EERA Joint Programme Energy Research – Status and outlook

Eberhard Diegele & Hans Seifert (KIT) ***Coordinators***

and the members of the JP ES Management Board

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Atle Harby (SINTEF)*, Matthias Noe (KIT), Peter Hall (U.Sheffield)*

International Workshop on Energy Storage in the Grid:
Low, Medium and Large Scale Requirements
January 9, 2014, Barcelona

Part I
What is EERA

- Homepage: www.eera-set.eu/index.php?index=79

Definition of EERA

www.eera-set.eu

- is an alliance of leading organizations in the field of energy research.
- was founded by leading European research institutes.

- **EERA is major tool to support SET-plan** by concentrating activities and resources.

- **EERA is integral part of Horizon 2020**

- **EERA is approached to represent the EU in international co-operations**

How Does it Work

EERA aims to:

identify and define Joint Programmes of research to be carried out by EERA coalitions consistent with the SET-Plan and taking into account the activities of European Technology Platforms and industry groupings;

share information and strategic plans

to help identify strengths, weaknesses, overlaps and gaps, in order to determine areas for coordinated effort;

engage proactively with industry

to create and build on partnerships of mutual interest and benefit.

Joint Programme – Policy *as of today*

- Participation in EERA Joint Programmes in principle open to all research organisations
- Not just a membership; need to bring in significant R&D capacity
- Mainly based on *own resources*
- EERA aims to be flexible & non-bureaucratic

