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Innovation in solar research and development

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All Energy – Australian Solar Innovations

10th October 2012

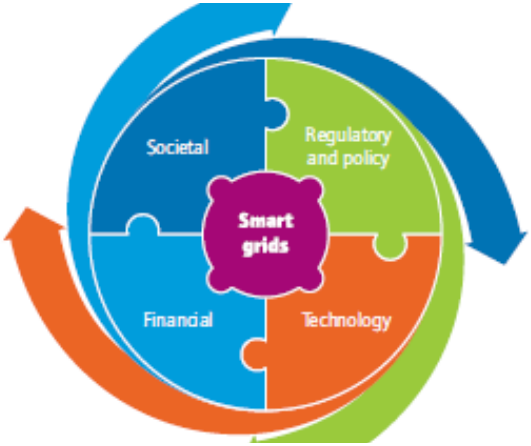



Summary

- Major trends
- Opportunities
- R&D Case studies from ASI's portfolio
- Policy and market drivers

Major trends shaping industry

- Solar growth and scale and associated policy cost debate now a mainstream topic
- Local costs now a major driver: PV device now <$1pW
- Technology – efficiency key to lower installed costs
- Business models and distributed generation regulation and policy settings critical factors
- Australian R&D critical part of global supply chain



Major Trends – Growth and Scale

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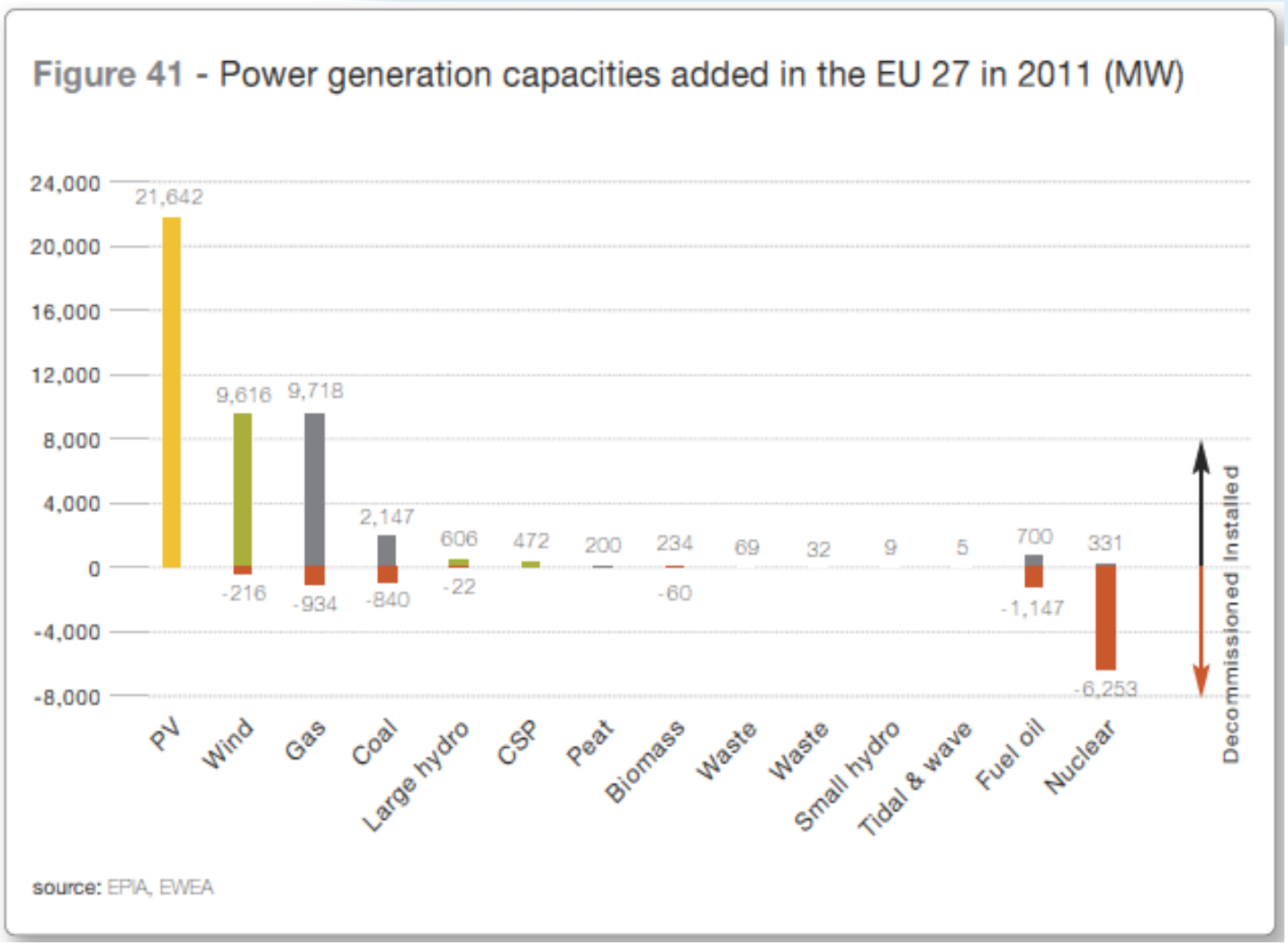
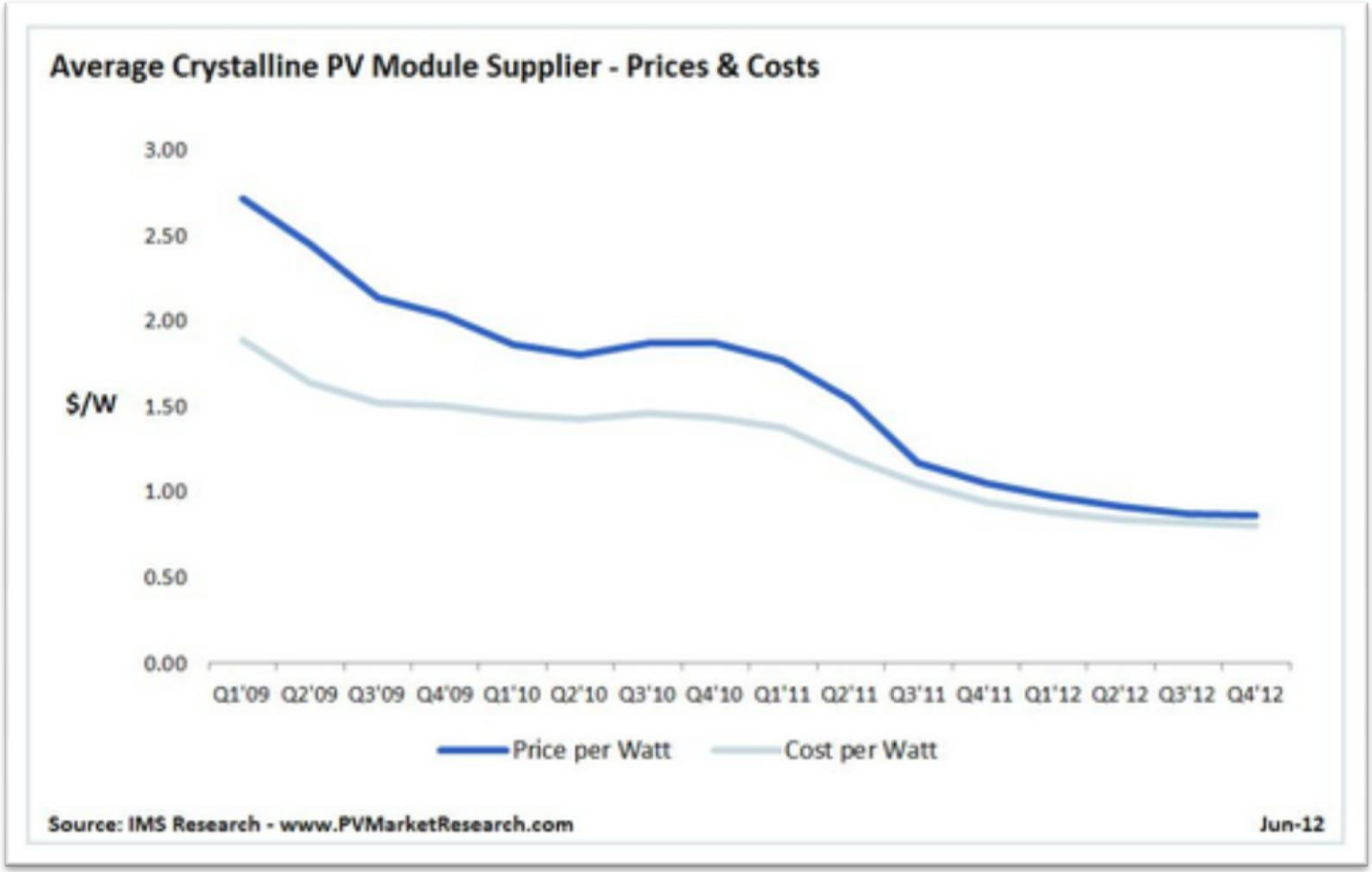


