



# Energy Storage – Enabling a Zero Carbon Future?

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# Aims and Objectives

AEA Group commissioned by the European Parliament's committee on ITRE

- Aim: to Review energy storage technologies

- Objective: Assess the most promising technologies for network electricity storage and transport applications.
  - Economics
  - Environmental issues
  - Carbon saving potential
  - Technical, commercial, regulatory and policy issues
  - Relevance and adequacy of current European R&D effort

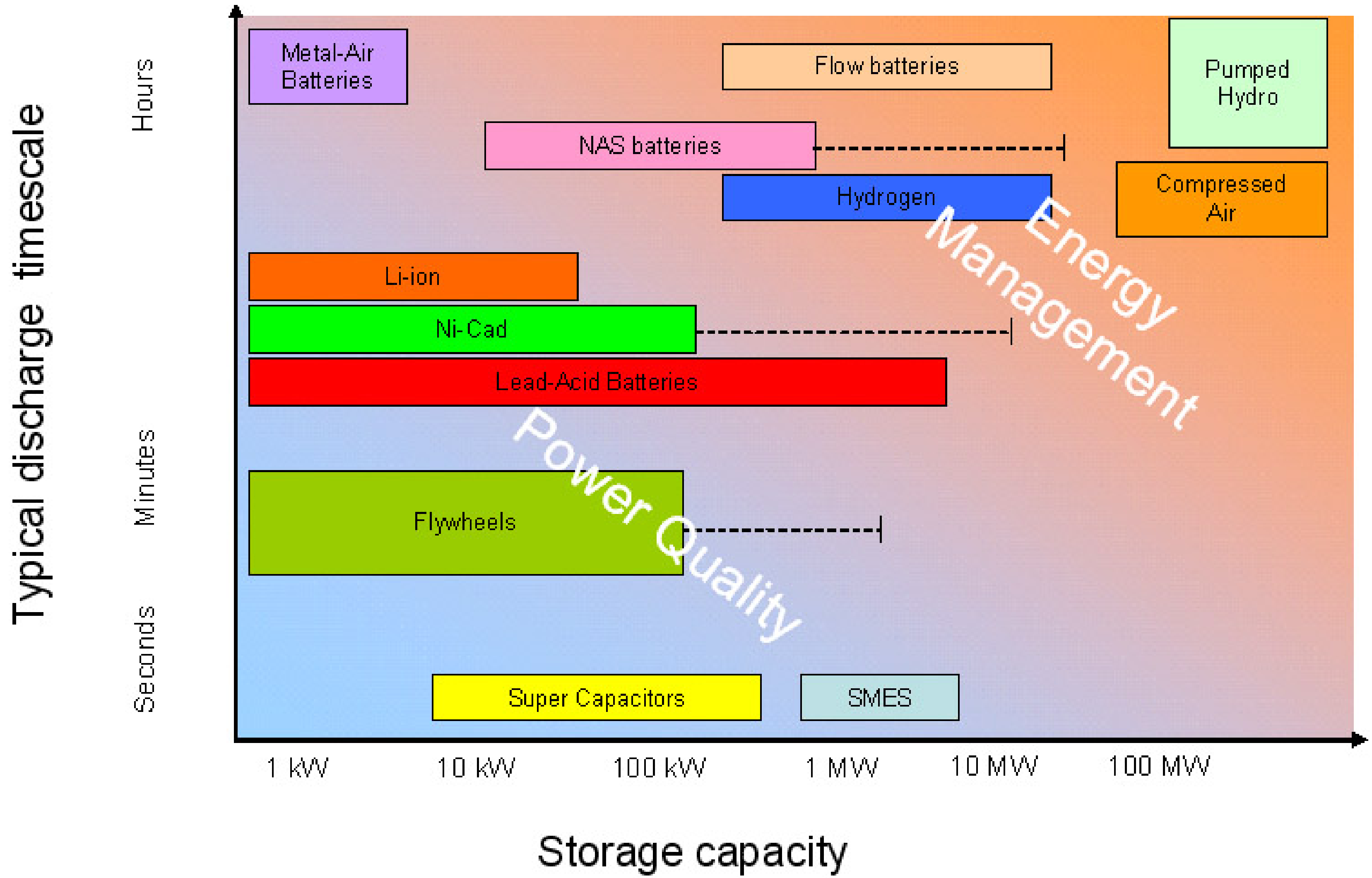
# Process

- Categorise the available technologies into the services they can supply
- Determine the most promising technologies in each area
- Present case studies for the application of these technologies
- Review European research in the energy storage area and set in the context of world wide research
- Assess the technical, commercial, regulatory and policy issues
- Conclusions and recommendations for future actions