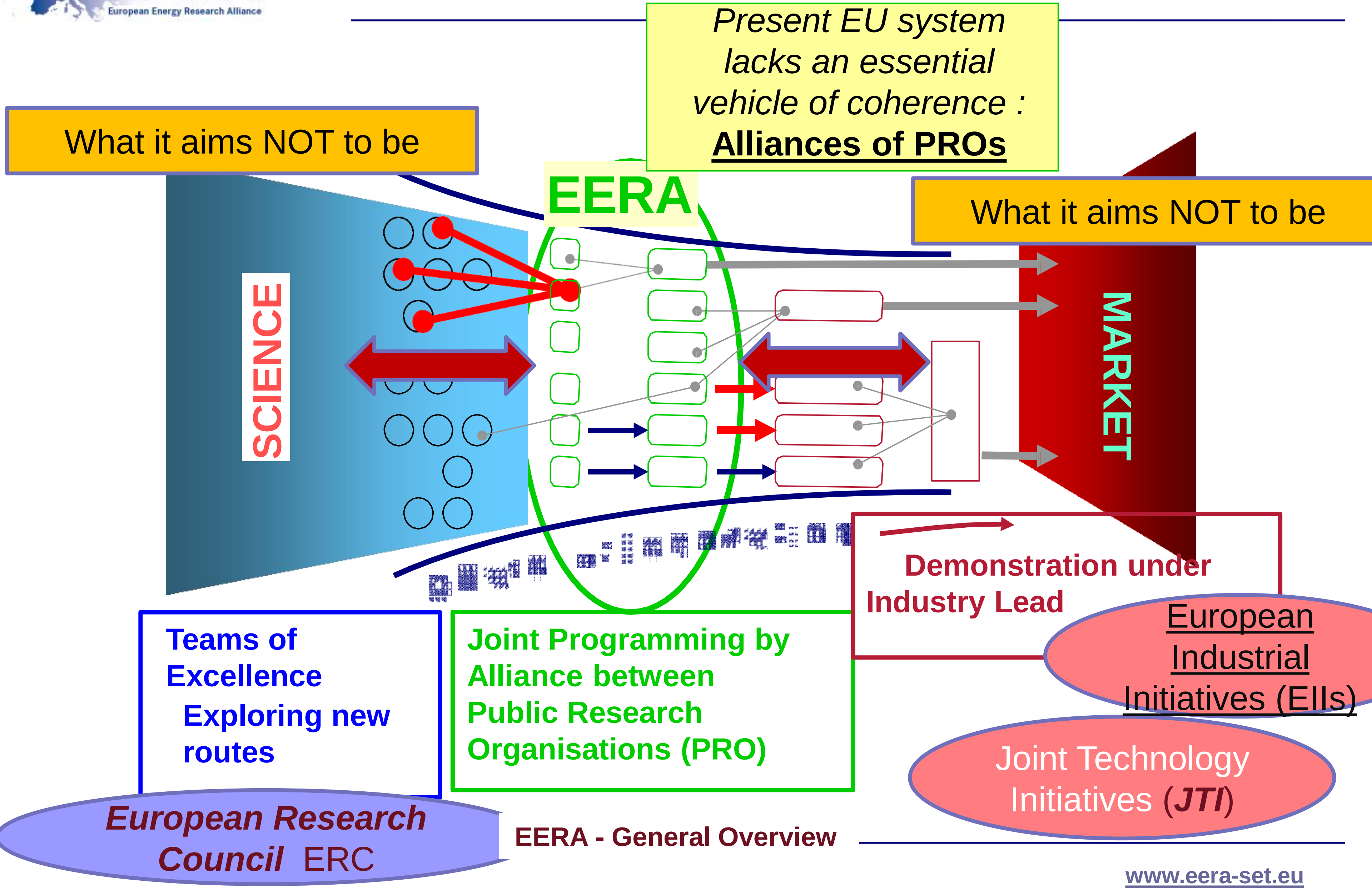
Joint Programmes - Approach

Long term strategy and work plan

- Agreed Objectives and Milestones
- Agreed Description of Work
- Agreed Division of Tasks and Responsibilities
  - Context supporting specialisation of Participants
  - Virtual centres working as one team on one topic

Clear and efficient coordination

Positioning EERA along the Chain of Innovation



EERA Joint Programmes

- Joint Programmes launched 2010
  - PV: ≈ 100 professionals*
  - Wind: ≈ 130 professionals*
  - **Geothermal**: ≈ **350** professionals*
  - Smart Grids: ≈ 100 professionals*
  - Bioenergy: ≈ 120 professionals*
  - CCS: ≈ 270 professionals*
  - Mat. Nuclear: ≈ 150 professionals*

Participation increasing
New organisations joining

* Full time Equivalent

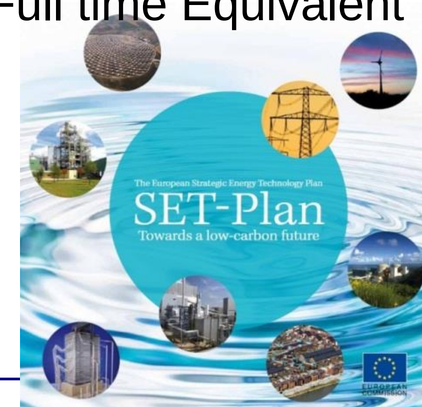
EERA Joint Programmes

- Joint Programmes launched November 2011
  - CSP: ≈ 80 professionals*
  - Ocean Energy: ≈ 35 professionals*
  - **AMPEA:** ≈ **250** professionals*
  - FuelCell&Hydrogen ≈ 130professionals*
  - **Energy Storage** ≈ **430** professionals*
  - Smart Cities ≈ 190 professionals*
- *launched April 2013*
  - *Economical, Enviroment and Social Impacts & Shale Gas*

Participation increasing
New organisations joining

EERA JPs it's :
- **more than 3,000 FTE**
- **about 150 members from all around Europe**
- **more than 400 Research Groups**

* Full time Equivalent



Part II
EERA Joint Programme Energy Storage

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European Energy Research Alliance

Joint Programme on Energy Storage

General technologies covered in 6 Sub-Programmes

1) **Electrochemical Storage** (Mario Conte, ENEA)
Lithium Ion Batteries, Super Capacitors