Major Trends
Is the price reduction sustainable?



Graphic courtesy of SolarBusiness (Nigel Morris)

Progress across the full set of costs is required to increase commercial viability and deployment

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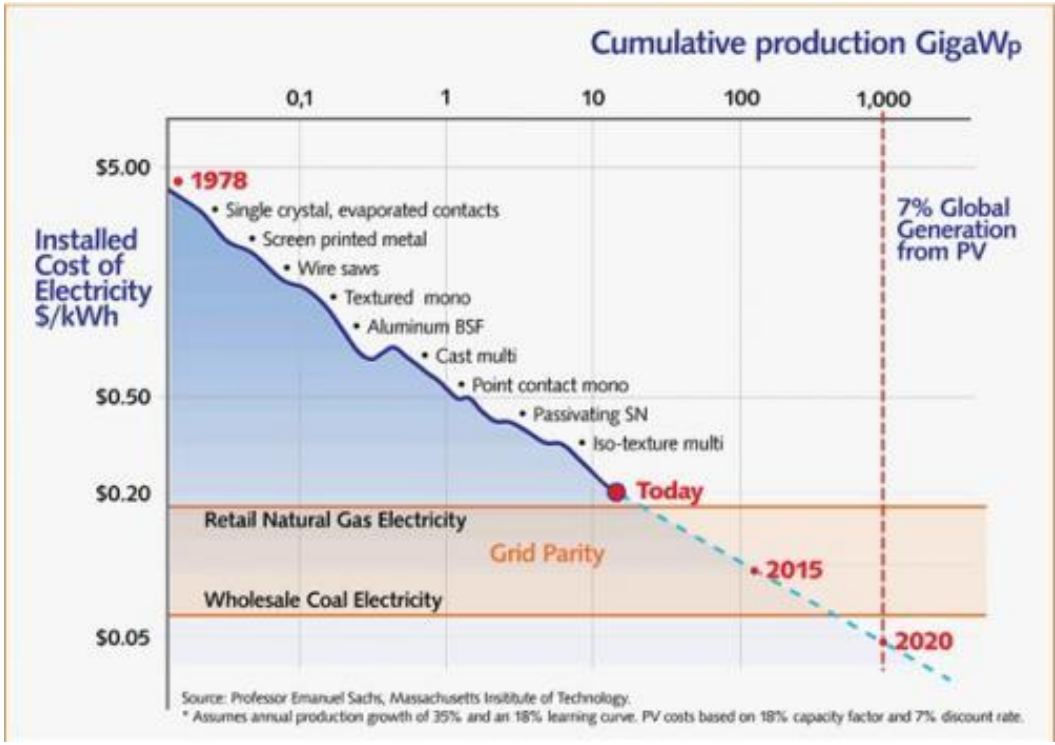
LCOE Drivers

- Finance Channel Margins
- Other Hardware, Civils, Install , Land, O&M
- Solar Device

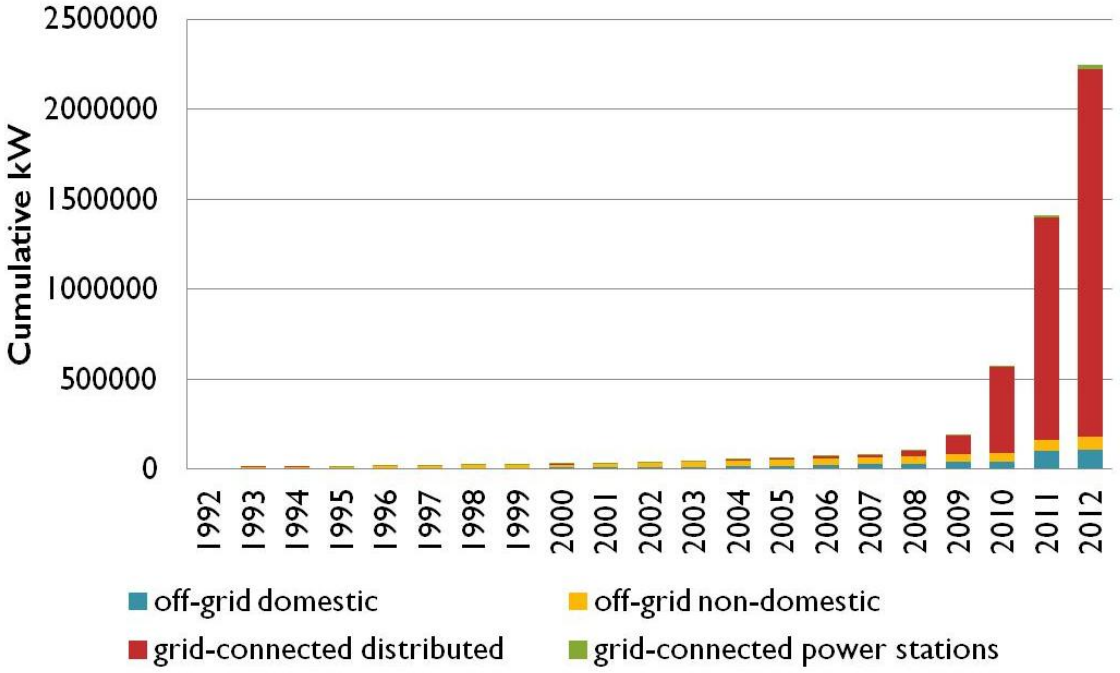
Local costs
70-80% of employment in these areas

