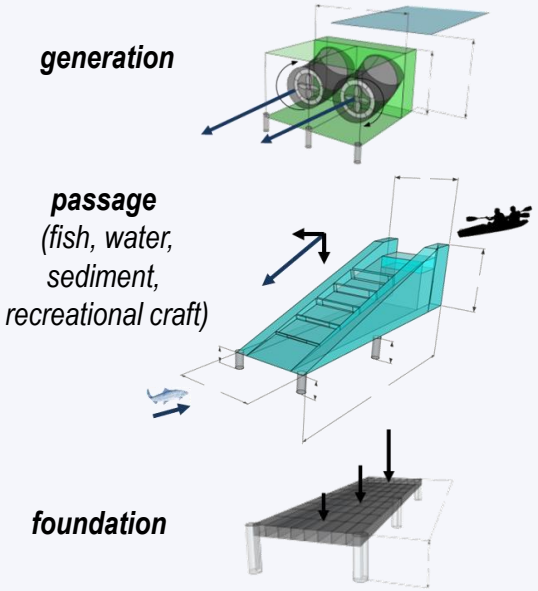
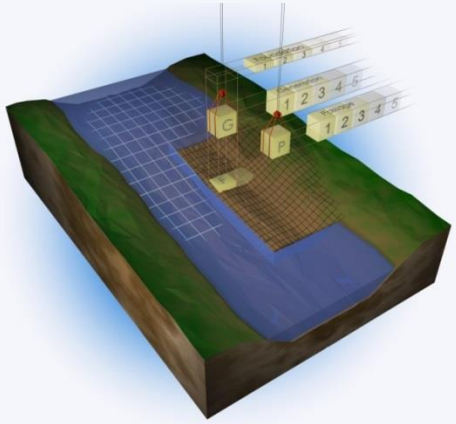
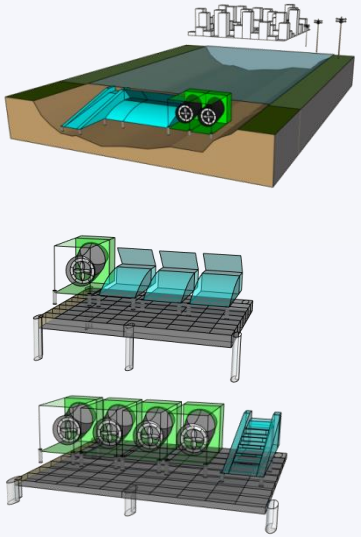


STANDARDIZED MODULE DESIGNS



MODULAR INSTALLATION



MODULAR DISTRIBUTED GENERATION

Standard Modular Hydropower (SMH)

Standard Modular Hydropower Technology Acceleration

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Standard Modular Hydropower (SMH) Technology Acceleration:

- Over the past few decades, new stream-reach hydropower development has been economically strained due to:
  - increases in the uncertainty of the cost and duration of the licensing process
  - the cost of site-specific design and customization of equipment and structures
  - evolving environmental constraints on design and operation
  - increased cost competitiveness of other energy sources.
- The ***purpose*** of Standard Modular Hydropower is to:
  - overcome these challenges
  - **fundamentally rethink small hydropower** development in the United States
  - enable previously unrealized levels of new project development with reduced costs, increased acceptance, enhanced environmental value, increased predictability of outcomes, and increased worth to stakeholders.
- The ***objectives*** of Standard Modular Hydropower are:
  - Demonstrate **standardization and modularity** as essential principles for technology cost reduction
  - Develop advanced structures and machines that ensure **environmental compatibility** of the facility during installation, operation, and decommissioning
  - Achieve wide **stakeholder acceptance** and approval to enable increased deployment
  - Investigate the feasibility of a **federal test facility** for small hydropower technologies.

