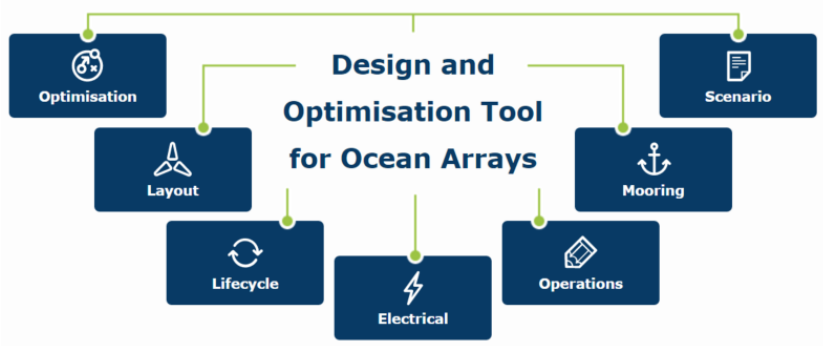

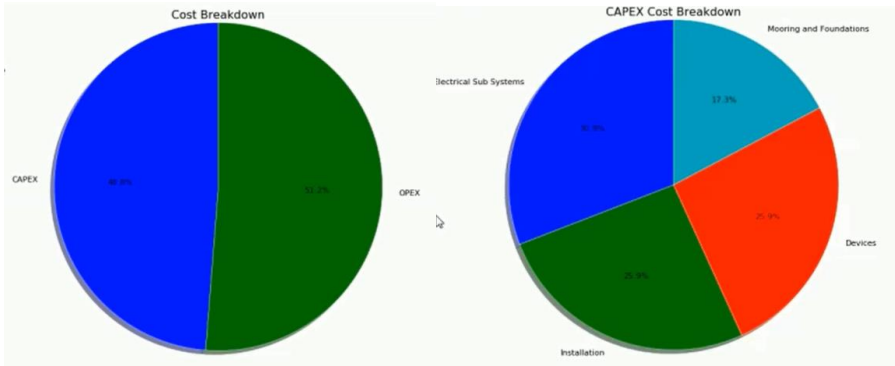

DTOcean (Optimal Design Tools for Ocean Energy)

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February 14-17, 2017

DTOcean: Optimal Design Tools for Ocean Energy

Goal: *Automate wave and tidal device array design* to accelerate decision making process for project development.

- **Reduce time and costs** for whole system evaluation
- **Optimize levelized cost of energy (LCOE)** to improve investment decisions

Barrier: Arrays systems are composed of many interdependent subsystems, all of which affect **Farm LCOE.**

Challenge: Whole system **LCOE optimization**

Partners: 17 European Institutions and Sandia Representing 11 countries

Program Strategic Priorities

Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- Conduct R&D for Innovative MHK 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 our 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