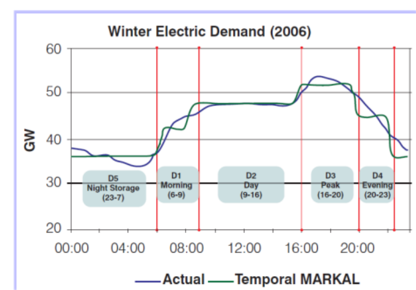
2) **Chemical Storage** (Jean-Philippe Nicolai, CEA)
Hydrogen, Methanol, Ammonia

3) **Thermal Storage** (Doerte Laing, DLR)
Advanced Fluids, PCM,
Thermochemical Heat Storage

4) **Mechanical Storage** (Atle Harby, Sintef)
Hydro, Fly wheels, Compressed Air

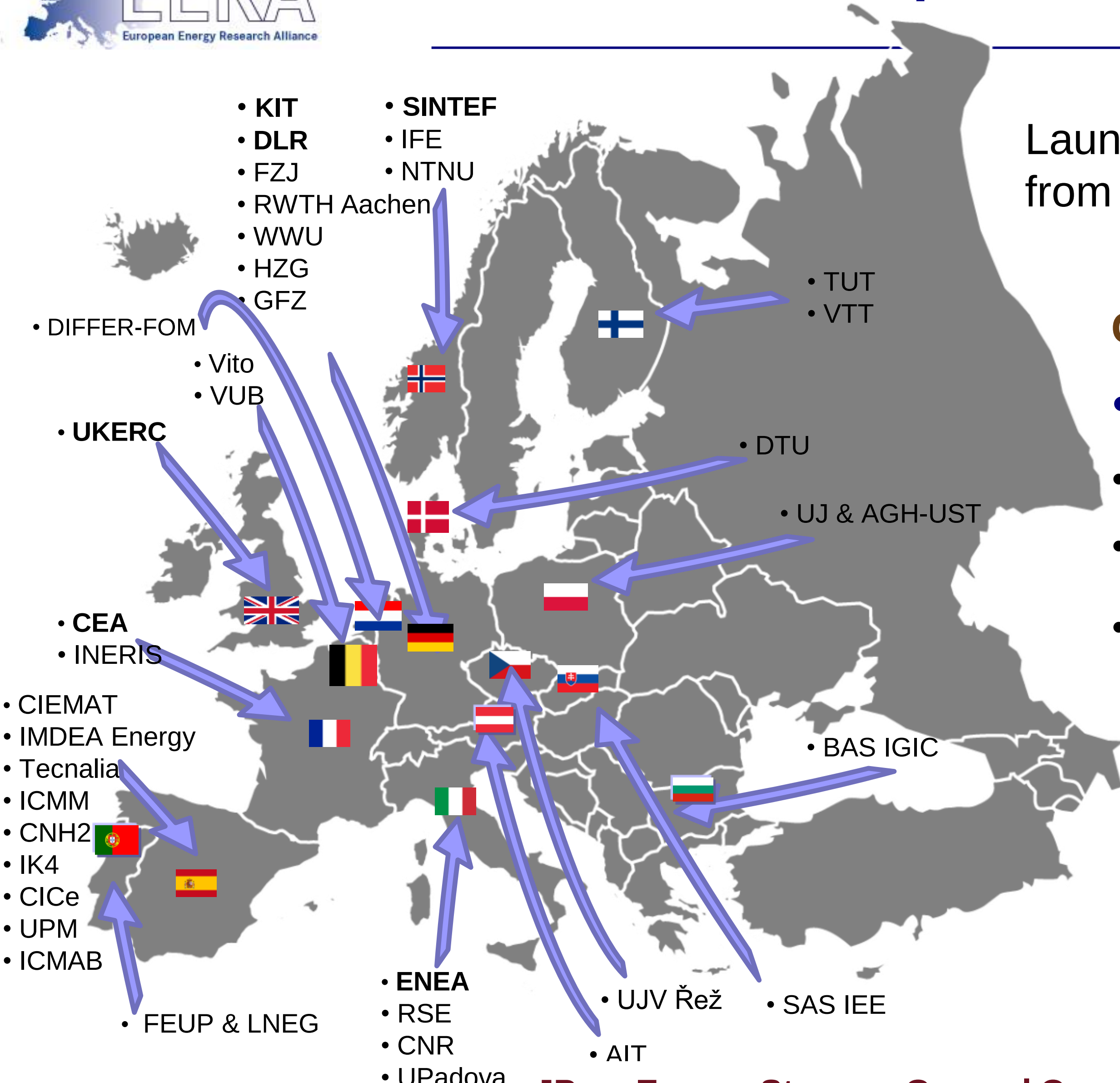
5) **Superconducting Magnetic Energy Storage**
(Mathias Noe, KIT)