Global costs
Technology IP key value

PV LCOE now <$200MWHr



Australian PV Market



The latest APVA figures show treble the growth vs. 2004 aspirational predictions

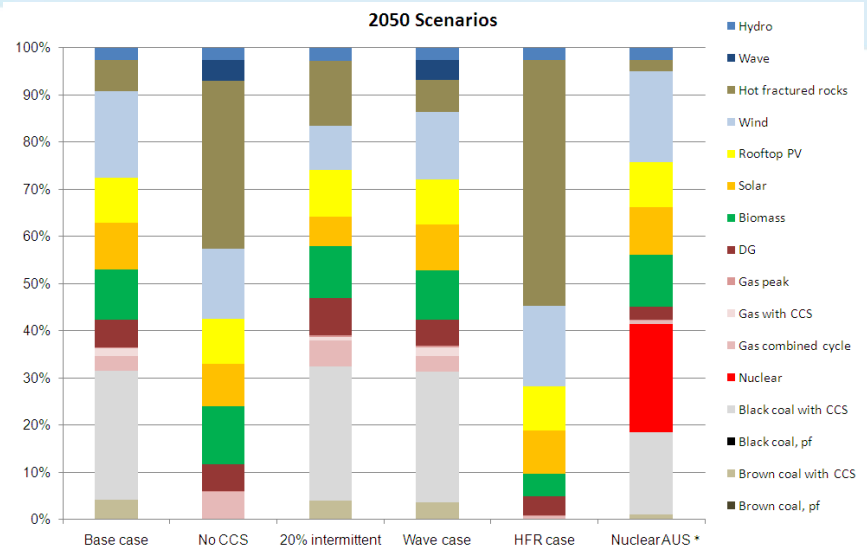
Source Dr Muriel Watt, APVA 2012

Sunrise targets

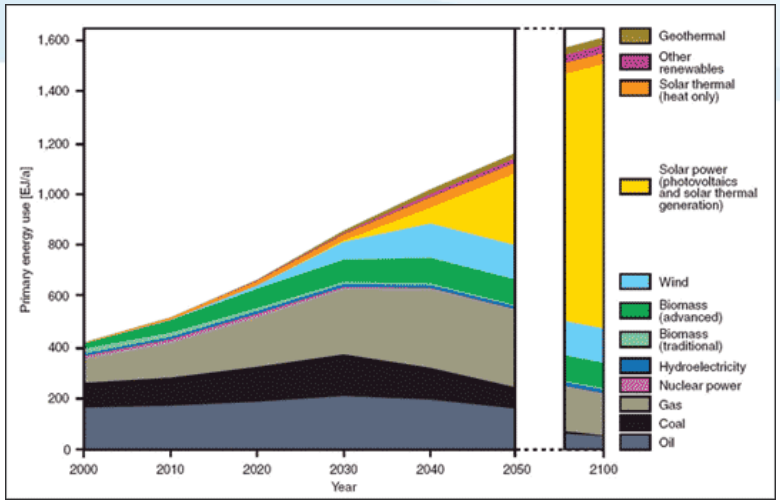
Australian PV industry	2003 actual	2010	2020
Installed Capacity (MW)	46	350	6,740
Employment	1,100	5,290	31,600
Total sales revenue ($ million)	204	1,180	5,160
CO_2 abated in year ('000 tonnes)	65	490	9,320

Australian PV Industry Roadmap, 2004

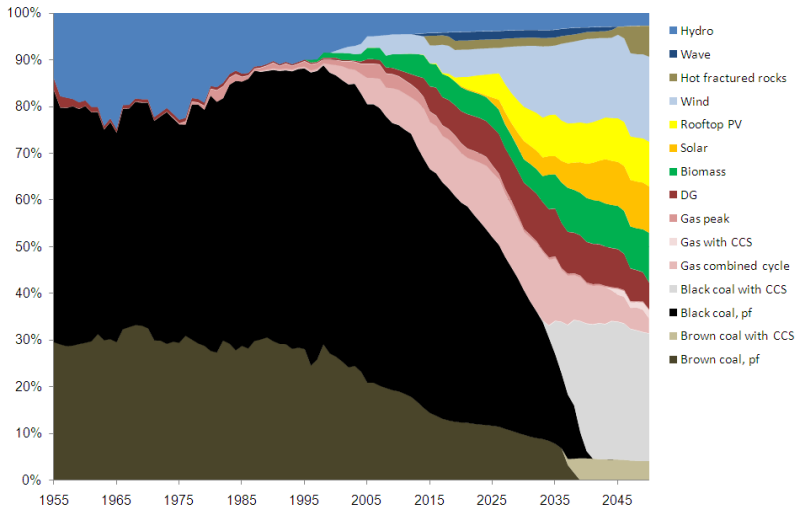
Continued solar growth forecasted

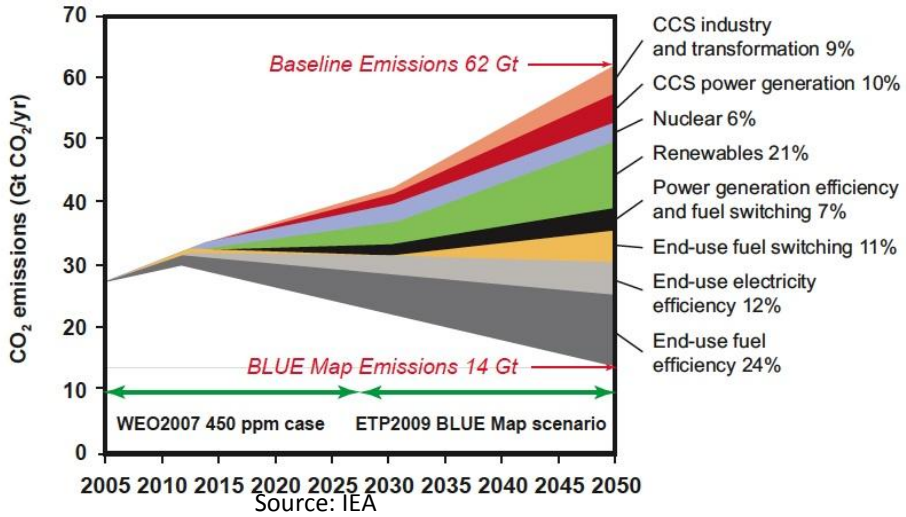


Source: CSIRO ESM Feb 2011



German Advisory Council on Global Change (WBGU)