Next Generation Hydropower (HydroNEXT)

Optimization

- Optimize technical, environmental, and water-use efficiency of existing fleet
- Collect and disseminate data on new and existing assets
- Facilitate interagency collaboration to increase regulatory process efficiency
- Identify revenue streams for ancillary services

Growth

- **Lower costs of hydropower components and civil works**
- Increase power train efficiency for low-head, variable flow applications
- **Facilitate mechanisms for testing and advancing new hydropower systems and components**
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

Sustainability

- **Design new hydropower systems that minimize or avoid environmental impacts**
- **Support development of new fish passage technologies and approaches**
- **Develop technologies, tools, and strategies to evaluate and address environmental impacts**
- Increase resilience to climate change

Next Generation Hydropower (HydroNEXT)

Growth

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The Impact

- TARGET: validated and stakeholder-accepted design specifications, design tools, and commercial designs for environmentally-compatible low-cost standardized modules and facilities for small hydropower development
- IMPACT: reduced-footprint, reduced-cost, and reduced-risk designs enable project developers and investors to undertake more new project development with greater assurance of success
- ENDPOINTs:
  1. An SMH **Exemplary Design Envelope Specification (EDES)** facilitated/published by Oak Ridge National Laboratory (ORNL) and adopted by the hydropower stakeholder community