Project Strategic Alignment

Technology Maturity

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

The Impact

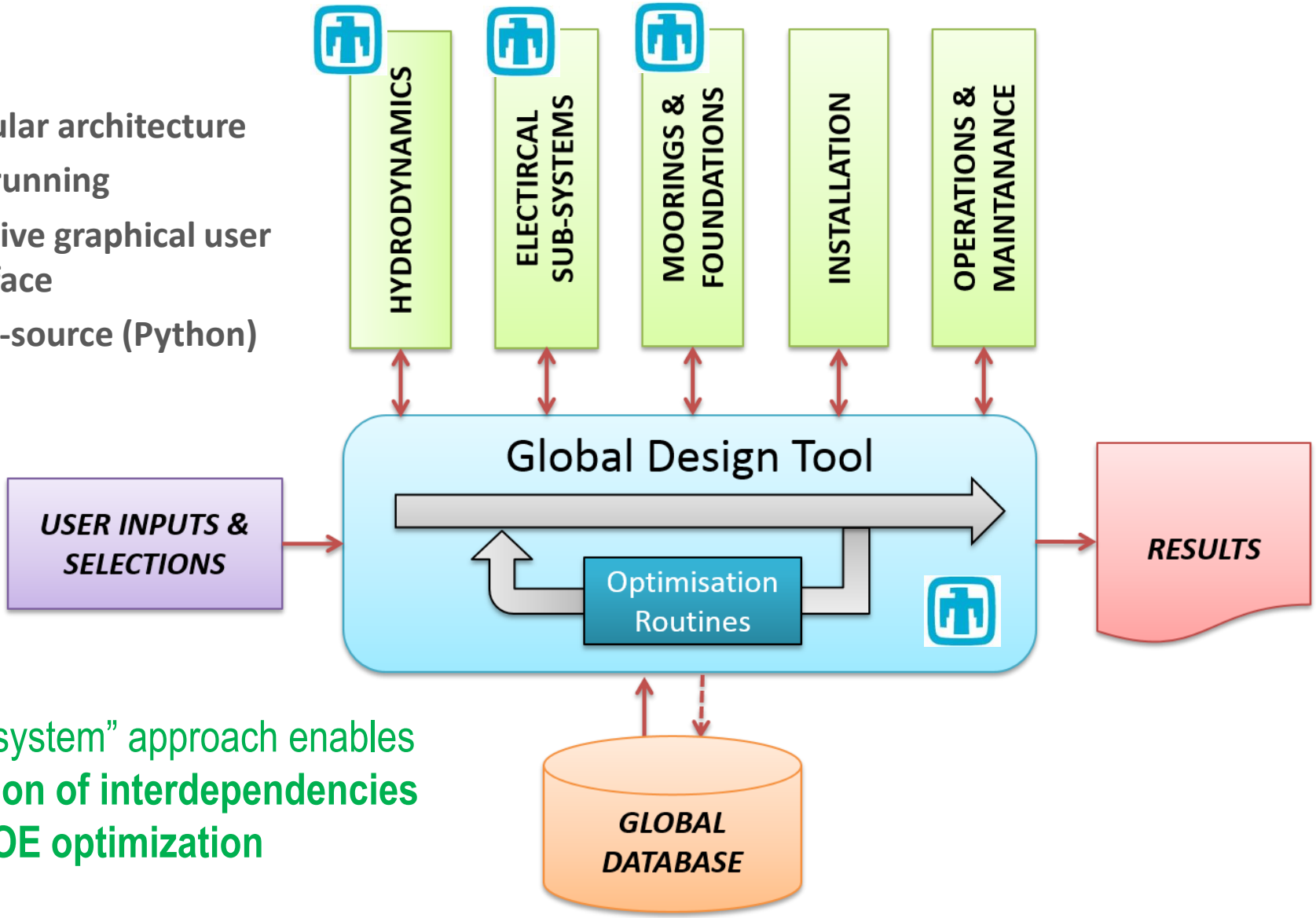
- **Enable array LCOE reductions**
  - Identify “whole-system” cost drivers
  - Identification of enabling technologies to:
    - reduce deployment and operations and maintenance costs, and
    - increase array performance
- **Increase investor confidence**
  - Rapid comparison of design alternatives
  - Reduce project investment risks

The Products

- Public, open-source, array design software tool
  - Manuals, tutorials, guidance
- Software evaluation and training for U.S. industry