Source: IEA

Source: ESSA; CSIRO ESM Mar 2011

Australian Energy Technology Assessment

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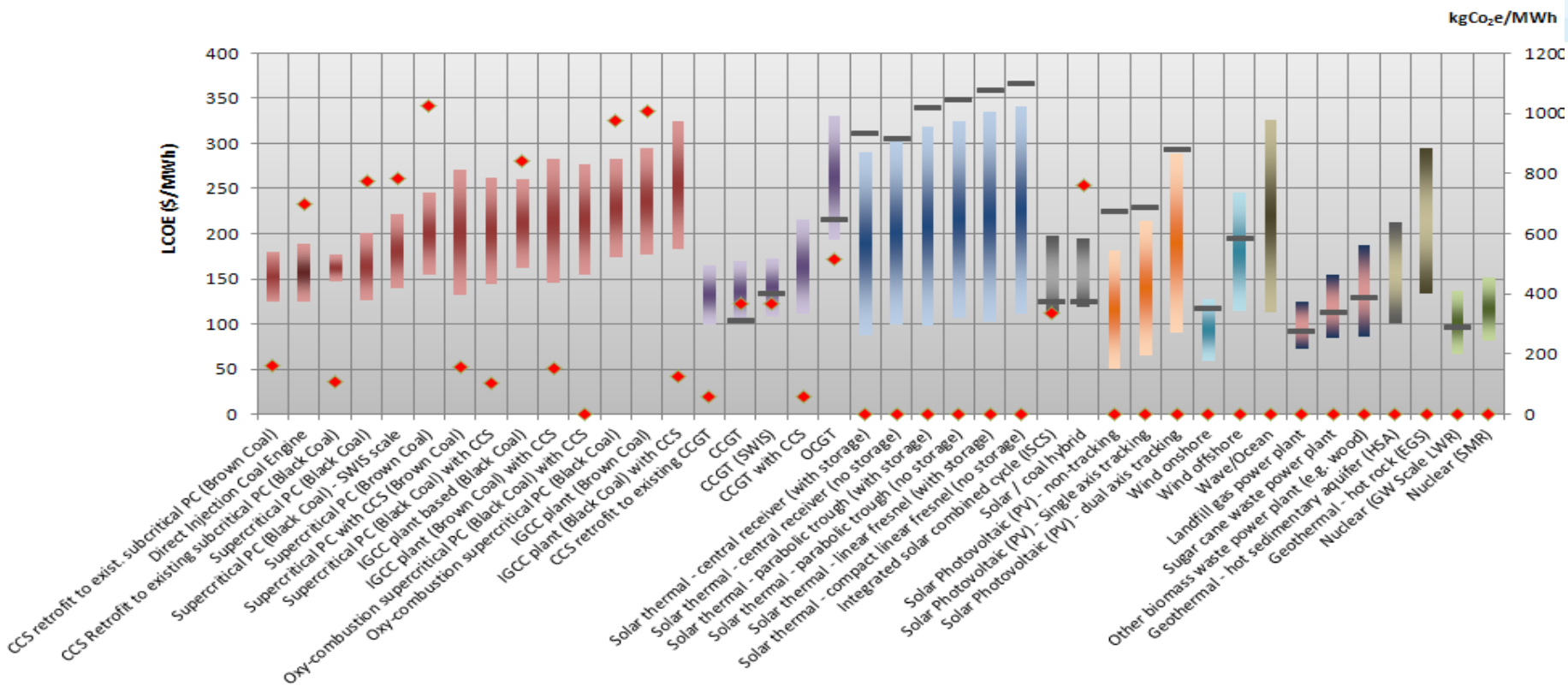


LCOE# includes, where relevant, allowance for:	LCOE excludes:	LCOE Sources of Uncertainty
• *Carbon Price* • *CO_2 transport and sequestration cost* • *Plant capital cost (EPC basis) within battery limits* • *Owners costs excluding interest during construction* • *Fixed and variable O&M* • *Fuel costs* • *Economic escalation factors*	• *Decommissioning costs* • *Project residual value* • *Network connection costs and augmentation* • *Effects of taxation* • *Financing costs* • *Plant degradation*	• *Capital Cost* • *Operating cost* • *Fuel cost* • *Carbon cost* • *Sequestration cost*

Legend

Emission Intensity (kgCO2e/MWh)

2012 LCOE mid-point (where technology is available in 2012)

Note: * Default region is NSW except brown coal technologies (VIC) and SWIS scale (as specified)

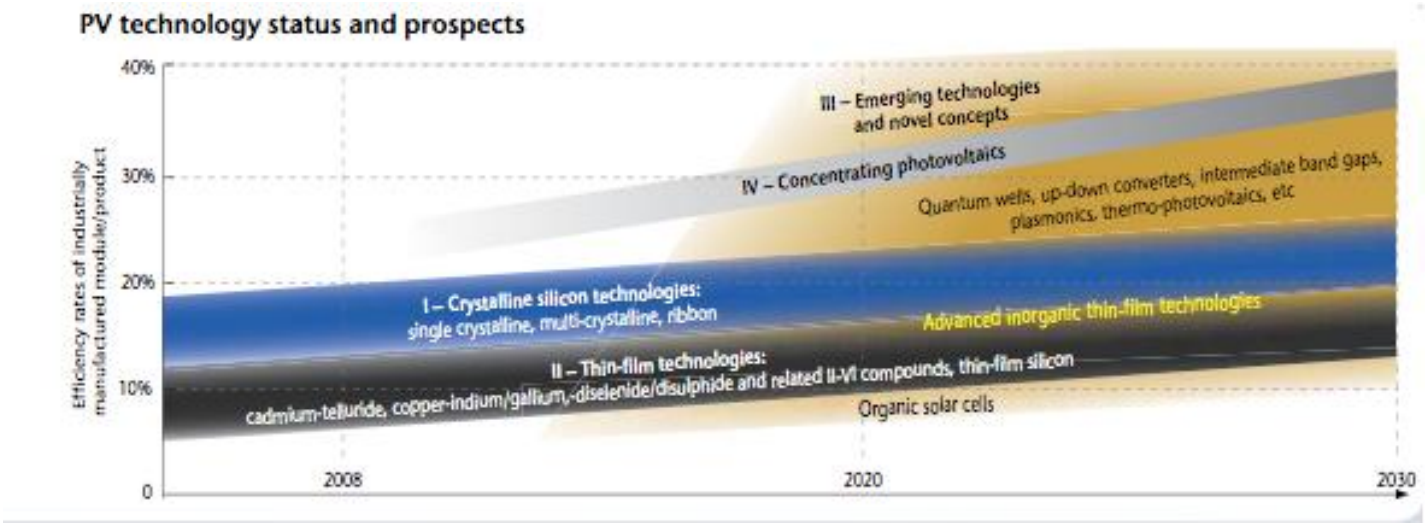
Levelised Cost of Electricity (LCOE)

Further Information:
www.bree.gov.au

31 July 2012

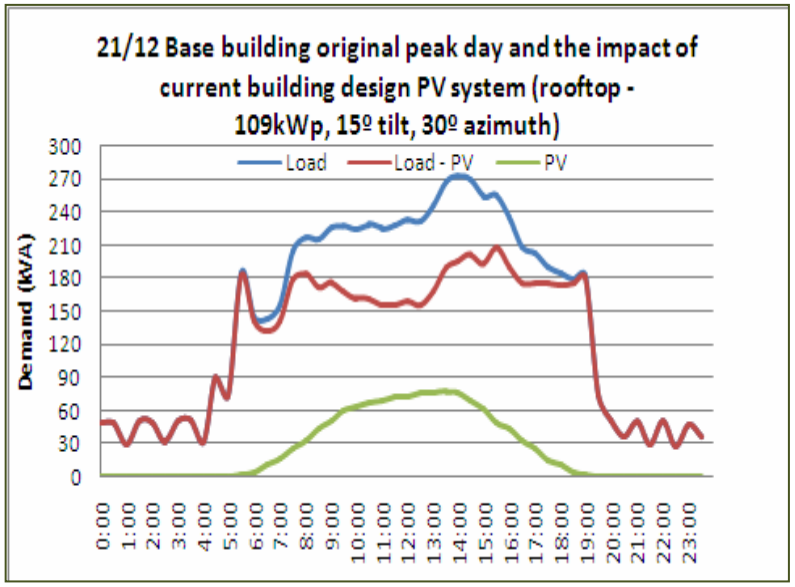
Current high level strategic technology roadmaps