6) **Techno-Economics** (Peter Hall, Grant Wilson
University of Sheffield)



JP ES coordinator: Hans Jürgen Seifert, Eberhard Diegele, KIT

Partnership and Resources



Launch Nov 2011: 26 participants from 12 EU-Member States

Current status 2013

- **39 participants**
- 32 full participants
- 7 associated participants
- from **16 EU member states**

Resources

committed

More than ***430 PY/Y***

Breakdown of Resources

Subprogramme	**Electrochemical Storage**	Chemical Storage	Thermal Storage	Mechanical Storage	Superconducting Magnetic	Techno-Economics
PY/Y	250	57	36	29	35	24
Participants	31	15	14	10	8	12
Countries	15	9	7	6	6	7

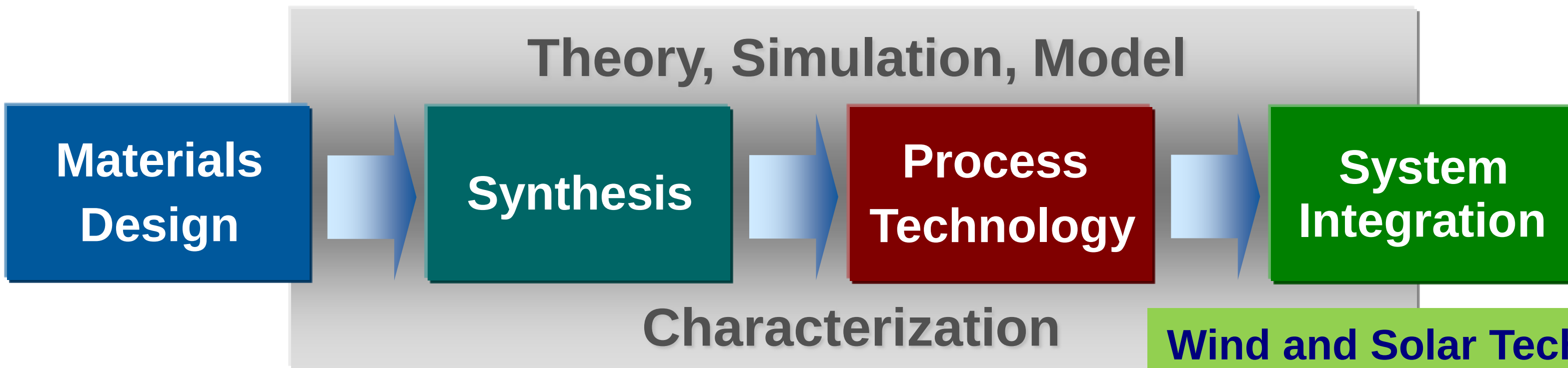
~ 60%

Total 430

The JP ES is on a good way to be established as one of the most important European research networks on energy storage

EERA JPES – Vision (one of many others)

Establishing European Platform for
Integrated Energy Storage Simulation (IESS)



