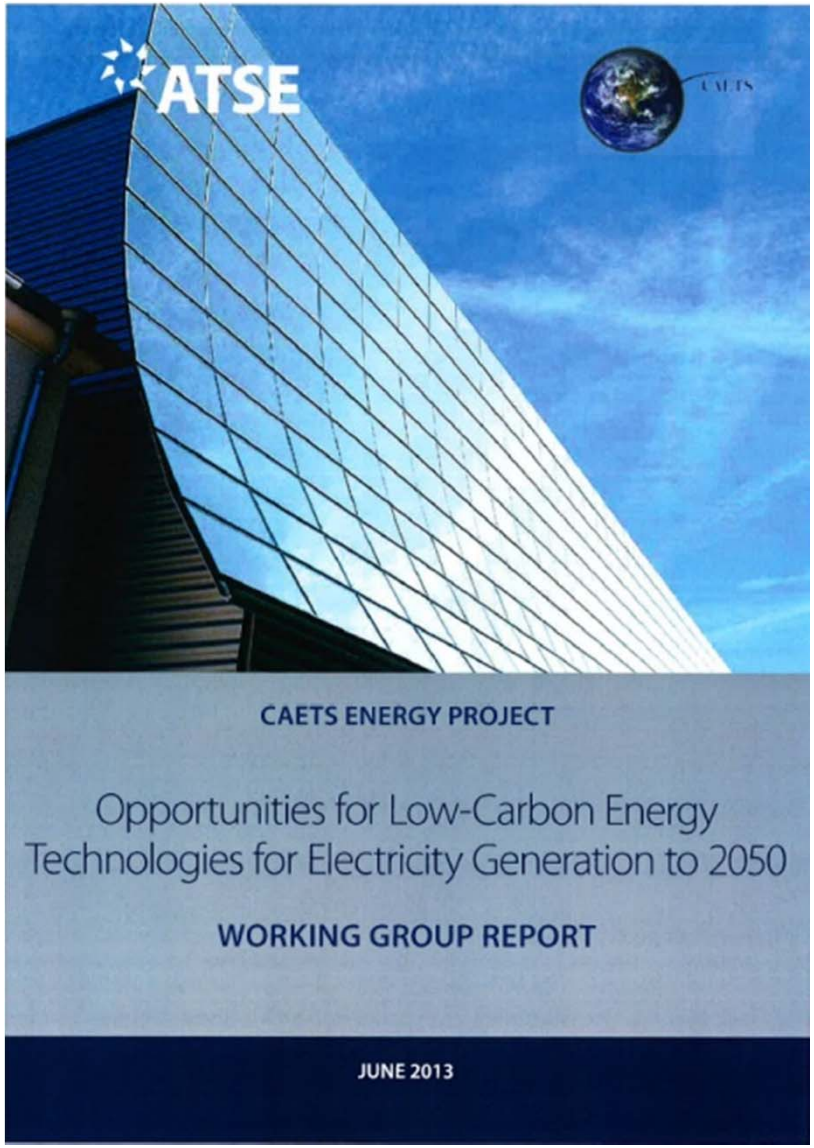
Opportunities for Low-Carbon Energy Technologies for Electricity Generation to 2050

CAETS Working Group Report

June 2013

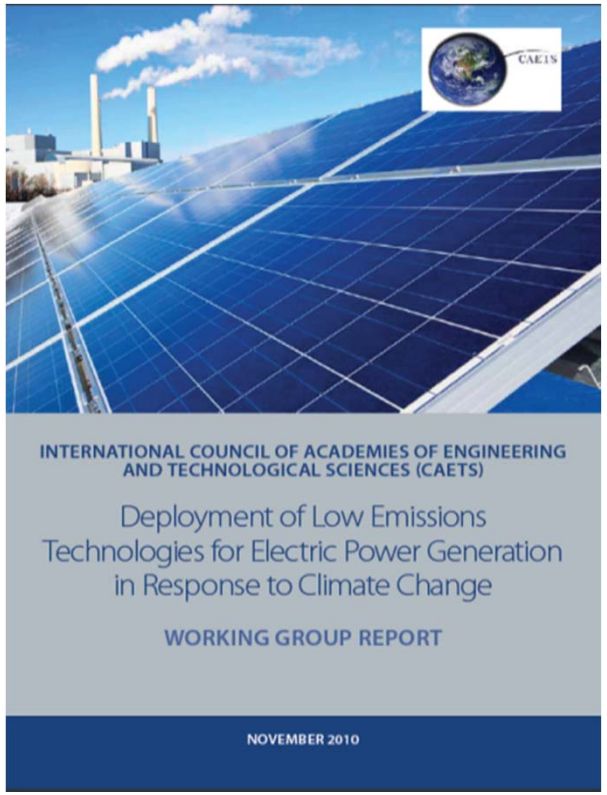


CAETS Background

- In November 2010, the CAETS Working Group Report *Deployment of Low Emissions Technologies for Electric Power Generation in Response to Climate Change* was published, following endorsement by CAETS at the Council Meeting, Calgary, July 2009.