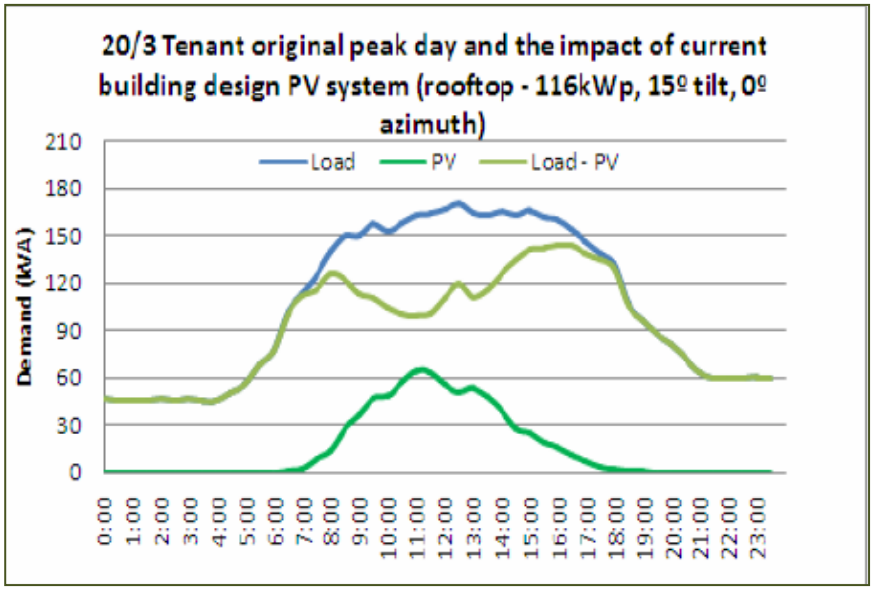
- Today's technology will continue to evolve, lowering costs and increasing efficiency
- New technology emerging that will accelerate trends



Commercial building market

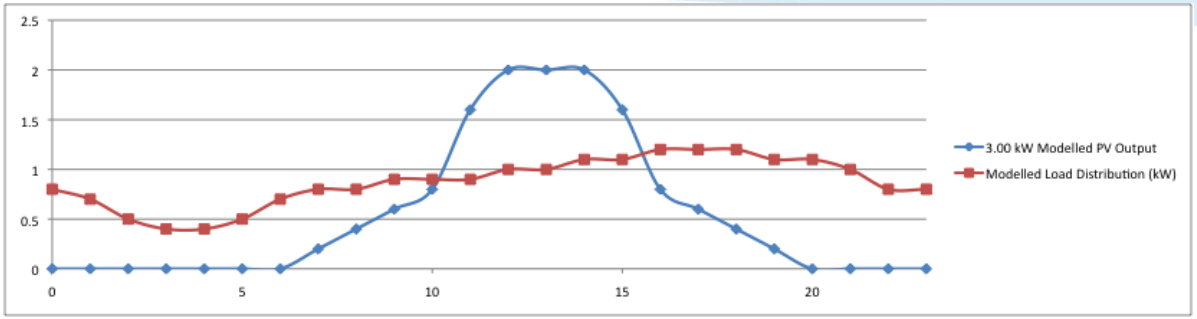
- 10% of Australia's GHG emissions
- 22% of Australia's electricity
- Increasing to 32% by 2029-30 (ABARE)



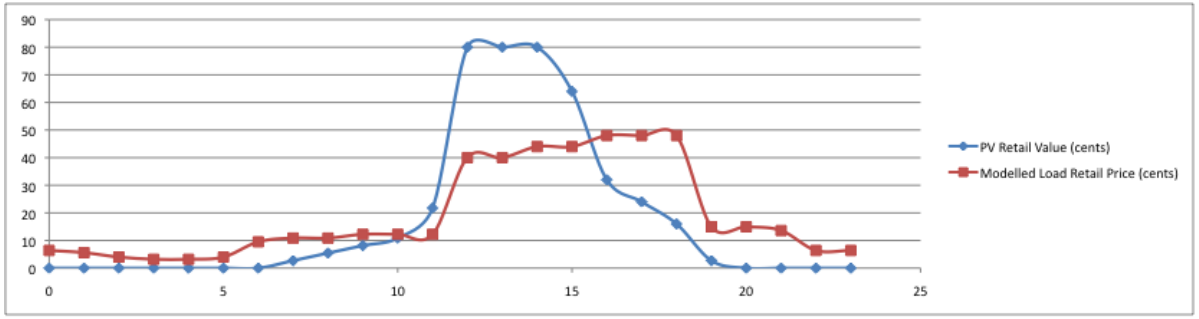


Source: Australian PV Association report 'Modelling of PV prices in the Australian commercial sector' 2011

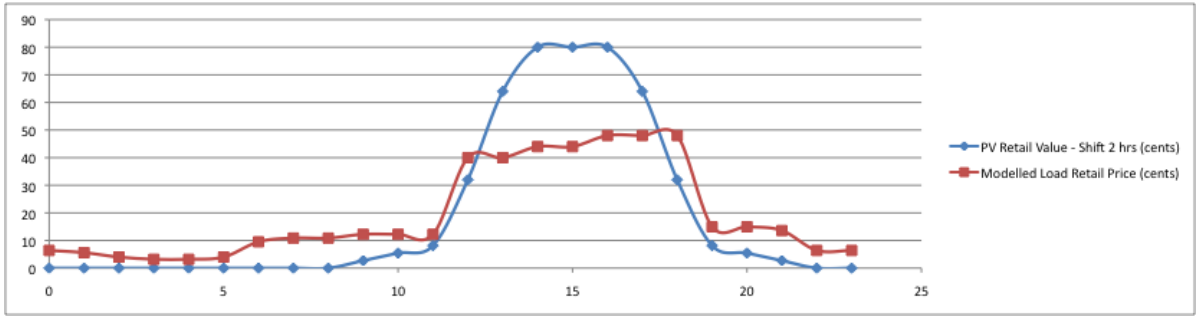
2011 time of day retail pricing shows a clear value proposition



3kW PV system
13 kWHrs output vs
21 kWHr load



3kW PV system
$retail output =
$home consumption
Off Peak 8c/kWHr
Shoulder 12c/kWHr
Peak 39c/kWHr



3kW PV system
2 hr shift by mix of
Facing west/storage
$retail output
>$home consumption