Wind and Solar Technologies, Smart Grids, Electro- and Hydrogen Mobility, Industrial Processing, …

Comprehensive Interdisciplinary Engineering by Design and use of Modeling and Simulation before processing starts in the lab or in industrial operation

Achievements

Road Map as joint effort with EASE

Numerous State-of-the-art reports and summaries

Joint EASE/EERA recommendations for a

European Energy Storage Technology Development Roadmap towards 2030

Launch event of joint Roadmap
EERA & EASE
Brussels, 17th April 2013

EASE: *European Association for Storage of Energy*

Energy Storage Segmentation
Added Value to the Electric Chain

Electric Chain

Conventional Generation	Transmission	Distribution	Customers Services
Black start	Participation of the primary frequency control	Capacity support	End-user peak shaving
Arbitrage	Participation to the secondary frequency control	Dynamic, local voltage control	Time-of-use energy cost management
Suport to conventional generation	Participation to the tertiary frequency control	Contingency Grid Support	Particular requirements in power quality
Renewable Generation	Improvement of the frequency stability of weak grids	Intentional islanding	Continuity of energy supply
DG Flexibilty	Investment deferral	Reactive power compensation	Limitation of upstream disturbances
Capacity firming	Participation to angular stability	Distribution power quality	Compensation of the reactive power
Limitation of upstream perturbations		Limitation of upstream perturbations	

As identified in the Roadmap

Actual State-of-the-Art Repartition

Electric Chain

Technologies aggregate in focus	Conventional generation	Renewable Generation	Transmission	Distribution	Customers services
Hydro energy storage	Suitable	Possible	Suitable	Unsuitable	Unsuitable
Compressed air energy storage	Suitable	Possible	Suitable	Possible	Unsuitable
Electrochemical	Possible	Possible	Possible	Suitable	Suitable
Chemical	Possible	Possible	Possible	Unsuitable	Possible
Electrical-magnetic or Flywheels	Unsuitable	Possible	Suitable	Suitable	Unsuitable
Thermal energy storage	Unsuitable	Possible	Unsuitable	Possible	Suitable

As from Roadmap – *(Some ratings, i.e. colours, are a matter of personal view)*

Achieved Deliverables (1st year)

State of the art Reports

- **SP2 – Chemical Storage: State of the Art report on chemical fuels**
- **SP2 – Chemical Storage: State of the Art report on gaseous and liquid hydrogen storage**
- **SP3 – Thermal Storage: Review of currently used small scale TES systems**
- **SP4 - Mechanical Storage: Overview of the existing grid and possible future development of connections between countries in Europe**
- **SP4 – Mechanical Storage: State of the art: Flywheels Report**
- **SP4 – Mechanical Storage: State of the art: CAES Report**
- **SP5 - SMES: Progress Report on "Low AC loss conductors"**
- **SP5 - SMES: "LIQHYSMES - Hybrid Energy Storage Combining Liquefied Hydrogen and Superconducting Magnetic Energy Storage for the Large Scale Integration of Variable Renewable Energy Sources"**
- **SP6 - Techno-Economics: Baseline Data on existing stores of energy**

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EERA JOINT PROGRAMME DELIVERABLE DRAFT REPORT
EERA Joint Programme on Energy Storage
Sub-Programme 6: Techno-Economics
M6.1 Baseline Data on existing stores of energy

EERA JOINT PROGRAMME DELIVERABLE
EERA Joint Programme on Energy Storage
SP2 – Chemical Energy Storage
State of the Art report on gaseous and liquid hydrogen storage

EERA JOINT PROGRAMME DELIVERABLE DRAFT REPORT
EERA Joint Programme on Energy Storage
Sub-Programme 3: Thermal Energy Storage
M3.8 Review of currently used small scale TES systems

EERA Joint Programme on Energy Storage
Milestone 5.3 Progress Report on "Low AC loss conductors"
January, 2013

"LIQHYSMES - Hybrid Energy Storage Combining Liquefied Hydrogen and Superconducting Magnetic Energy Storage for the Large Scale Integration of Variable Renewable Energy Sources"
Progress Report R5.2
March 2013

Overview of the existing grid and possible future development of connections between countries in Europe
Deliverable M 1
April 2013

EERA Joint Programme on Energy Storage
SP2 – Chemical Storage
State of the Art report on chemical fuels
Milestone M2- Deliverable D2.1

Information on selected Sub-Programmes

- Homepage: www.eera-set.eu/index.php?index=79

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Information on selected
SP1 - Electrochemical Storage

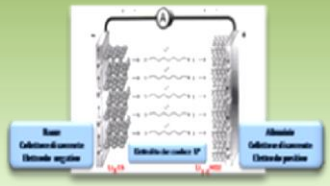
SP1, Electrochemical Storage - Objectives

1. • Creation of a strong European research network.
2. • Identification of key performances and specific research needs.
3. • Selection and investigation in a coordinated manner of key materials.
4. • Application of modelling and simulation.
5. • Formation of young researchers on material research, cell preparation and testing.
6. • Development of pre-normative joint horizontal activities.
7. • **Preparation of joint roadmaps for further research and development of materials**.

   e.g. EU Integrated Energy Roadmap
   Under progress this year
8. • **Preparation of joint research projects and selected consortia**.

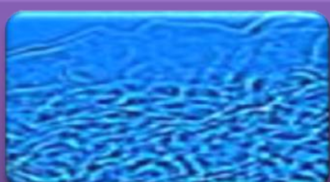
   Near future, after EC launch of WP 2014-15

SP1, Electrochemical Storage - Work Breakdown

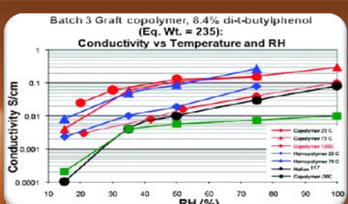


WP1: **Lithium-based batteries**: novel materials, design, integration and safety through lab characterizations

WP2: Supercapacitors: materials, advanced design, hybrid configurations, cost reduction, characterization



WP 3: Advanced and alternative power systems: basic materials and design study for Metal-air, Liquid Metal, Redox flow, Mg, Solid state batteries



WP4: Supporting activities: <u>testing procedures, integrations, modelling</u>

Batteries R&D status and future roadmap

- SV batteries
- LTO
- New anodes
- SV + new anodes
- Electrolytes
- ....

- Li-S
- Li-Polymer
- Li-Solid electrolyte
- Zn-Air
- Li-Air

- Na-Ion
- Redox flow organic
- Molten metal
- Al, Mg?

New material needs by 2020	
LiMnNi(Co) oxides $LiNiPO_4$ $LiCoPO_4$ $LiVPO_4$ + others	class cathode materials 4,5 - 5V
LTO C/Metal composites Si, Sn-intermetallics	class high capacity nem anodes
additives electrolyte SV electrolytes	stable electrolytes

<table>
<tr><th colspan="2">New material needs by 2030</th></tr>
<tr><td>Li and Sulphur, improved conductive polysulphides</td><td rowspan="3">- Na-Ion materials
- new redox flow systems materials
- molten metal/salt systems
- introduction of Al or Mg in metal-air, metal-sulphide or ion based systems</td></tr>
<tr><td>Development of new solid electrolytes (non-polymer)</td></tr>
<tr><td>Development of correctly rechargeable Zn or Li-anodes, electrolytes and air cathodes</td></tr>
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Information on selected

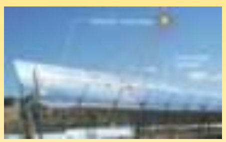
SP2 - Chemical Storage

Hydrogen, Methanol, Ammonia

SP2 - Chemical storage : Vision

Production

Distributed Solar Energy Generation



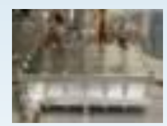
Centralized Nuclear Power Generation

Storage

Electrochemical Thermal, mechanical, superconducting …

Chemical storage

Hydrogen (gaseous, liquid and solid form)



Others chemicals (NH3, carbon based,…)

Demand

Industry
Energy suppliers

Hydrogen
& hybrid vehicles

Fuel Cells

Electric, hydrogen
& hybrid vehicles

SP2 Chemical Storage – Work Breakdown

Electricity

Heat

Inlets (water, $CO_{2,..}$)

Energy Conversion Systems

WP 1 – Hydrogen for Energy Storage (CEA,CNH2,CNR,ENEA,KIT,…)
1. Gaseous and liquid hydrogen storage
2. Solid hydrogen storage

WP 2 – Other Chemicals for Energy storage (*UKERC, CEA, CNR, DTU*)
1. NH_3
2. Other synthetic fuels: MeOH, HCOOH,CH_4

Energy Conversion Systems

WP 3 – Towards Multicriteria Evaluation (*CEA*)
1. Identification of criteria
2. Multicriteria evaluation methodology and database creation
3. Implementation / analysis

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Information on selected
SP3 - Thermal Storage

- Homepage: www.eera-set.eu/index.php?index=79

THERMAL ENERGY STORAGE

MOTIVATION

- Thermal energy storage is essential for effective and efficient generation and utilisation of heat where heat supply and heat demand do not match
- => Key element for fuel saving and climate protection
- Few storage technologies in high temperature range > 100 ºC commercially available
- => too expansive for broad application
- Different applications require specific solutions concerning heat rate, capacity and system integration
- Development of innovative high temperature storage technologies required

Thermal Energy Storage

Existing high temperature storage technologies

Commercially available > 100 ºC:

– Hydraulic accumulator up to 150 ºC
– Ruth‘s – steam accumulator ca. 100-300 ºC
– Regenerator/Cowper Storage > 500 ºC
– Molten salt storage up to 400/565 ºC

District heating, Theiß, Austria

Steam accumulator, Aerated concrete manufacturing

Cowper storage, blast furnace industry

Molten salt storage, Andasol power plant, Spain

Thermal Energy Storage

Objectives

Overall objectives are:

- to provide cost effective, efficient and reliable heat storage systems
- to contribute to more wide-spread use and market penetration of the technology in the domestic, industrial and power generation sector

⇒ **cover all types of heat storage technologies: sensible, latent and thermochemical storage**

⇒ **Main goal is cost reduction**

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THERMAL ENERGY STORAGE

RESEARCH NEEDS

Research Needs

- Development of advanced storage materials - sensible, latent and thermochemical - with increased energy density of storage
- Identify advanced heat transfer mechanisms for charging and discharging
- Development of advanced storage for solarthermal power plants
- Development of multi-functional materials combining heat storage, heat transfer and heat transformation
- Integration of phase change materials in building element materials
- Development of electrically heated thermal storage for PV self consumption

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Information on selected
SP4 - Mechanical Storage

Mechanical energy storage with focus on hydropower
– status and future development
By Atle Harby - this workshop (Thursday morning)

Compressed Air Energy Storage (CAES)
By Jihong Wang - this workshop (Friday morning)

Information on selected
SP6 - Techno-Economics

Evaluating the Economics, Social Benefits and Technology Needs of Energy Storage

By Peter Hall, Sheffield University, Sheffield. UK.

This Workshop

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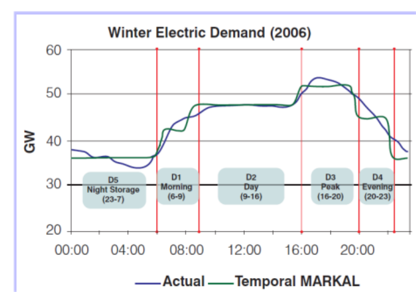

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