- Report took a broad global perspective and considered detailed country overviews

- The 2013 WG report takes a broad assessment of LCE technologies and considers in some detail initiatives and risks



Working Group Members

- Dr Vaughan Beck, ATSE (Chair)
- Professor Frank Behrendt, acatech
- Professor Robert Evans, CAE
- Dr Philip Lloyd, SAAE
- Professor John Loughhead, RAEng
- Professor Myongsook Oh, NAEK
- Dr Baldev Raj, INAE
- Dr Maxine Savitz, NAE

Report Caveats

- A CAETS Working Group report
- “The views contained in the Working Group report are not necessarily endorsed by each member Academy of CAETS”
- Takes a global perspective on LCE technologies
- Observations not necessarily applicable to any one nation.

Report Contents

- Technology Costs
- Technology Assessments
- Technology Overviews
- Conclusions & Recommendations

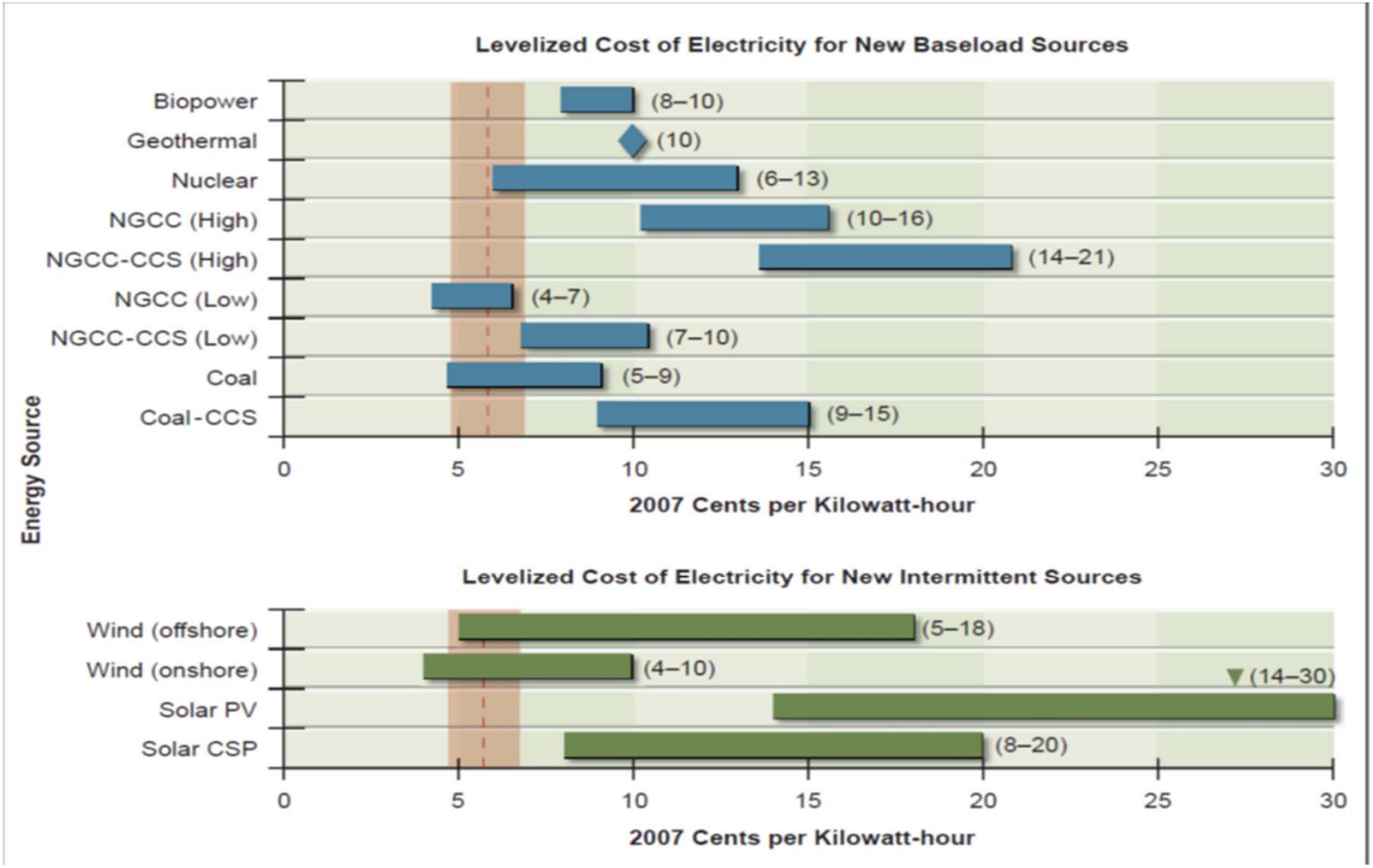
LCE Technologies Considered

Hydroelectric Power Generation	Biomass
Solar Energy	Gas
Geothermal Energy	Coal
Marine and Tidal Energy	Carbon Sequestration*
Wind	Nuclear Energy