CSP offers potential to complement variability of PV and Wind generation

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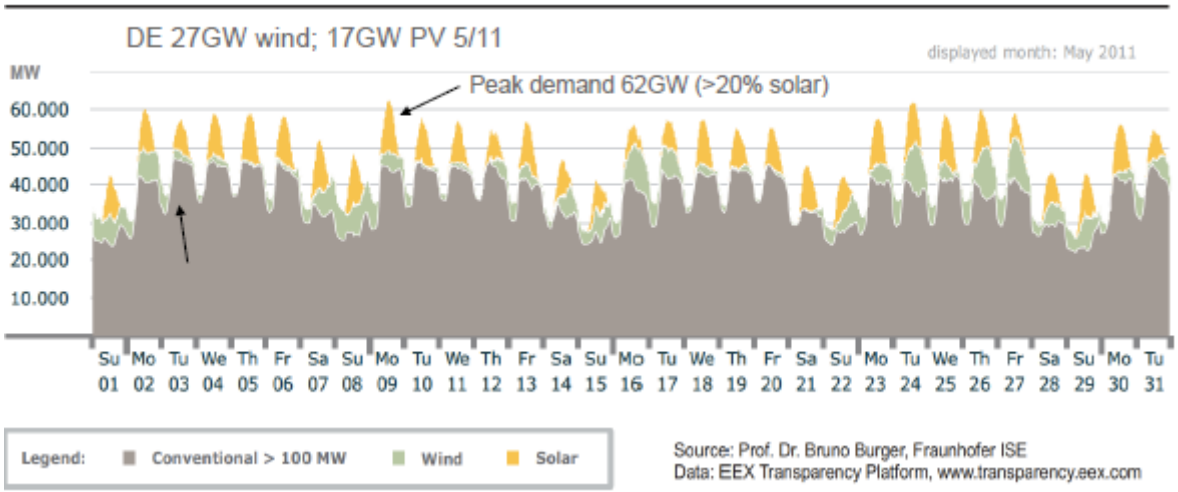
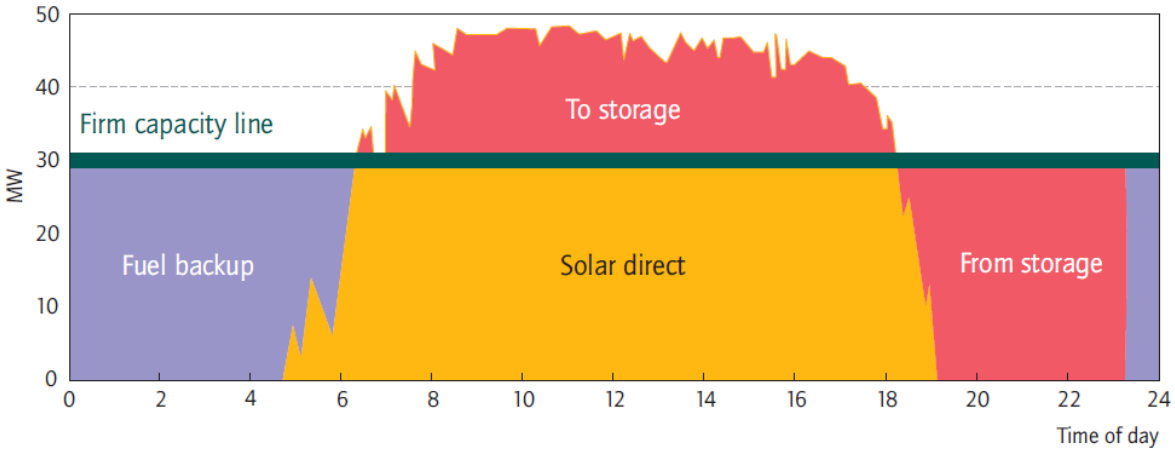
Actual production



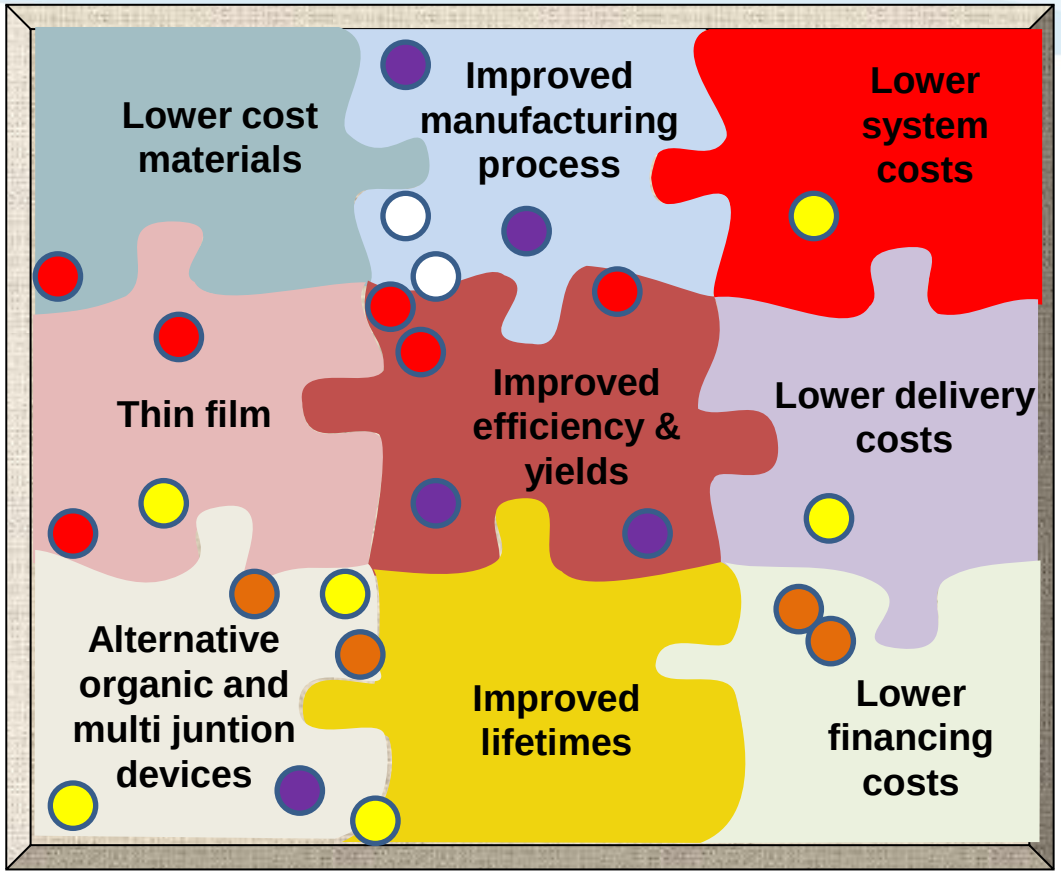
Source: Prof. Dr. Bruno Burger, Fraunhofer ISE
Data: EEX Transparency Platform, www.transparency.eex.com



Source: Geyer, 2007, *SolarPACES Annual Report*.

