Large-scale Diurnal Storage Study

Presentation at DOE ESS Peer Review
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Project Objective

- Characterize and assess emerging innovative bulk ES technologies and relevant applications
  - Focus on concepts using pumped storage or compressed air with capacities greater than 100 MW
- Recommend strategy for DOE to hasten the commercialization of these innovative technologies.

Project Details

- Project Duration:
  - May through December 2010
- Sandia Delegated Representative:
  - Georgianne Huff
- Joint project with KEMA Consulting:
  - Poonum Agrawal, Sentech, Inc., now part of SRA International
  - Rick Fioravanti, KEMA Consulting
  - Paul Gordon, Sentech, Inc. , now part of SRA International
  - Larry Markel, Sentech, Inc. , now part of SRA International
  - Ali Nourai, KEMA Consulting
  - Nellie Tong, KEMA Consulting

Overview

- Technical Approach
- Application Selection for Bulk Energy Storage
- Application Requirements
- Technologies Reviewed
- Characteristics Reviewed
- Feasibility Assessment Methodology
- Feasibility Assessment Results
- Summary/Conclusions
- Future Tasks

Technical Approach

1. Identify relevant applications and needed requirements for bulk energy storage ✓
2. Characterize novel technologies ✓
3. Assess and screen technological feasibility ✓
4. Analyze gaps and barriers (in process)
5. Recommend needed R&D (in process)

Application Selection

- Evaluated 19 applications
- Applied two criteria to assess suitability
  - Discharge Duration
  - Frequency of Use
- Identified 6 applications appropriate for bulk energy storage

Application Requirements

Applications	Capacity (MW)		Discharge Duration (Hours)		Desirable Minimum Energy Efficiency (%)	Response Time
	Low	High	Low	High		
Electric Energy Time-shift	1	≥500	2	8	75%	2 hours
Electric Supply Capacity	1	≥500	4	6	75%	2 hours
Load Following	1	≥500	2	4	75%	2 hours
Renewable Energy Time Shift	<1	≥500	3	5	75%	2 hours
Renewable Capacity Firming	<1	≥500	3	5	75%	5 minutes
Wind Generation Grid Integration- Long Duration	<1	≥500	1	6	75%	2 hours

Novel Technologies Reviewed

Pumped Storage Hydropower

1. Aquifer
2. Archimedes' Screw Storage
3. Below Ground Reservoir
4. In ground storage pipe with piston
5. In-reservoir tube with bubbles
6. Energy Island
7. Ocean Pumped Storage
8. Variable-Speed

Compressed Air Energy Storage

1. Adiabatic
2. Diabatic Renewable
3. Near-isothermal
4. Liquid Air Energy Storage
5. Transportable CAES
6. Underwater CAES
7. Other: Adsorption Enhanced
8. Other: Hydrokinetic
9. Other: Vehicle compression

Characteristics Reviewed

Business Characteristics

1. Commercial Status
2. Permitting
3. Siting
4. Capital Cost
5. Annual O&M Cost
6. Calendar Life
7. Construction Lead Time
8. Companies Involved
9. Studies/Project Installations