  2. **SMH Modeling and Design Tools** that enable designers and stakeholders alike to project and visualize energy and environmental performance
  3. Proposals, awards, and successful tech development outcomes between DOE, industry, and other agencies that are enabled by the SMH EDES and related modeling and design tools.

Next Generation Hydropower (HydroNEXT)

Growth

- Lower costs of hydropower components and civil works
- Increase power train efficiency for low-head, variable flow applications
- **Facilitate mechanisms for testing and advancing new hydropower systems and components**
- Reduce costs and deployment timelines of new PSH plants
- Prepare the incoming hydropower workforce

The Impact

- TARGET: Validation of safety, performance (energy and environmental), and reliability of innovative hydropower technologies is carried out at a U.S. federal hydropower test facility
- IMPACT: A test facility would provide U.S. hydropower technology developers with a credible avenue to validate their results, without developing a commercial FERC-licensed project, giving assurance to project developers and financiers who are unlikely to take a chance on unproven technologies
- ENDPOINT: The pathway to public acceptance and the ultimate feasibility of innovative technologies is through a dedicated federal hydropower test facility.

Next Generation Hydropower (HydroNEXT)

Sustainability

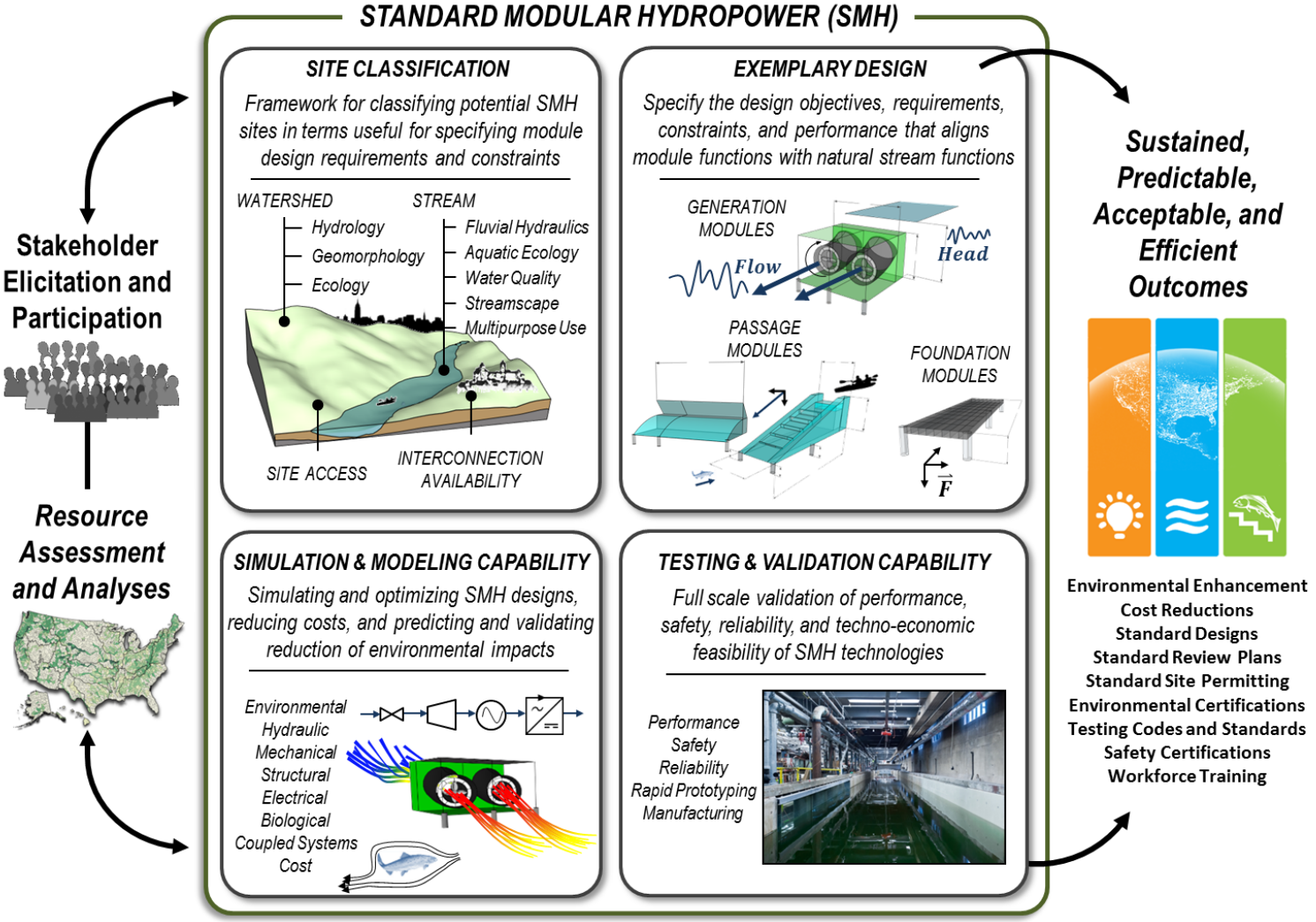
- **Design new hydropower systems that minimize or avoid environmental impacts**
- Support development of new fish passage technologies and approaches
- Develop technologies, tools, and strategies to evaluate and address environmental impacts
- Increase resilience to climate change