Costs, Assessments & Overviews

Photo: iSTOCKPHOTO.COM

Technology Costs



Technology Assessments - Common Headings

Current Status	Investment
Key Initiatives	Timescale
Integration	Other Risks
Risks to Deployment	Technology Ranking

Technology Overview - Broad Findings

- Promising initiatives - investment and deployment
- Integration and combinations of technologies to accelerate investment and deployment
- Risks to deploy LCE technologies at scale
- Engineering challenges to deploy at scale
- Challenges facing industry and governments

Promising Initiatives

- Most LCE technologies require a substantial change to accelerate deployment
- Fossil fuels ~ 67 %of world electricity generation, then CCS is important for future viability
- Few commercial-scale operations that demonstrate the integrated CCS process
- An increasing carbon price trajectory over a 10 to 20-year period will assist commercial viability of such plants.

Integration & Combinations

- Such as combination of technologies (e.g. CCS in conjunction with fossil fuel power generation plants
- Pumped Water Storage. When excess - pump water into storage -use this to generate electricity when insufficient generation (e.g. from intermittent renewable sources).
- Solar Thermal (e.g. linear Fresnel Reflectors) can be used to heat feed water to fossil-fuel boilers – Hence reduce carbon emissions from electricity generation.

Key Issues

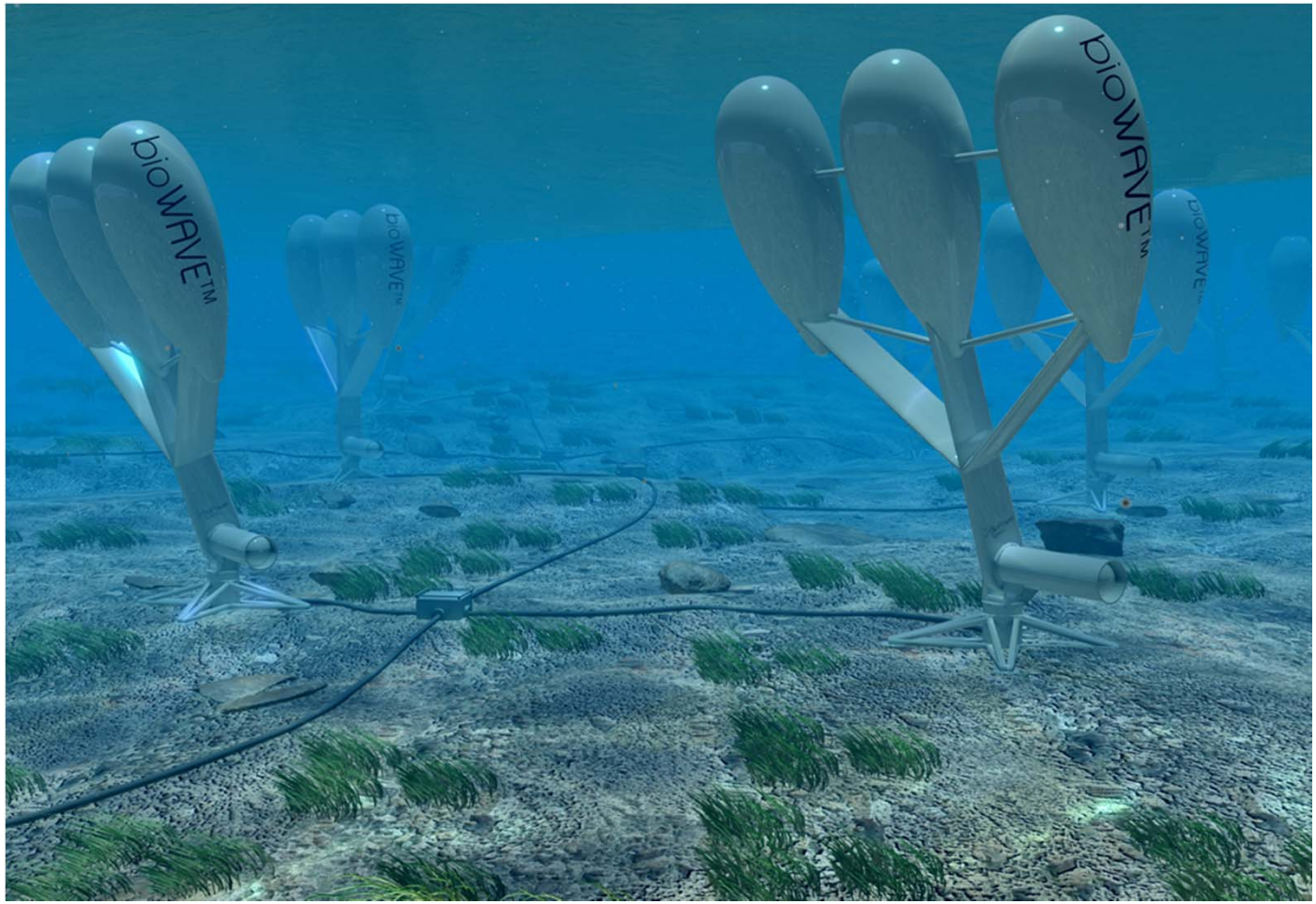


Photo: BioPower Systems Pty Ltd

Key Issues

Achieving a transition to a lower-carbon electricity generating system is technically feasible provided:

1. significant investments are made to scale-up the development and deployment of LCE technologies (including carbon capture and storage (CCS)) for electric power generation by the end of this decade; and

2. consistent and significant government policy action is taken immediately.

Key Issues (Part II)

- No single preferred LCE technology. Costs are expected to broadly converge over time. Hence a portfolio of technologies can be expected to be deployed.
- Promising initiatives for each LCE technology are identified, but significant technical and financial risks must be overcome.
- Opportunities identified for LCE technologies to be integrated with other LCE technologies or with fossil-fuel technologies to expedite commercial deployment.

Key Issues (Part III)

- Most LCE technologies do not have intrinsic commercial advantage - need sustained government support for research, development and deployment (RD&D).
- First-of-a-kind technologies have high risk and financial support is not readily available. Opportunities for government support - e.g. some form of subsidy (for example, cash or tax benefit).
- Even with support, major engineering challenges must be overcome to achieve a low-carbon electricity generating system.

Key Issues (Part IV)