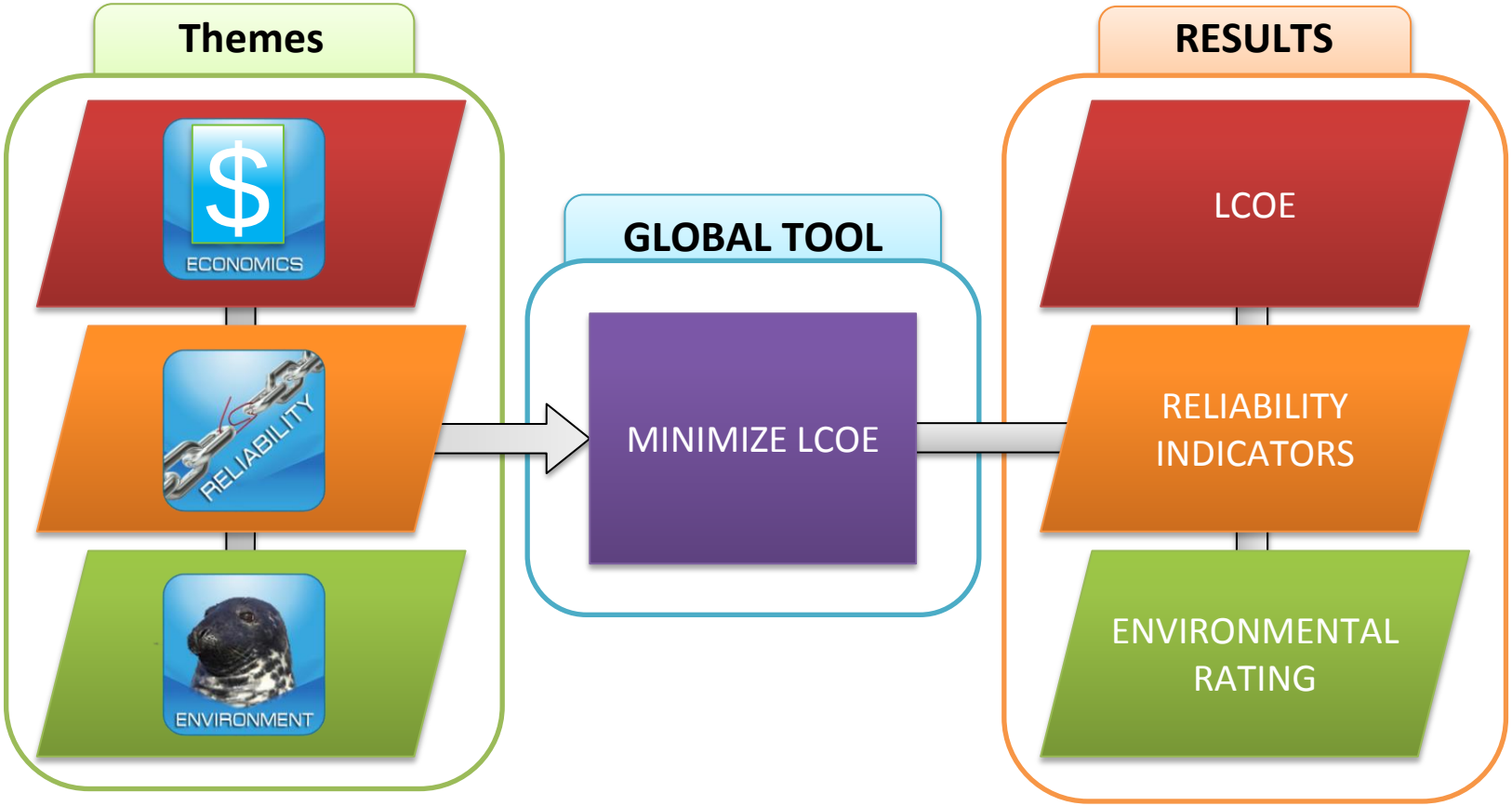
Technical Approach
Whole System Software

- Modular architecture
- Fast-running
- Intuitive graphical user interface
- Open-source (Python)