# Why energy storage?

- Energy storage can have a broad meaning
- Traditionally, electricity systems have stored energy in the form of fuel for an electricity generator:
  - Coal
  - Oil
  - Gas
  - Nuclear
  - Gravity (hydro power)
- Because of the nature of low and zero carbon energy sources this may have to change
- Renewable energy sources are zero carbon but many are not storable at a power generation site – they are intermittent in nature
- Use when available to generate electricity (or hydrogen?) and store

# Energy Storage Technologies



# Range of storage technologies

- Advanced batteries
  - Sodium sulphur batteries
  - Lithium ion batteries
- Electrochemical
  - Vanadium redox flow
  - Supercapacitors
- Mechanical
  - Flywheels
- Fluid
  - Pumped storage
  - Compressed air
- Electro-magnetic
  - Superconducting magnetic
- Hydrogen

# Potential future roles for energy storage technologies

1. Increasing the value of intermittent renewables in energy markets
2. Facilitating stable operation of low or zero carbon electricity networks
3. Transport applications

# Electricity System Basics

- A.C. Electricity systems must match supply with demand on a continuous basis to maintain system stability
- The grid operator procures a range of services to ensure stability
  - Power quality services
  - Energy management services
  - Spinning reserve
  - ‘Hot’ plant
  - Reserve

# Low and Zero Carbon Grid Characteristics

- A low or zero carbon grid will rely on various forms of renewable energy and possibly nuclear power to generate electricity
- Many renewable energy sources are intermittent in their output – the energy produced fluctuates both on a short and longer term timescale
- Nuclear plant for technical and economic reasons operates as base load (continuous output)
- To maintain grid stability there will need to be flexible plant to ensure supply is matched to demand
- Options:
  - Open Circuit Gas Turbines
  - (Clean?) Coal Plant
  - Biomass
  - DSM
  - Energy Storage

# Relevance of current EU research and development

- Current R&D in the area of energy storage does not appear to reflect the potentially key role that electricity network energy storage may be able to play in enabling a cost effective low or zero carbon electricity system with full utilisation of intermittent renewable energy electricity generation
- The focus of R&D in the recent past has been on heat storage and in the area of transport batteries and fuel cells.  The latter area is now close to market and best be driven by legislation, mobilising the resources and financial strength of the automotive industry
- Given the combined commercial, regulatory and technical barriers to the development of electrical network energy storage identified, we endorse the priority given to this area of research in the Commission Communication COM(2007) 723.

# Conclusions:  Grid – RES targets

1. Network-scale electricity energy storage does not have to be a requirement for delivering the EU 2020 and 2050 renewable energy targets but…..
2. Cost-effective electricity energy storage is likely to allow the delivery of the targets at a reduced overall cost and enhanced grid flexibility
3. The present range of renewable energy support mechanisms being applied in the EU affects the way that the costs of managing intermittency are attributed within the energy markets – this leads to uncertainty for storage

# Conclusions:  Electricity markets

1. Currently the European electricity market remains fragmented. The inconsistent operational and regulatory approaches, and different markets, have variable consequences for energy storage. The result is a lack of clarity on who is responsible for bringing forward energy storage technology solutions and whether they should be at the project level, the network level or a combination of both
2. The necessary operational management and regulation of electricity networks across the EU is likely to place energy storage technologies at a disadvantage unless their value within these networks clearly exceeds their costs.  At present there is little practical experience or knowledge of how energy storage technologies might be valued within these networks.

# Conclusions: Transport & Overall

**Transport**

1. Energy storage technologies for the transport sector are already a cost-effective solution for some applications
2. Application of these technologies in the transport sector can be expected to increase in the face of high fuel costs and an increasing emphasis on European emissions regulation through voluntary or other means

**Overall**

1. The deployment of hydrogen-based systems for storage should remain a long-term goal within the electricity and transport sectors

# Recommendations - Grid storage

1. European research on energy storage should be more clearly focused on the key technologies
2. Work should be undertaken to confirm possible options for the stable operation of European electricity networks with very high penetrations of renewable energy (and possibly nuclear generation) in line with the 2020 and 2050 energy targets
3. The EU should investigate ways of supporting field trials of network scale electricity energy storage devices
4. Work should be conducted to assess the impact of electricity network management and regulation requirements on the future prospects for energy storage
5. The effects of renewable energy support mechanisms on electricity energy storage should be assessed

# Recommendations - Transport

1. EU research support should continue to reflect the long-term goal of hydrogen-based systems for storage making a major contribution to the electricity and transport sectors
2. The wider deployment of existing BEV and HEV energy storage technologies across the EU should be monitored, and should be encouraged in Europe-wide dialogue with vehicle manufacturers.

# Summary

- The study has reviewed the status of energy storage technologies from technical, economic, regulatory and policy perspectives, to establish how they can contribute to addressing the EU's key policy challenges of energy security, RES deployment and greenhouse gas emissions reduction.
- We have focussed on energy storage for:
  - electricity networks and their operation - particularly in terms of the management of networks with large percentages of intermittent renewable energy generation
  - transport.

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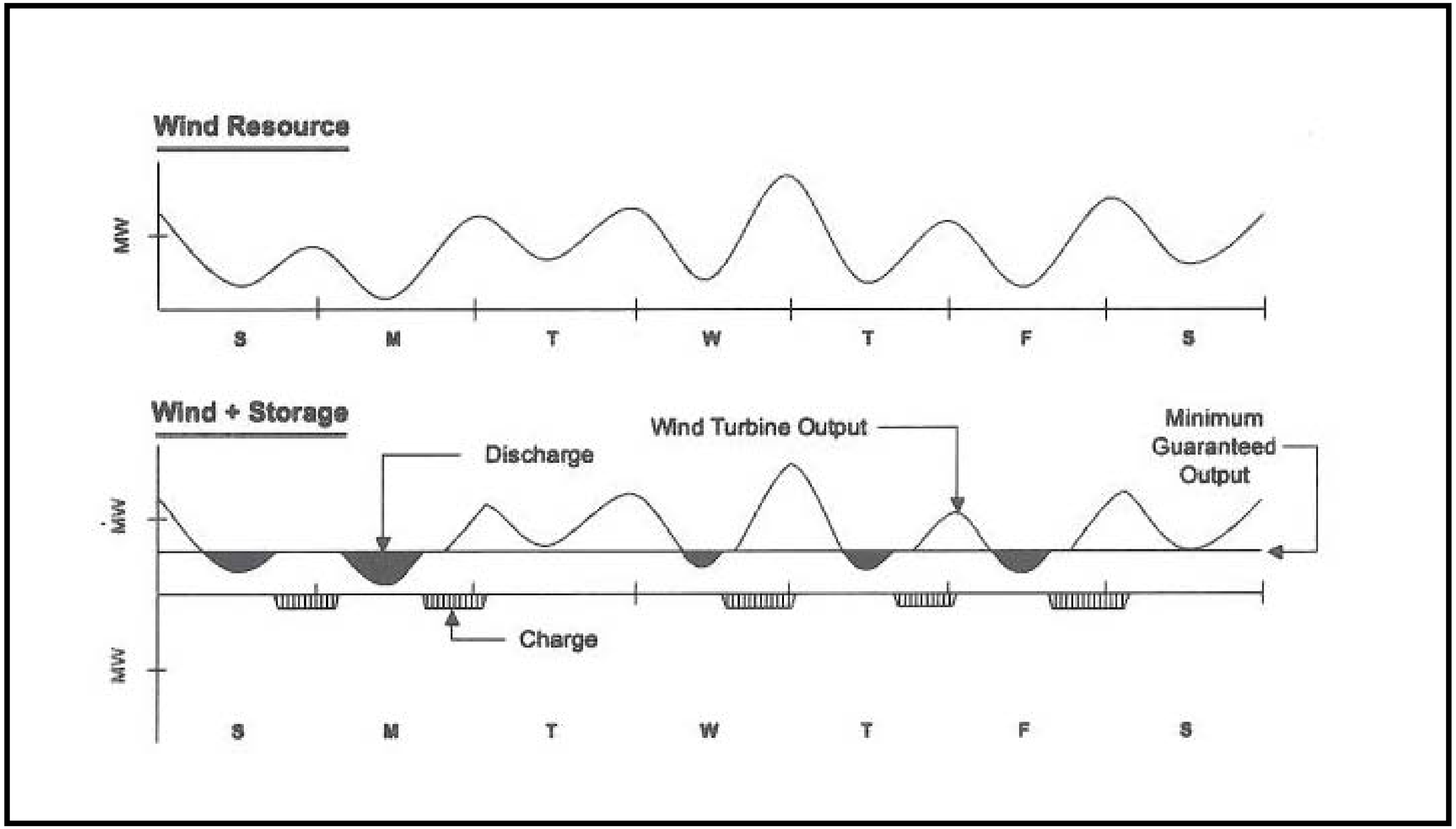
# Making Intermittent Renewables ‘Dispatchable’

- A.C. networks must match supply with demand
- Electricity markets place a premium on accurate forecasting of output into the future
- Intermittent renewables (e.g. wind, solar) cannot forecast accurately beyond an hour or so
- Energy storage can be used to make intermittent renewables ‘dispatchable’ – able to deliver a given quantity of energy at a particular time in the future and hence have ‘capacity’ value
  - Value placed on ‘dispatchability’
  - Penalties for not generating or generating at times of low demand
  - Cost of energy storage technology
  - Sorne Hill wind farm in Ireland – proposal is to make a 6MW wind farm dispatchable using a 2MW electrochemical redox energy store (VRB)

# ‘Firming up’ intermittent renewable output




(Energy Storage, Baxter, 2006)