- Substantial investments are required in new electricity generating plant. E.g. ~US$ 6.4 trillion is required over a 10-year period for electric power generation technologies.
- Successful deployment will normally require partnerships between research, industry and government. Appropriate policy settings can make a clear difference in inducing innovation &international diffusion of LCE technologies.

Conclusions & Recommendations

Photo: Stefan Moore: Energy from the sun – the National Solar Energy Centre, Newcastle

Observations - General

- Many LCE energy technologies in existence for years – but majority of generation is provided by fossil fuels. Proportion of LCE technologies will increase substantially, fossil fuels significant short & medium term.
- Risks & challenges to be overcome for widespread LCE commercial deployment.
- Most renewable technologies transform an energy source (e.g. solar) into electricity. As renewables increase - substitution of some current energy sources with electricity (e.g. for transportation, heating and industrial processes). Thus increase the importance of electricity and generation in the energy mix.

Recommendations

Report doesn't recommend development strategies or electricity generation technology mixes; the province of individual nations.

- GHG reduction is a global issue – hence international RD&D collaboration should be supported with adequate resources, particularly in critical areas such as CCS.
- Governments and industry collaborate on: strategic development & acquisition of skills and resources for R&D, manufacture, deployment and possible international diffusion of LCE technologies.

Use of Report

The report can be used by:

- **Academies:** engage with key stakeholders in their respective countries about strategies to facilitate deploy LCE technologies.
- **CAETS**: engage with relevant international organisations and inform them on:
  - Technical and financial feasibility of particular LCE technologies;
  - Promising initiatives that could be undertaken to accelerate their deployment; and
  - Risks to be addressed.

Issues Noted - Not Considered

- Traditional power systems challenged by the introduction of new LCE technologies.

  E.g. network issues - integration, intermittency and storage. Further, locally distributed electricity grids being developed & pose separate challenges.

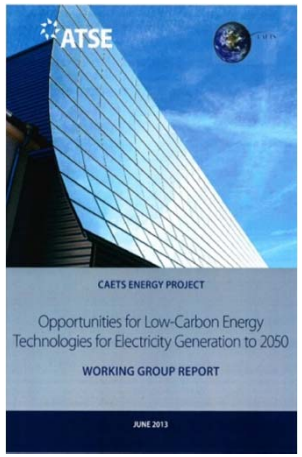
- Energy efficiency perhaps most cost-effective mechanism near term to lower GHG and new electricity generation capacity.

  This will provide window of additional time & opportunity for emerging LCE technologies to mature & become more cost competitive.

Future Project

- Energy Committee - formation
- The next topic: xyz.
- We invite other Academies to nominate a representative to the Energy Committee.
- Happy to discuss.

Thank You



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