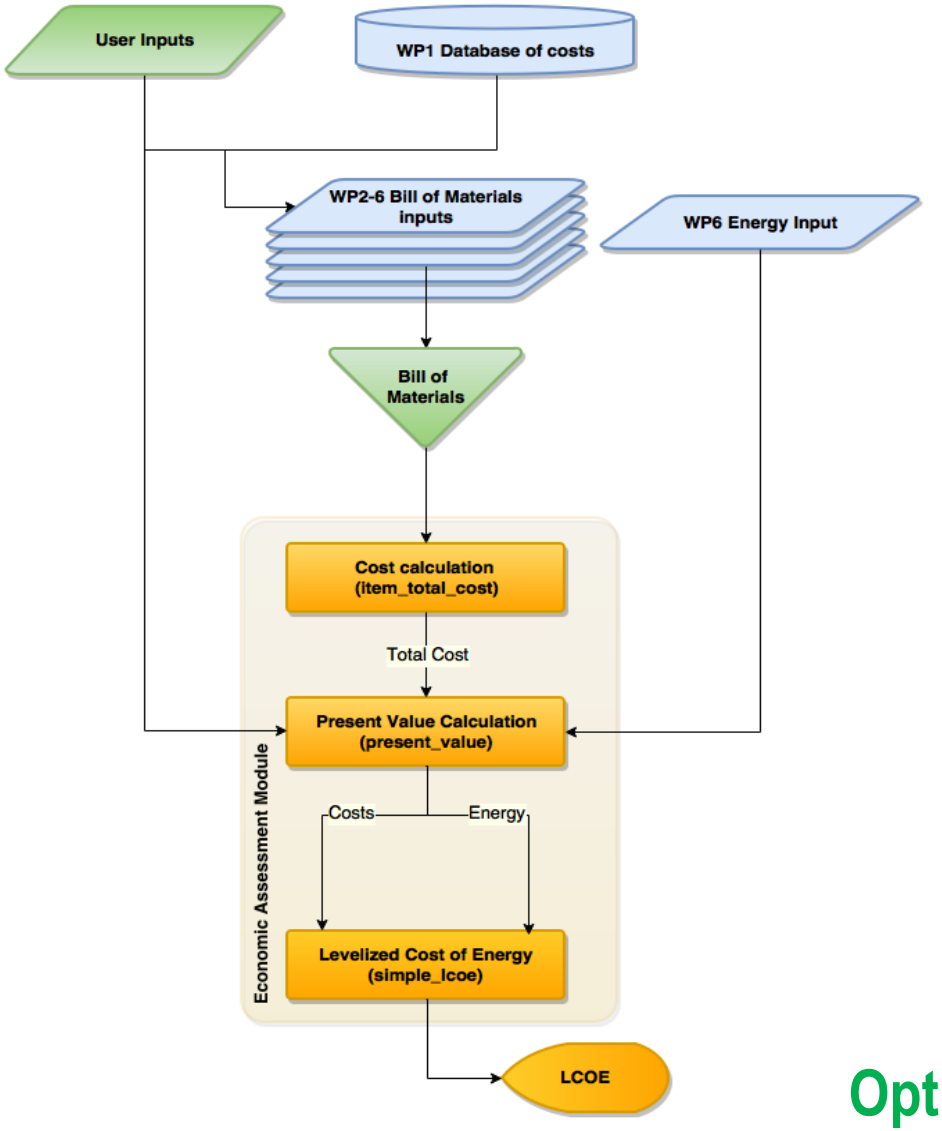
"Whole system" approach enables **evaluation of interdependencies and LCOE optimization**

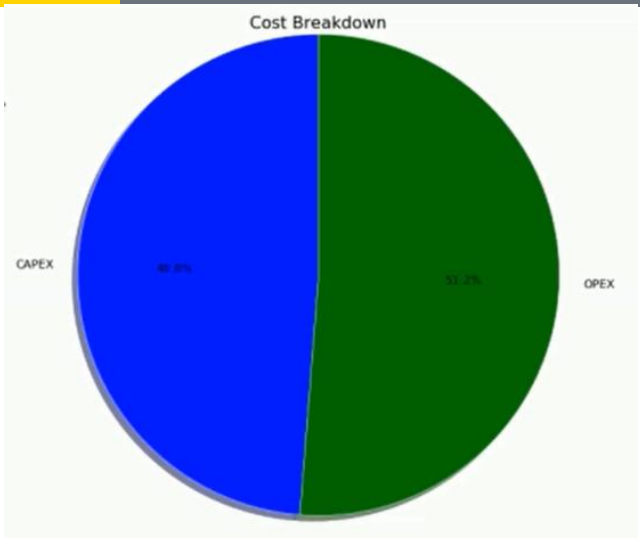
The software uses three thematic assessments:

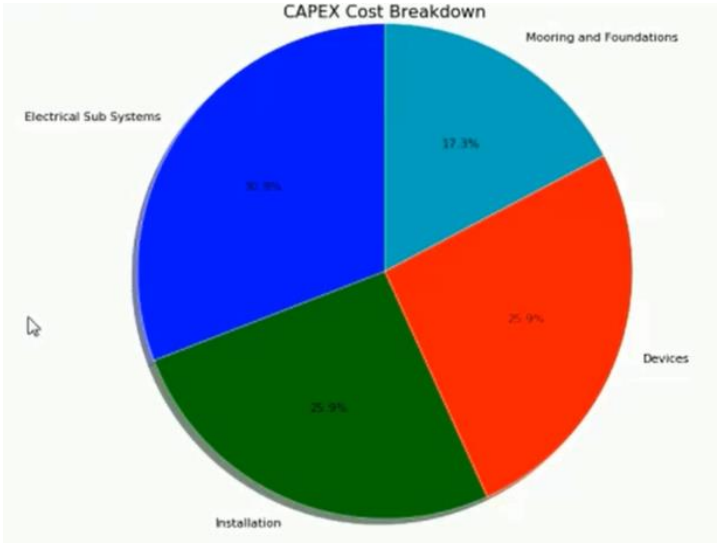


Minimizes LCOE and provides insight into **environmental acceptability,** and identifies/ranks **reliability concerns** for array components