Grid Characteristics

1. Power
2. Energy
3. Energy Efficiency
4. Ramp Rate or Response Time
5. Other Features

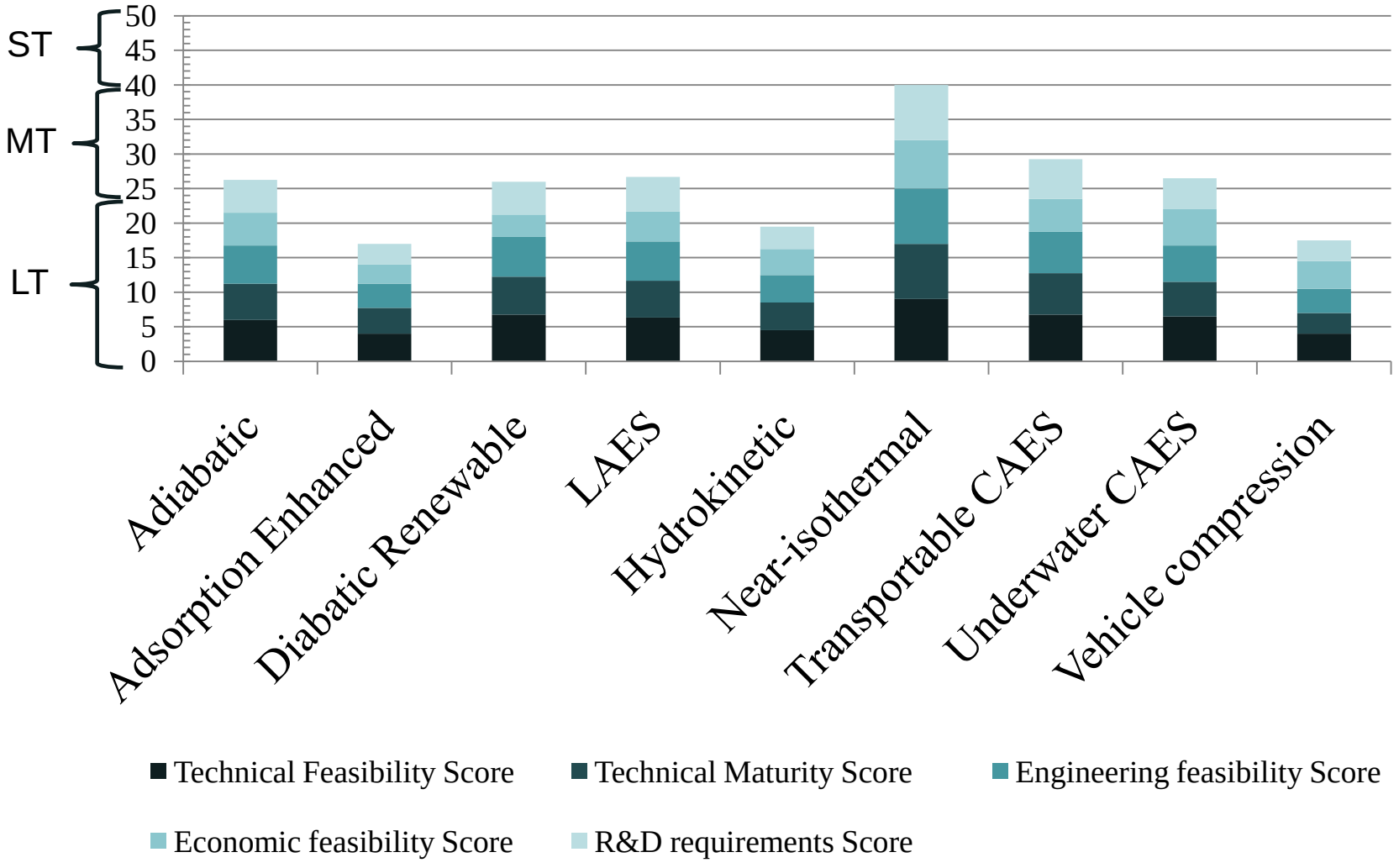
Feasibility Assessment

- Technical Feasibility
- Technical Maturity
- Engineering Feasibility
- Economic Feasibility
- R&D Requirement