The Impact

- TARGET: Develop cost-optimized modules capable of sustaining the natural passage of fish, recreational watercraft, sediment, and water at sites within a pre-determined environmental classification system
- IMPACT: Standardized passage modules with dedicated functionality that minimize environmental disturbance could substantially reduce the cost and time associated with new stream-reach development
- ENDPOINT: A standardized assessment scheme determines which passage modules are needed and ensures they are compatible with development of a site.

Technical Approach

The exploration of standardization and modularity is carried out through four coordinated research pillars that define and focus the scope of SMH research, development, and demonstration activities:



Technical Approach

Key issues and the technical approach to address them

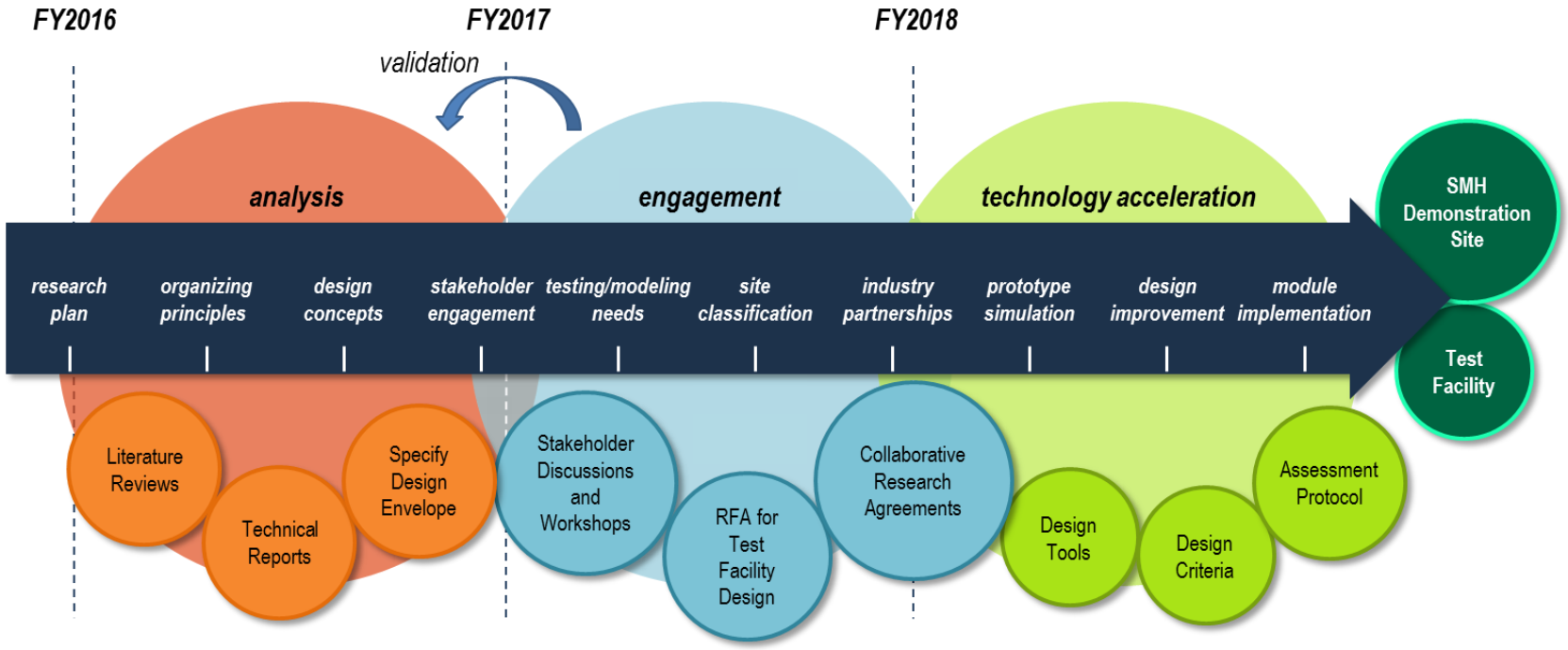
- **Lower cost throughout project lifecycle**
  - **Standardized and interchangeable modules** designed for generation, passage, and foundation functionality
  - **Standardized facility design** and environmental disturbance assessment
  - Advanced machine design incorporating **variable speed technology**
  - **Additive manufacturing** of turbine and components
  - Develop **full-scale testing capability** to improve and validate module safety, performance, and reliability.
- **Sustain environmental functions of pre-developed site**
  - **Develop dedicated environmental functionality** for individual modules, constrained by scientifically informed objectives, requirements, constraints, and desired performance characteristics
  - **Site classification** to identify environmental attributes and inform module design requirements and constraints.
- **Increase stakeholder acceptance**
  - **Stakeholder validation** of environmental functionalities for each module
  - **Standardization of environmental performance reviews**
  - **Targeted stakeholder outreach**, interviews, workshops, and webinars.

Technical Accomplishments:

Month-FY	Destination	Technical Accomplishment
March 2016	N/A	First Draft, Multi-Year Research Plan
May 2016	Oak Ridge National Laboratory	SMH Research Team Workshop - solicit input from all subject matter experts
June 2016	N/A	First Draft, Exemplary Design Envelope Specification report
July 2016	Minneapolis, MN	Panel Presentation for HydroVision International 2016 New Technology Track
July 2016	Minneapolis, MN	Poster Presentation at HydroVision International 2016
July 2016	N/A	SMH website live (http://hydropower.ornl.gov/smh/)
September 2016	N/A	First Draft, Test Facility Capability report
September 2016	N/A	Partner on 5 FOA proposals for modular turbine development