Accomplishments and Progress
System-Wide Optimization



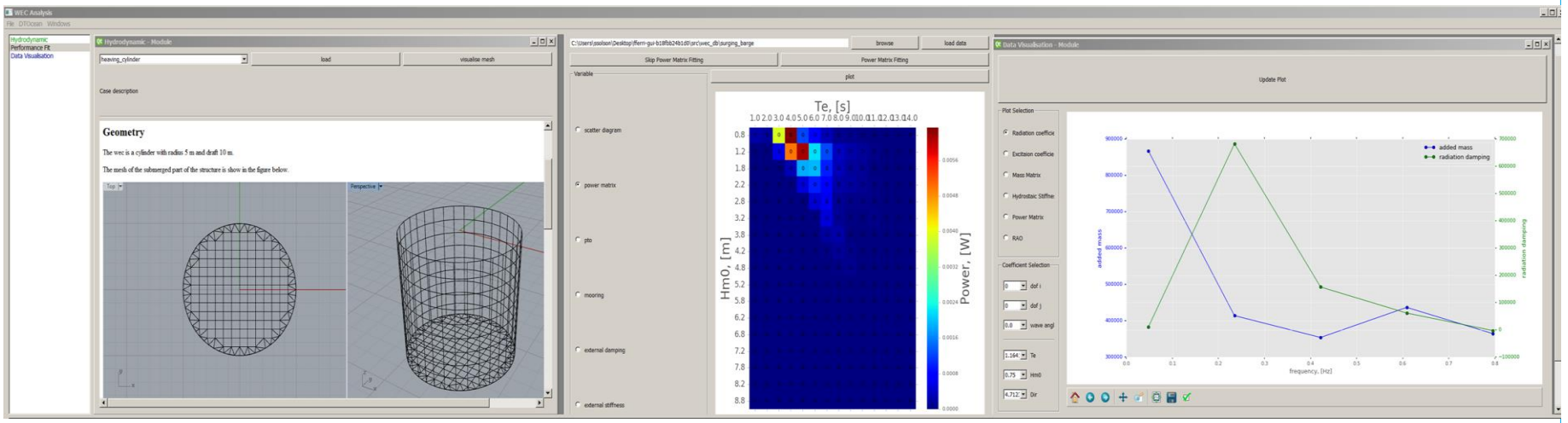




Optimize costs and identify cost drivers

Accomplishments and Progress
Software Development

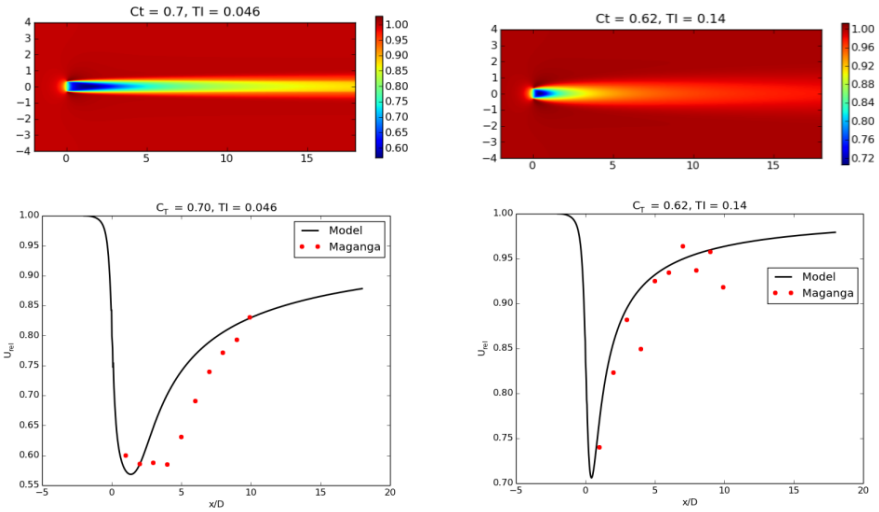
- **Completed Beta-Version of DTOcean Software**
  - **Final version** for public December 2016 (estimated)
- **Completed 54 deliverables**
  - Sandia co-authored over 20 deliverables
  - Lead author for D4.2: Critical inputs for foundation design

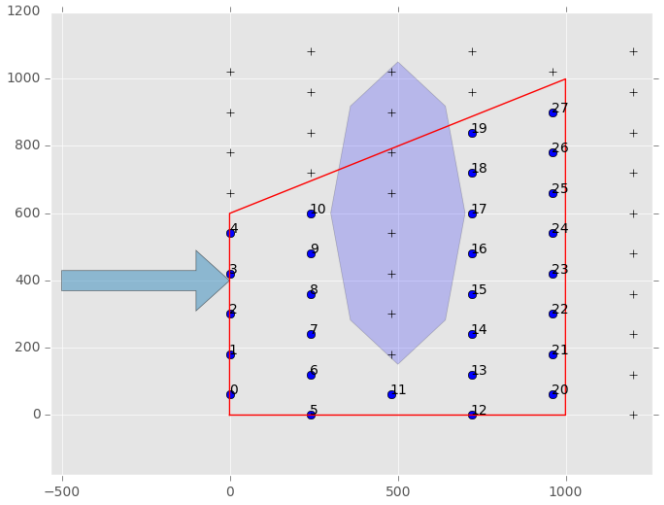


Freely available, open-source software and initial **industry training**

- **Fast-running CEC wake tool**
  - Interpolated database of over 600 CFD model runs
- **Algorithms for hydrodynamic array layout optimization**
  - Configuration and lease area constrained
- **Verified and validated software modules**

Enables fast-running optimal array design to reduce LCOE





Project Plan & Schedule

- **Software Development:** October 2013 – October 2016
  - Collaborative development with EU partners
  - Includes code development, validation, release, and global outreach
  - Large team and technical challenges led to software delays
    - Minimized time for software evaluation in FY16

- **U.S. Software Evaluation:** November 2016 – June 2017
  - Consider both wave and tidal arrays

- **U.S. Industry Outreach:** June 2017 – September 2017
  - Webinar to summarize software evaluation and tool demonstration

Accelerate adoption and transfer to U.S. industry

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$250k	-	$250k	-	$250k	-

- ~10:1 funding ratio (European to U.S.)
- ~$100k carried over into FY17

All Sandia **milestones met on time** and **on budget**

Research Integration & Collaboration

Partners and Collaborators:

Communications and Technology Transfer:

- Comprehensive project website (www.dtocean.eu)
  - Project description, reports, publications, events, manuals, tutorials...
- Strategic advisory board included industry developers (built into software)
- Workshops: All Energy Glasgow (2015); Renewables UK Marketplace (2016)
- Video tutorials (8) and HTML/PDF software manuals and guidance
- Publications: 16 conference papers, four journal articles
- Website: 20,354 website visits and 10,711 document downloads

International team with intent on **legacy** through **open-source** development

Next Steps and Future Research

FY17/Current research:

- Deliver DTOcean software, manuals, tutorials, guidance
  - Strategic Energy Technology Information System (SETIS) website by European Commission
- U.S. Software Evaluation
  - 1 wave, 1 tidal site
- US Industry Outreach
  - Summary of software evaluation (webinar)
  - Web-based software demonstration/training

Proposed future research: N/A