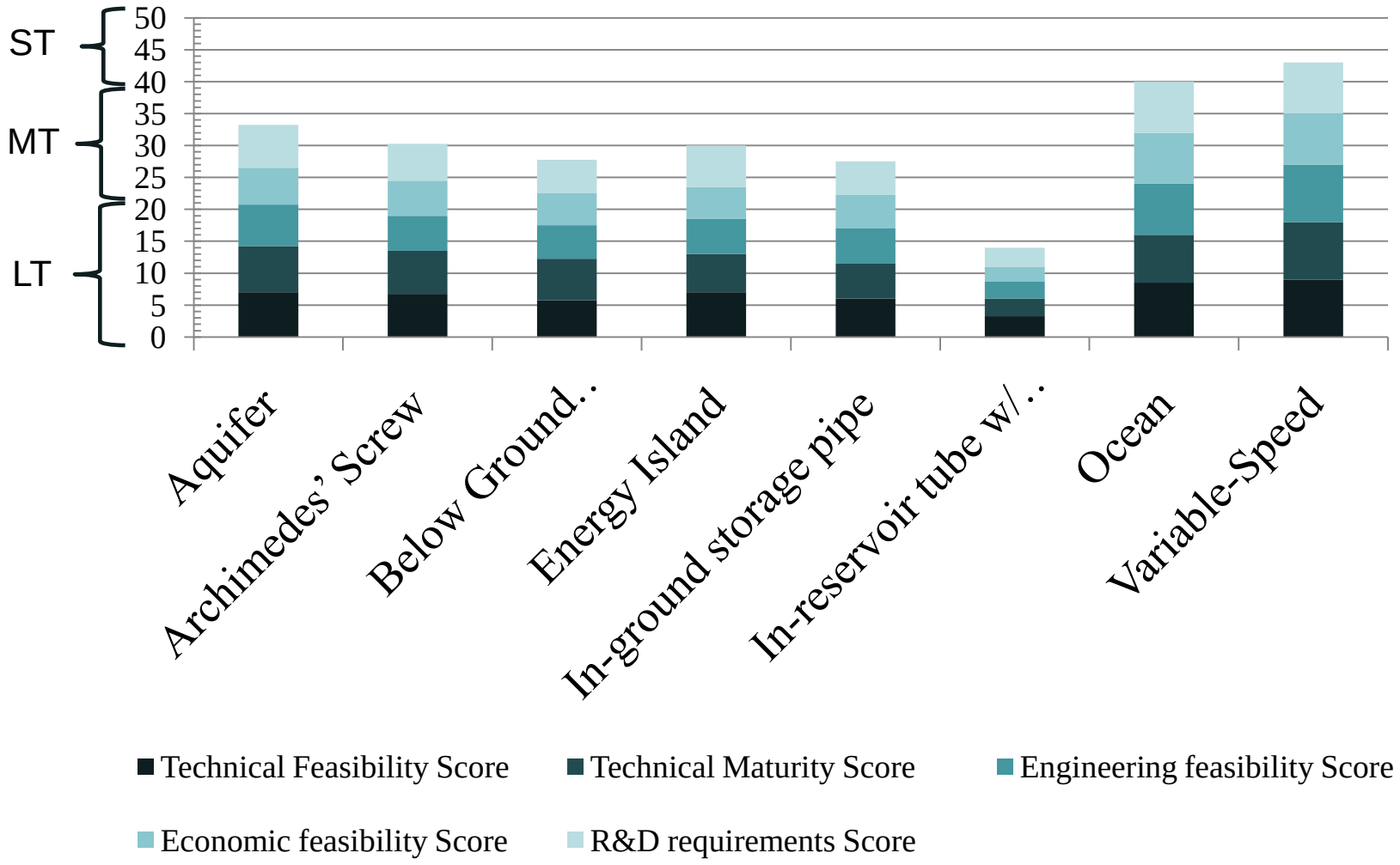
Screening Approach

- Assessed each of the technologies by the 5 attributes and scored them on a scale of 1-10
- 4 reviewers
- Averaged scores, discussed and reconciled outliers
- Identified the technologies by development timeframe:
  - Score > 40: Short-term (< 5 years)
  - Score between 25 and 40: Medium-term (between 5 - 10 years)
  - Score < 25: Long-term (> 5 years)

Feasibility Assessment Results - CAES



Feasibility Assessment Results - PSH



Time to Commercialization

	Short-term (< five years)	Mid-Term (5-10 years)	Long-term (>10 years)
PSH	• Ocean • Variable Speed	• Aquifer • Archimedes' Screw • Below Ground Reservoir • Energy Island • In-ground storage pipe	• In-reservoir tube with bubbles
CAES	• Near Isothermal	• Adiabatic • Diabatic Renewable • Liquid Air Energy Storage • Underwater	• Adsorption Enhanced • Hydrokinetic • Transportable • Vehicle compression

Summary/Conclusions

Based on the preliminary assessment it is recommended that DOE fund R&D, demonstration and incentives for commercialization based on the timeframe for development for each technology.

		Time to Commercialization		
		Short-term (< five years)	Mid-Term (5-10 years)	Long-term (>10 years)
Type of Government Support	R&D funding		✓	✓
	Funding for Demonstrations	✓	✓	✓
	Incentives for Commercialization	✓		

Future Tasks

- Incorporate feedback from peer review
- Complete gap and barrier assessment
- Develop R&D recommendations
- Complete final report by November 2010
- Present final results to DOE Energy Storage and Wind and Hydropower Programs by December 2010

Contact Information

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