SAND2019-11478C

International Long-Duration Energy Storage Roadmap for the Electrical Grid

Task I Proposal: Solar Thermal Electric Systems

Task I Meeting
September 30, 2019
Daegu, South Korea

Proposer: Dr. Clifford K. Ho, Sandia National Laboratories

Task Operating Agent: Mark Mehos

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Investigators

Name	Institution	Country
Dr. Cliff Ho	Sandia National Laboratories	USA
Dr. Zhiwen Ma	National Renewable Energy Laboratory	USA
Dr. John Pye & Dr. Wojciech Lipinski	The Australian National University	Australia
Dr. Gilles Flamant	CNRS-PROMES	France
Dr. Roberto Solimene	IRC-CNR	Italy
Dr. Reiner Buck	DLR	Germany
Dr. Woei Saw and Dr. Gus Nathan	U. Adelaide	Australia

Problem Statement

- Increasing intermittent renewable energy sources requires energy storage for increased reliability and resilience
  - Short-term storage (seconds to hours) for daily shifts to address periods of overgeneration and inability to meet peak loads
  - Long-term storage (days to weeks) for seasonal shifts and response to natural disasters

"Long-term" storage refers to the amount of time that the energy needs to be stored

"Long-duration" storage refers to the duration of time that energy can be produced from storage

For the purposes of this proposal, "long-term" and "long-duration" storage are assumed to be correlated. I.e., a storage technology that can store energy for longer periods is expected to be able to produce energy for longer periods.