Project Plan & Schedule

- **Project duration:** October 2016–September 2018

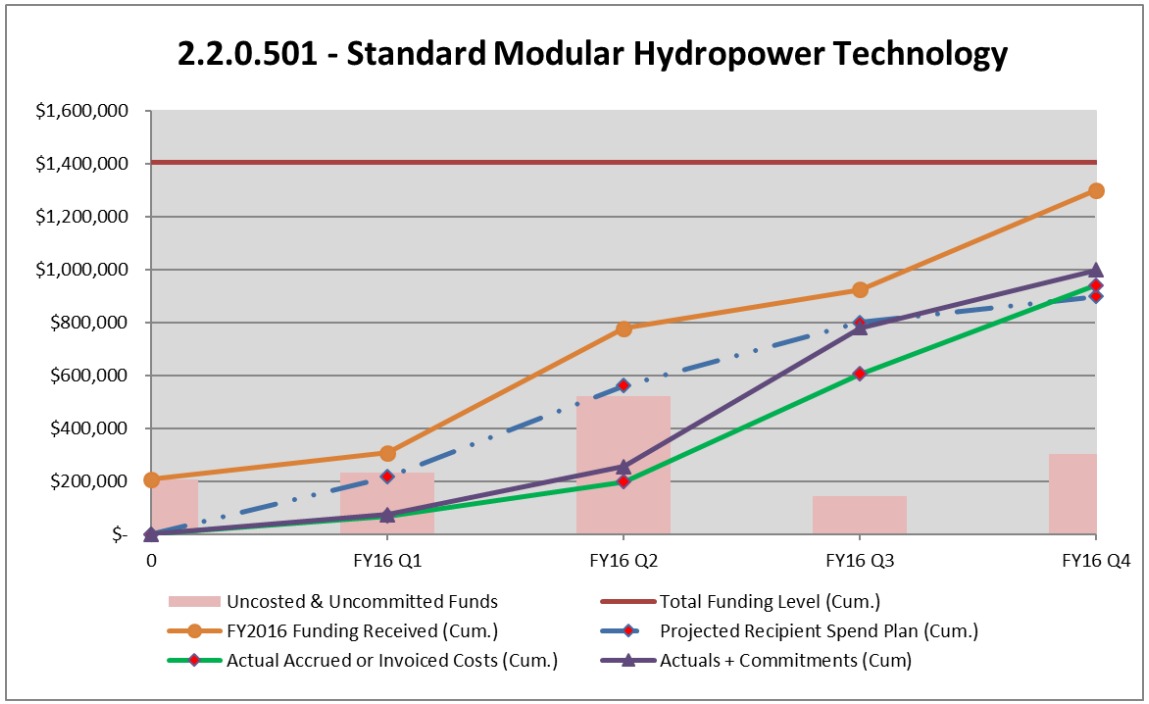


- **FY16 Go/No-Go decision for Federal Hydropower Test following facility need and feasibility assessment, (July 15, 2016; delayed):** modified from cost-benefit criteria to need-criteria. Cost-benefit analysis and decision will require interaction with federal site owners in FY17 Q1 and Q2.

Project Budget

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
N/A	N/A	N/A	N/A	$1,200k	N/A

- ORNL requires a 25% planned carryover target, meaning $899.527k was budgeted for FY16
- Through FY16, Q4 total costs: $941.797k (variance: +5%)



Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, *Subcontractors, and Collaborators:

- ORNL Energy-Water Resource Systems Group (water resources, aquatic ecology and biology, hydraulics and hydrodynamics, and hydropower project design)
- ORNL Power Electronics and Electric Machine Group (electrical machine design and simulation)
- *University of Tennessee-Knoxville (water resources, hydraulics and hydrodynamics, passage design)
- *Knight Piésold Consulting (water resources, hydraulics, and hydropower project design)
- *McKeown & Associates (stakeholder engagement)

Communications and Technology Transfer:

- SMH Research Team Workshop (May 2016)
- HydroVision International 2016 (July 2016)
  - Panel Presentation for New Technology Track
  - Poster Presentation and Technical Paper on Test Facility Development
- Website (http://hydropower.ornl.gov/smh/) created (July 2016)
  - 325 sessions from 92 unique users in one month (November 14, 2016 through December 14, 2016)
- Partnered with technology innovators to submit five proposals to DOE for the modular turbine development funding opportunity (DE-FOA-0001455, Topic Area 1)
- Supported emerging technology developers through discussion and consultation on SBV and SBIR applications for modular hydropower technologies

Next Steps and Future Research

FY17/Current research:

- FY17 research efforts are focused on engagement with stakeholder groups through facilitated discussions, workshops, and webinars.
- Stakeholders are encouraged to reference existing technical documents to validate proposed SMH framework.
- The results of stakeholder engagement will be used to refine SMH design, simulation, and testing concepts.
- Initial research, framing, and piloting of a Site Classification Scheme will be conducted.
- An RFA will be proposed for site and engineering design of a small hydropower test facility.

Proposed future research:

- A focus on **continuous stakeholder engagement** will ensure design concepts address challenges and needs identified by industry.
- Research into **advanced manufacturing and materials**, electrical interconnection modules, sensors/controls, and foundation classification may provide significant benefit toward reducing SMH technology cost and risk.