PV R&D Portfolio Mapping
ASI cA$47m leveraging cA145m

- Foundation Projects
- Round 1
- Round 2
- Round 3
- USASEC
- Aust.-Germany



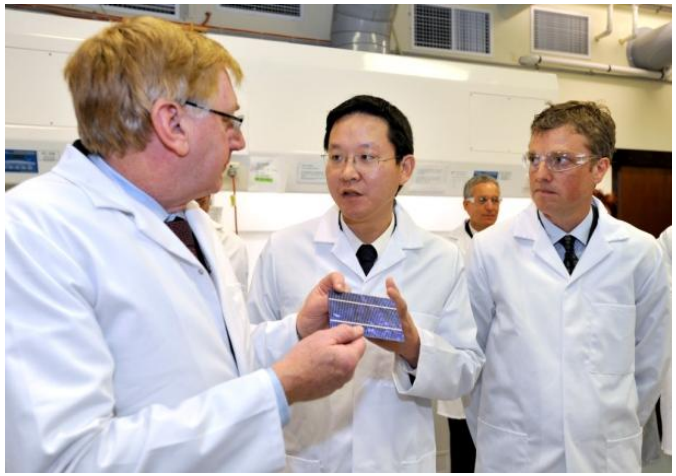
Full details on ASI website – R&D Projects

Case study: Overcoming the fundamental performance limitations of commercial solar cells

- The University of NSW and Suntech
- A$4.4m for A$14.7 million project
- Investigating improvements to device performance and reduced manufacturing costs while delivering high production yields for solar cells, potentially opening up new avenues for cost effective industrial manufacturing.
- 2012 Collaborative Innovation Award for collaboration on Pluto technology

Case study: Industry ready n-type silicon solar cells led by ANU

- $3.3m ASI funding for $10.3m project combining existing fast and inexpensive methods used to make today's standard p-type silicon solar cells, with the latest advances in higher efficiency n-type silicon cells. 3 parts:
- Developing 20% efficient n-type cells with Trina Solar
- Improving standard p-type cell to 19% with Trina Solar
- In collaboration with UNSW, developing industry-ready n-type cells with >22% efficiency

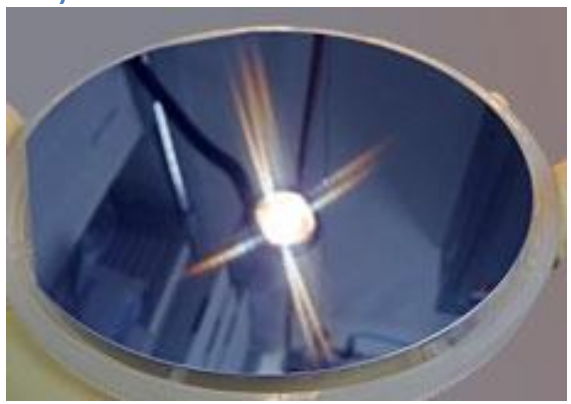


Case study: Expanding the value proposition for Building Integrated Photovoltaics

- Australia's BlueScope Steel Ltd, Germany's Fraunhofer Institute for Solar Energy Systems ISE, The Sustainable Buildings Research Centre at The University of Wollongong (Australia)
- $0.5m ASI funding for $1.6m project
- Develop a systematic approach and methodology to optimise the design configuration and sizing of building integrated photovoltaic thermal (BIPV-T) systems to suit installation on existing Australian buildings.
- This project will result in a decision support framework and tool specific to Australian conditions that could lead to manufacturing and widespread deployment of thin-film solar cells integrated into Australian buildings.

USASEC Case study: Cost effective gallium arsenide top solar cell grown on a high performance, low cost silicon solar cell

- UNSW, Arizona State University, University of Delaware, NREL, Amberwave Inc, Veeco Inc
- $2.5m ASI funding for $6.3m project that aims to cut solar energy costs by developing a high voltage cell that will be 40% more efficient than conventional solar cells
- Combining world record solar cell developed by UNSW with novel high performance, low-cost silicon germanium solar cell grown as the top cell using an innovative set of processes developed by US partners.



Case study: Roof-mounted hybrid CST system for distributed generation of heating, cooling and electricity

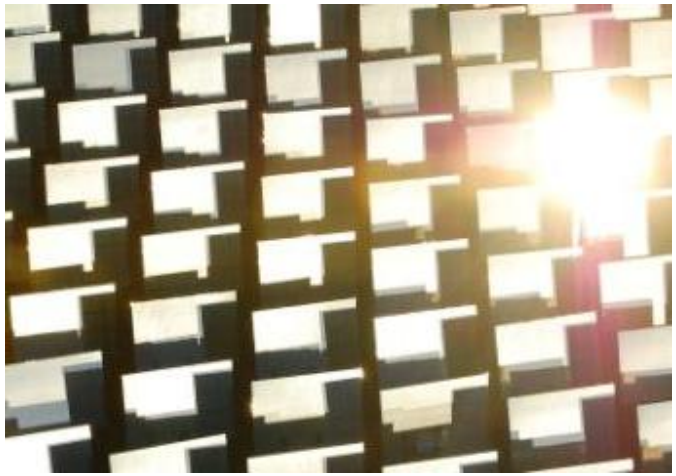
- $3.2m ASI funding for $9.5m project to develop and commercialise an improved roof-mounted hybrid solar concentrator PV/ thermal product for cost effective delivery of heating, cooling and electricity.
- Key innovation is use of spectral splitting of sunlight to improve effectiveness and novel cooling technology.
- Thermal and electrical energy will be delivered to the energy meters, where energy prices are triple wholesale energy prices.

Case study: CSIRO Solar Thermal Research Hub

- Largest of its kind tubular receiver solar air turbine system, which doesn't require water
- Aiming to prove that a target of 10-14 cents/kWh is achievable in commercial CST deployments- required to compete with wind generation
- Systems approach focused on increasing the efficiency of CST systems options (higher temperatures at the receiver) and proving storage while at the same time reducing capital and operating costs
- $5m from ASI

Case study: Validation of performance modelling for 1.2MWth solar array with high temperature receiver and integrated thermal storage

- Vast Solar Pty Ltd, Twynam Agricultural Group, The University of NSW, RMIT University
- $0.4m ASI funding for $1.3m project
- Vast Solar has developed unique technical innovations in the design of high efficiency / low cost components for solar thermal central receiver power plants with integrated thermal energy storage (HTF).
- This project seeks to validate performance modelling at pilot scale by extending an existing testing and demonstration facility in Jemalong, (near Forbes) NSW.
- Modularised concept will provide tangible demonstration of the technology to Series B investors.

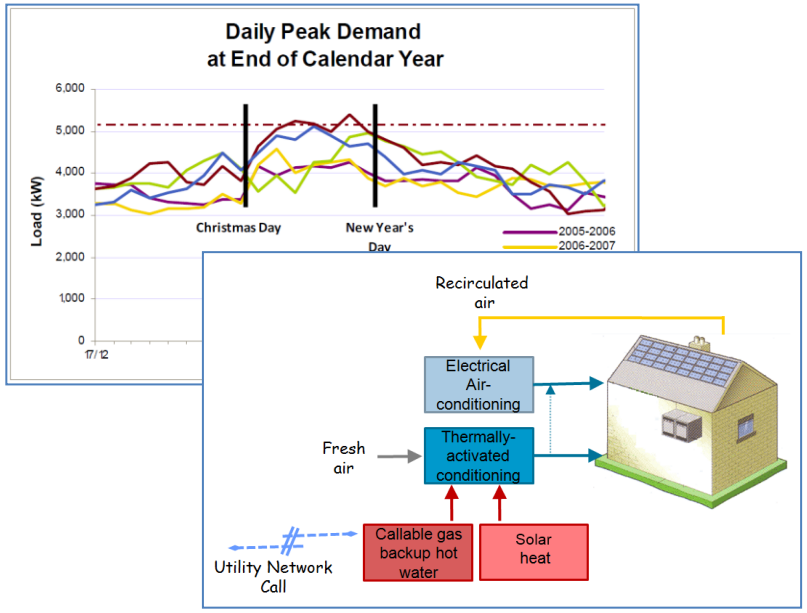


Case study: Central Receiver CPV Pilot Project – Stage 2

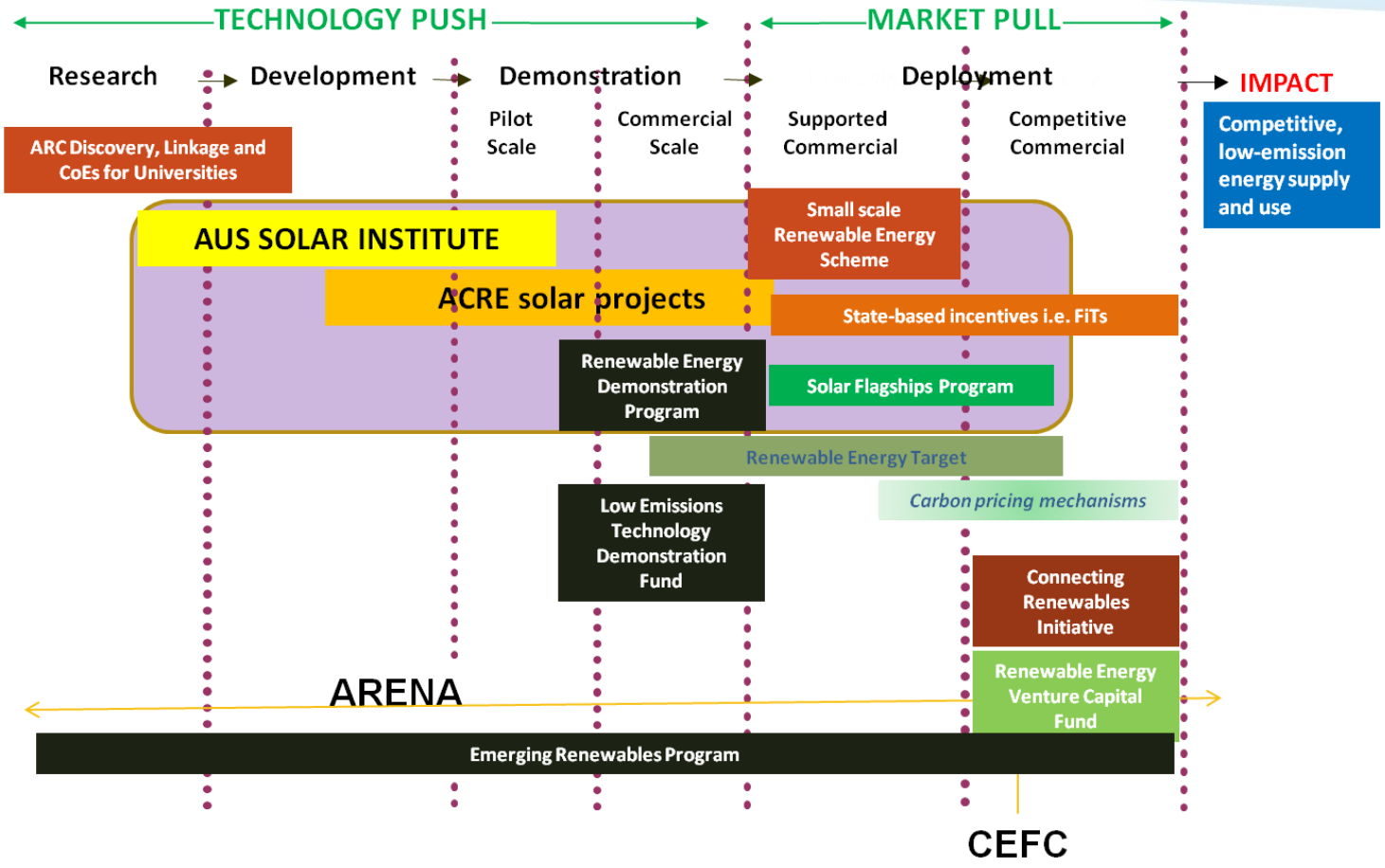
- RayGen Resources Pty Ltd, Boeing Spectrolab, Proteus Engineering Group, Able Engineering, Ceramet Technologies, Gannawarra Shire Council
- $1.8m ASI funding for $3.6m project
- Construct and commission 200kW commercial scale pilot plant using RayGen's proprietary Central receiver Concentrator Photovoltaic (C2PV™) technology - the world's first pre-commercial pilot of a heliostat central receiver system that uses PV energy conversion.
- Project will complete the development and demonstration of the C2PV™ technology, processes and knowledge base to advance to scale testing, 5MW p.a. manufacturing set-up and downstream commercialisation.

Case study: Solar Energy Management (SEM) system for utilities

- CSIRO, Ergon Energy, GWA Group
- $A0.2m ASI funding for $A0.6m project
- Combines CSIRO's thermally-driven residential desiccant solar cooling technology with a novel Solar Energy Management system and natural gas-powered back-up to reduce peak electrical consumption from the grid with certainty while providing continuous operation of air-conditioning.
- The SEM technology will be tested in 3 residential buildings to verify its ability to address grid stability issues and test customer acceptance as "winx3" for the environment, consumers and utilities.

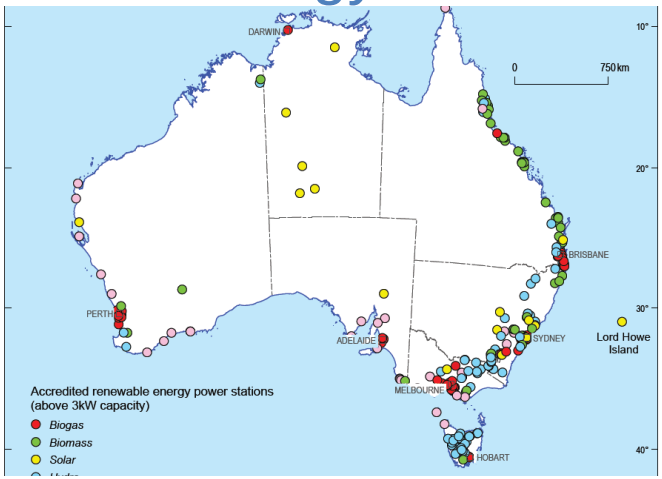


Solar related Policy drivers



ARENA

- Consolidates $3.2 billion funding for renewable energy technology innovation
  - Improving the competitiveness of renewable energy technologies
  - Increasing the supply of renewable energy
- Functions
  - Financial assistance
  - Analysis and sharing of knowledge and information
  - Advice to Government
  - