



Energy Storage:- the opportunity for Scotland

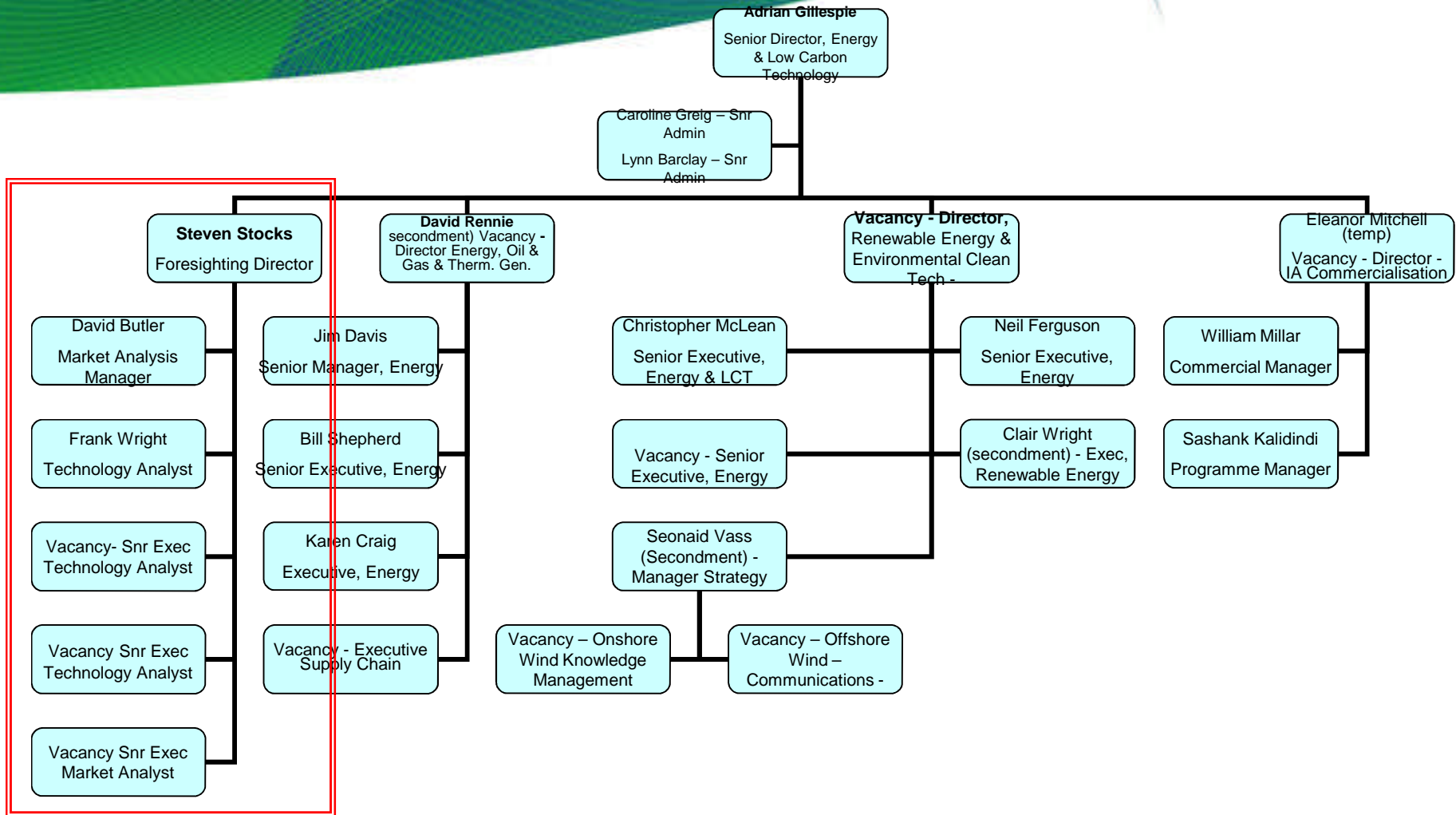
by

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Presentation to All-Energy 2010, Aberdeen, Scotland,
Wednesday 19th May 2010



Scottish Enterprise Energy & Low Carbon Technology Team



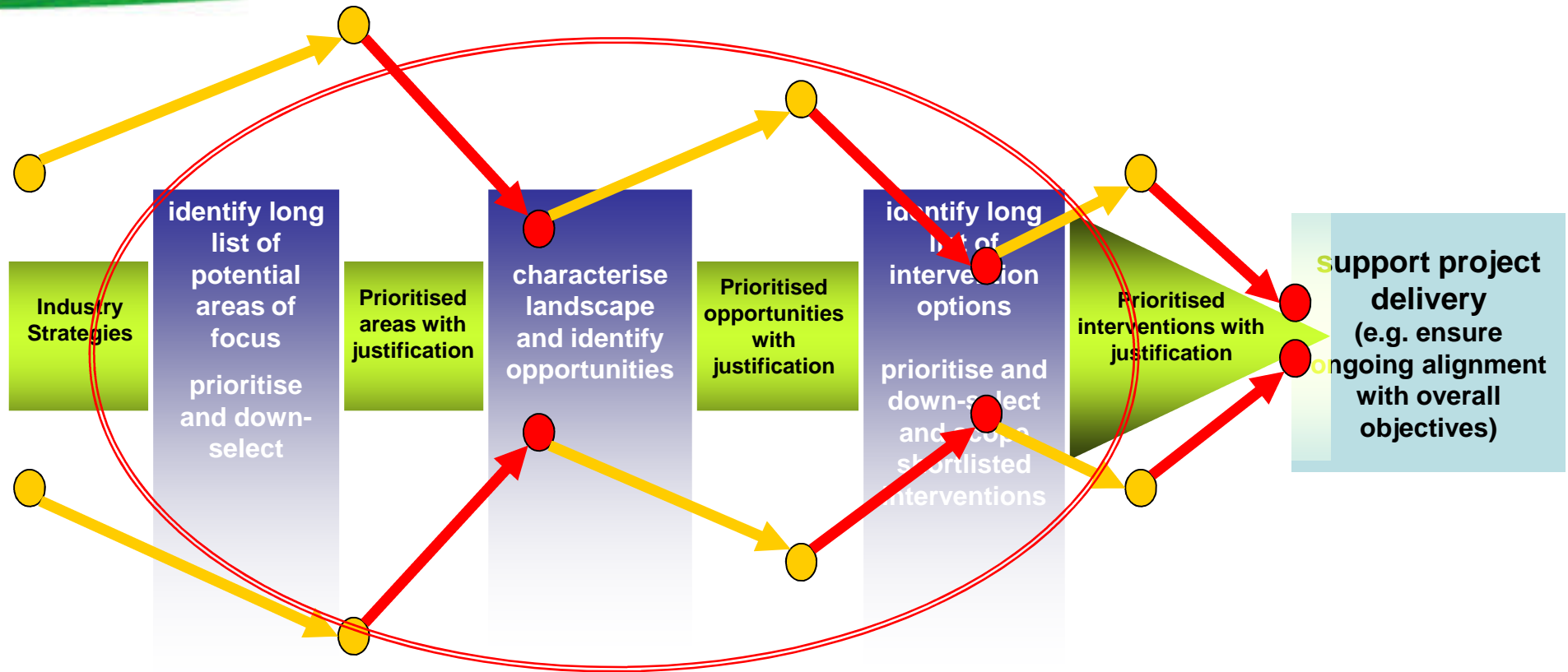
Previous Foresighting Focus Areas

- Mature Oil and Gas Assets (2004)
- Low Cost Renewables (2005)
- Future Power Networks (2005)
- Energy Storage (2005)
- Improved Reservoir Imaging (2006)
- Conventional Power Generation (2006)
- Materials for Hydrogen Storage (2006)
- Microgeneration (2006)
- Torrefied Biomass (2006)
- Power Electronics (2007)
- Non-grid Connected Micro-generation (2007)
- Condition Monitoring of Wind Turbines (2007)
- Advanced Blades for Offshore Wind (2008)
- Sustainable Transport Fuels (2008)
- Electric and Hybrid Electric Vehicles (2008)

Current Areas of Focus

- Off-shore Wind
- Carbon Capture & Sequestration
- Marine
- Energy Storage

Scottish Enterprise Foresighting Framework



Screening Criteria

Market Opportunity

- Size of market segments
- Market growth rates
- Importance of any unmet needs
- Underlying market trends/drivers
- Cost of new tech vs market price
- Speed of change in market
- Degree of competition
- Alternative tech in market
- Barriers to exit

Technology opportunity

- Disruptive/paradigm changing tech ?
 - Critical enabling technology ?
 - Clear benefits ?
 - Capital cost vs alternatives (inc all costs to adopt it)
 - Operating cost vs alternatives
 - Flexibility/adaptiveness (eg operating range)
 - Breadth of applicability
- Capabilities/benefits (what it offers – eg core product +)
- Environmental
 - Barriers to adoption (capital, know-how, land etc)

Ease of Commercialisation

- Time to market
- Cluster fit
- North Sea Region fit
- Cost to market
- Barriers to enter market
- Regulation
- Certification
- IP issues
- Denseness of IP
- Competitors' tech
- Incumbent technology
- Ability to influence market

Foresighting Outputs

- The identification of areas of opportunity for potential future economic development initiatives
- Inform industry strategy direction and development of key themes through identification of market trends and opportunities
- Inform programme delivery by contributing to due diligence and assessment processes
- Inform shaping and scoping of the current product pipeline
- Inform development and commissioning of Intellectual Assets
- Inform strategic direction
- Inform project prioritisation

Energy Storage Study Overview:

- Provides an insight into a structured programme of techno-economic market foresighting in relation to Energy Storage, performed on behalf of Scottish Enterprise;
- The work aims to inform and support Scottish Enterprise in their consideration of future supporting actions

Essential Terms-of-Reference

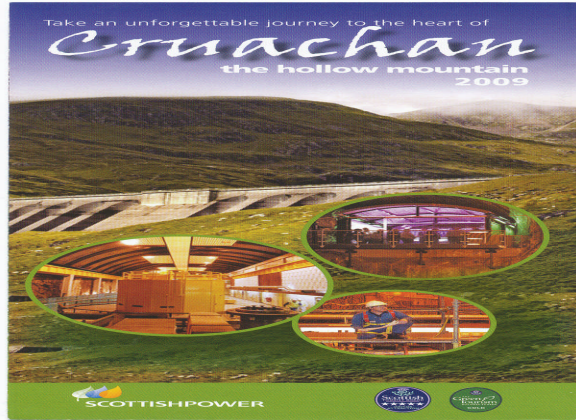
i. Market Sectors

- 1) Electrical power systems/renewables integration/SmartGrids
- 2) Electrification-of-Transport
- 3) Space heating
- 4) Medical
- 5) Consumer electronics

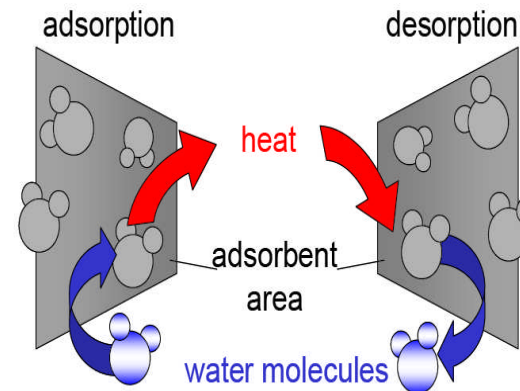
ii. Technologies

- Limited to “re-chargeable” systems and thereby excluding fuel storage systems, per se
- Coverage of a broad range of technologies and systems
- Recognition of the potential of hydrogen systems, but without in-depth assessment or coverage within present assignment

“Electrical” Energy Storage



“Thermal” Energy Storage



Source: ZAE-Bayern

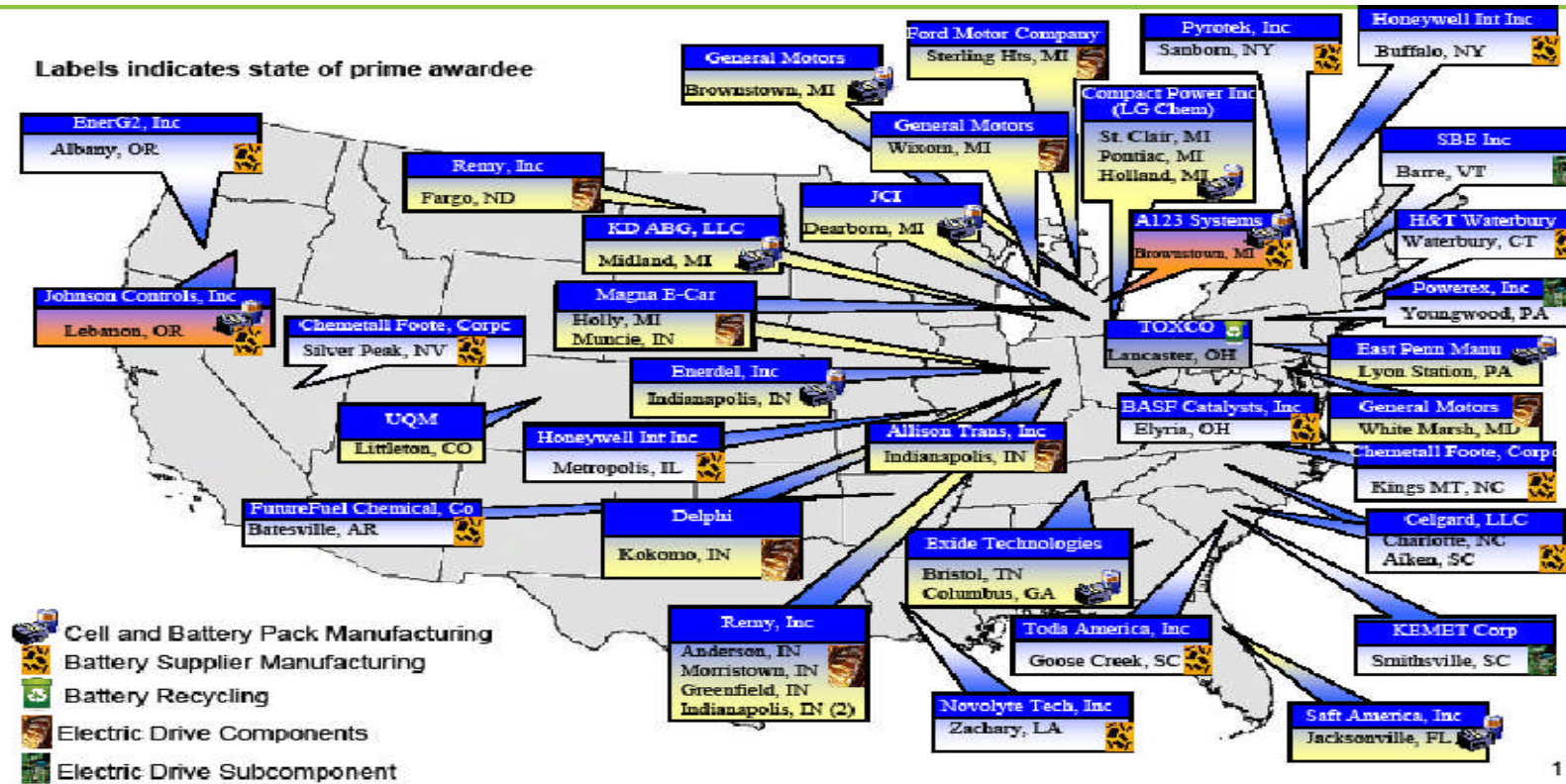
Market Needs Analyses

- **Completed for each of the 5 x market sectors identified**
- **Assessment via series of detailed matrix charts**
- **Supporting (qualitative) assessment of degree to which market needs are presently satisfied**
- **Degree of unmet needs in combination with market size/potential, provides an indication of the relative strength of the market drivers**

Market Analyses

- Detailed market analyses completed by EnerStrat Consulting in relation to the electrical power systems/renewables integration and Electrification-of-Transport sub-sectors;
- Such analyses indicate, in each of these two sub-sectors, \$ multi-billion revenue pool potentials over the next decade and beyond;
- Such market potentials are such as to sustain multiple suppliers in a global industry;
- Thereby represents a significant opportunity for Scotland

US DOE Battery Awards, October 2009



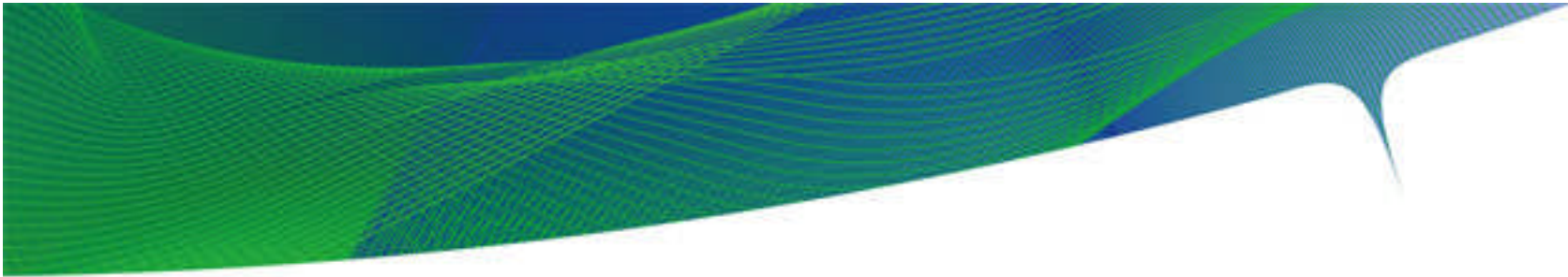
Source: US DOE, 5th August 2009

Technology Foresighting

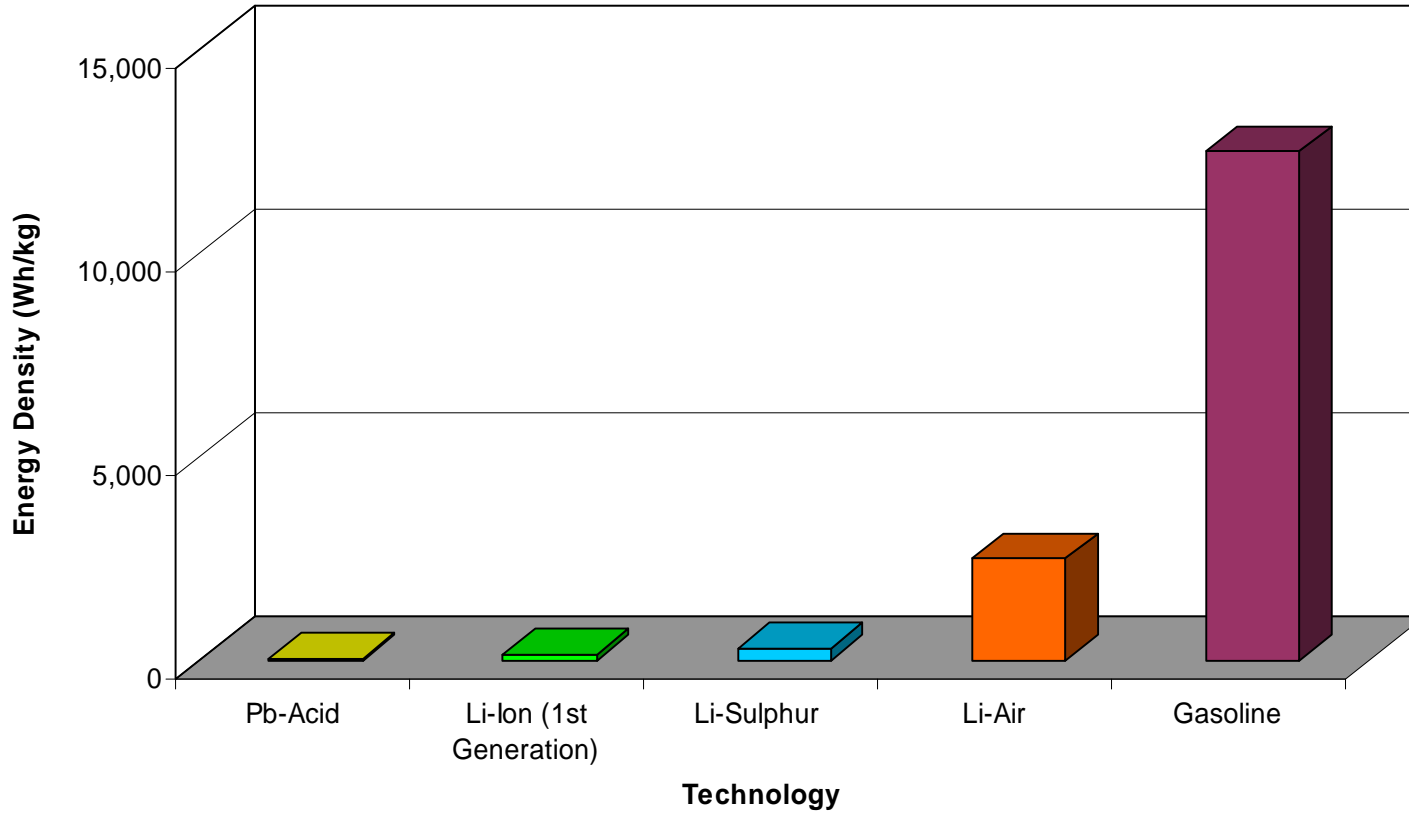
- **Diverse range of Energy Storage technologies available and/or under development, including:**
 - **“Electrical” energy storage technologies and systems**
 - **“Thermal” energy storage technologies and systems**
 - **Hydrogen technologies/systems**
 - **Others, including thermochemical systems and energy carriers**

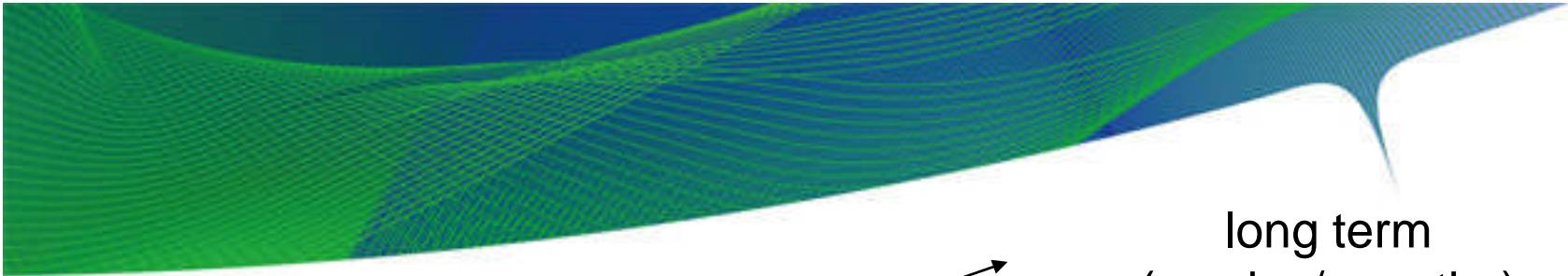
“Electrical” Energy Storage

- **Pumped-hydro**
- **CAES**
- **Thermodynamic cycle/heat engine**
- **Electrochemical**
 - Batteries
 - Flow cells
- **Electrolytic**
- **Kinetic energy storage**
- **Concentration cells**
- **Others**



Indicative Battery Performance Levels





short term
(hours / days)

long term
(weeks / months)

Storage Duration

Thermal Energy Storage

Storage Type

sensible
e.g. underground
tanked water

latent
e.g. PCM
ice

thermochemical
e.g. reversible reactions
water release from zeolites
fuel production



Opportunities Identification

- The first stage of the project allowed for the identification of a range of opportunities;
- These were then presented and discussed at a Stakeholder Focus Group Meeting, held Glasgow, 30th March 2010;
- Accommodation of Stakeholder feedback allowed for a “long-list” of potential opportunities to be derived

“Long List” Opportunities

- 22 “long list” opportunities were specifically identified and categorised under the following headings:-
 - Power utility/renewables integration/SmartGrids opportunity area (8);
 - Electrification-of-Transport opportunity area (3);
 - Research, business & industrial opportunity area (11).

Screening, evaluation and assessment

- The 22 “long listed” opportunities formed the input to a systematic programme of screening, evaluation and assessment, in relation to the following considerations:-
 - The available/accessible market opportunities;
 - The technology opportunities;
 - Ease of commercialisation in the Scottish context
- The subsequent assessment and peer review process led to the derivation of a “short list” of 5 specific opportunities, for further consideration by Scottish Enterprise, alongside other potential storage opportunities

Potential Areas of Opportunity

- Specific potential opportunities, identified for further consideration, included:-
- Adoption of a portfolio approach for the support of a series of lithium based battery developments;
- Demonstration, application and uptake of distributed electrical energy storage systems;
- Development of an indigenous developmental and demonstration facility for medium scale power utility electrical energy storage systems;
- Exploitation of the latent potential of the indigenous high penetration electric heating base “smart heating”;
- Investment/support for fully serviced battery test, qualification and approvals facility.

Conclusion:- Scotland's Energy Storage Industry, year 2020?

- ▲ Power Utility HQ
- ▼ Pumped-hydro storage
- ★ Technology development
- ◆ Cell/battery design & manufacture
- Academic R&D
- ⌋ Re-cycling facilities
- ⚑ Test and demonstration facilities



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