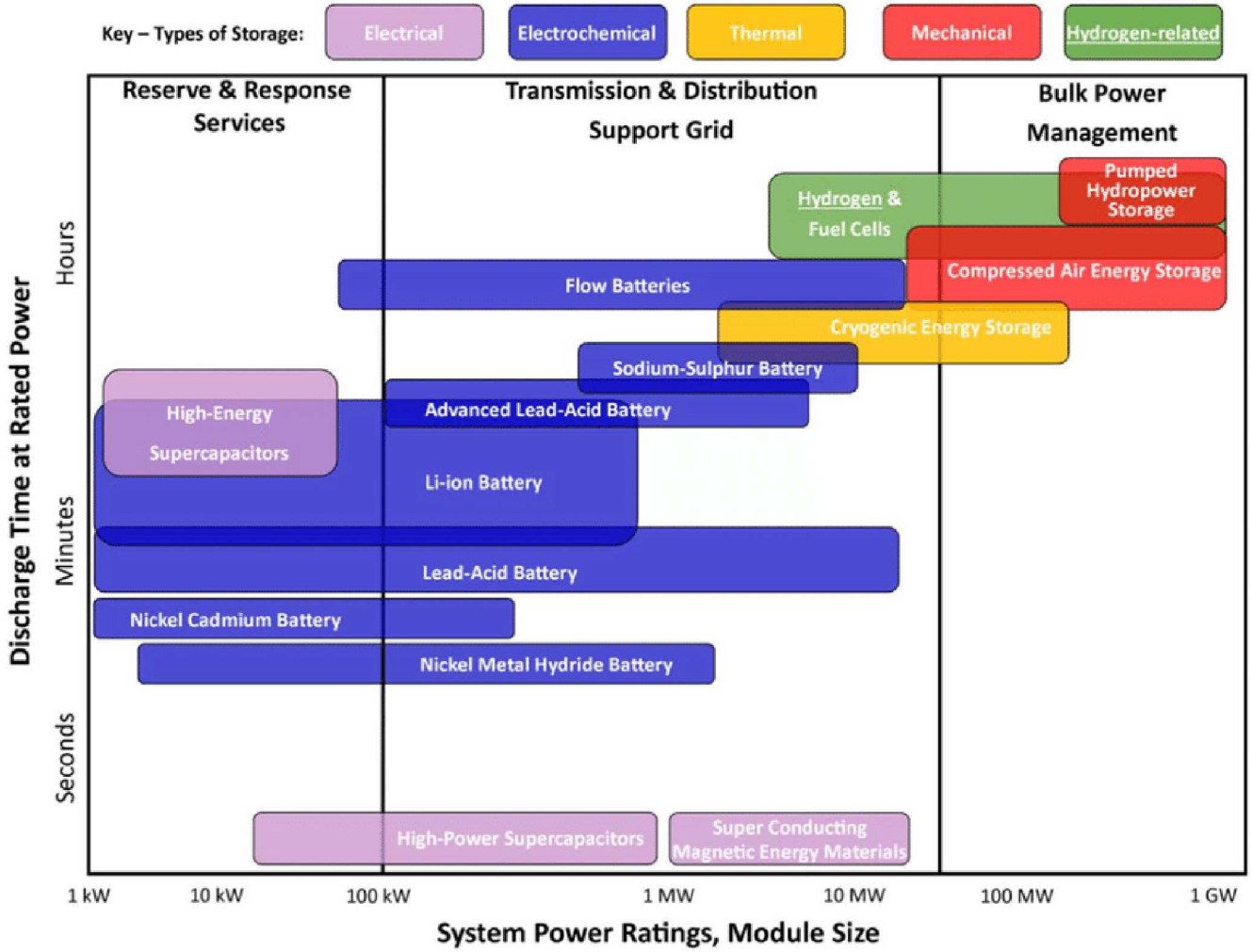
Problem Statement

- Recent funding programs have addressed long-duration storage needs, but they do not address performance requirements as a function of location, market, and variable percentages of intermittent renewables on the grid
  - DOE ARPA-E Duration Addition to electricity Storage (DAYS)
  - FY19 DOE Solar Energy Technologies Office CSP FOA
  - 2012 – 2016 SolarPACES Roadmap to Solar Fuels

Objectives

- The proposed work will coordinate tasks, meetings, and workshops among SolarPACES member countries to develop an international long-duration energy storage roadmap
  1. Estimate country-specific long-duration energy storage requirements
  2. Identify and evaluate available long-duration storage technologies and associated gaps with an emphasis on CSP and thermal-based storage (sensible, latent, thermochemical)
  3. Develop a 20-year plan for meeting future long-duration energy storage needs in each participating country

Discharge Time and Capacity of Energy Storage Technologies



Moller et al. (2017, Progress in Natural Science-Materials International)

Thermal energy storage technologies often not considered in energy storage analyses

This work will emphasize CSP-based thermal storage technologies (sensible, latent, thermochemical)

Work Plan and Milestones

- **Task 1 (0 – 9 months):** Identification and implementation of methods to estimate amount of energy storage required (both power and energy capacity) for up to 100% penetration of carbon-free electricity generation using local, regional, and/or national markets as examples
  - Evaluate methods defined in Copp et al. [3] to estimate energy storage requirements as a function of intermittent renewable energy penetration for specific locations and load profiles
  - Consider various sources of carbon-free electricity generation including intermittent renewables (solar PV and wind), nuclear, hydro, geothermal, or other sources that are deemed viable by each country
  - Delineate long-duration (days to months) from short-duration (seconds to hours) energy storage needs
  - **Milestone 1:** Interim report on energy storage requirements for up to 100% penetration of carbon-free electricity generation using local, regional, and/or national markets as examples **(Month 9)**

Work Plan and Milestones

- **Task 2 (6 – 12 months):** Evaluation of available storage technologies and their ability to provide long-duration storage on the order of days to months to address identified needs
  - Identification of CSP-based thermal storage technologies (sensible, latent, thermochemical) that can address long-duration storage needs
  - **Milestone 2:** Interim report on available storage technologies and gaps for long-duration storage technologies **(Month 12)**

Work Plan and Milestones

- **Task 3 (12 – 18 months):** 20-year plan for meeting future long-duration energy storage needs in each participating country
  - Include types and amounts of CSP-based thermal storage technologies required, along with other complementary long-duration storage technologies
  - Provide timelines based on each country's local, regional, and/or national goals

Final Deliverable

- **Final Deliverable (18 months):** Submit final report that details activities and results from Tasks 1 – 3. Full report will be published as referenceable SAND report; distilled version will be published as SolarPACES paper.

Goals

- Short Term
  - Develop an international roadmap that details the needs, technologies, and future requirements for long-duration energy storage (days to months) with consideration of country-specific resources, needs, and markets
  - The roadmap will identify CSP-based thermal storage technologies (sensible, latent, or thermochemical) that can fill in the gaps associated with current technologies

Goals

- Long Term
  - Increase the security, reliability, and resilience of the grid
  - Enable greater penetration of intermittent renewable energy sources
  - Promote the growth and economics of global renewable energy
  - Reduce CO_2 emissions from the power sector.

Budget and Cost Structure

- Task 1: EUR 120K labor* + EUR 30K travel (includes EUR 75K in-kind)
  - Budget divided among participating institutions
    - Attend monthly web-based meetings and in-person workshop
    - Perform modeling to estimate storage requirements and delineate short-duration vs. long-duration needs
    - Write interim report

*Labor and In-Kind Funding: Labor estimates include activities involving coordination, logistics, documentation, and compilation of assessments of requirements, technologies, and needs. These types of activities have been funded in previous SolarPACES projects such as guiSmo, Roadmap to Solar Fuels, and Particle Technology Working Group. R&D-like work, when necessary, will be performed primarily with in-kind funding.

Budget and Cost Structure

- Task 2: EUR 60K labor* + 10K travel (includes EUR 35K in-kind)
  - Budget divided among participating institutions
    - Attend monthly web-based meetings and in-person workshop
    - Assess available state-of-the-art technologies to address long-duration storage and identify gaps
    - Write interim report

*Labor and In-Kind Funding: Labor estimates include activities involving coordination, logistics, documentation, and compilation of assessments of requirements, technologies, and needs. These types of activities have been funded in previous SolarPACES projects such as guiSmo, Roadmap to Solar Fuels, and Particle Technology Working Group. R&D-like work, when necessary, will be performed primarily with in-kind funding.

Budget and Cost Structure

- Task 3: EUR 60K labor* + 20K travel (includes EUR 40K in-kind)
  - Budget divided among participating institutions
    - Attend monthly web-based meetings and in-person workshop
    - Develop 20-year plan for long-duration storage with consideration of country's local, regional, and/or national goals
    - Write final report and publish as SolarPACES paper

*Labor and In-Kind Funding: Labor estimates include activities involving coordination, logistics, documentation, and compilation of assessments of requirements, technologies, and needs. These types of activities have been funded in previous SolarPACES projects such as guiSmo, Roadmap to Solar Fuels, and Particle Technology Working Group. R&D-like work, when necessary, will be performed primarily with in-kind funding.

In-Kind Funding Sources

- ARPA-E DAYS project at NREL
- DOE CSP SETO and Gen 3 projects at SNL
- Sandia-funded long-duration energy storage initiative
- Sensible particle heat storage project at CNRS-PROMES
- Thermochemical and sensible particle storage projects at DLR
- Projects within the Australian-German Energy Transition Hub
- ARENA-funded thermochemical storage project with reacting particles at ANU
- Projects within the Australian Grand Challenge program and the Energy Change Institute
- Calcination/carbonation thermochemical storage projects at IRC-CNR in Italy

Summary

- The proposed work will coordinate tasks, meetings, and workshops among SolarPACES member countries to develop an international long-duration energy storage roadmap
  1. Estimate country-specific long-duration energy storage requirements
  2. Identify and evaluate available long-duration storage technologies and associated gaps with an emphasis on CSP and thermal-based storage (sensible, latent, thermochemical)
  3. Develop a 20-year plan for meeting future long-duration energy storage needs in each participating country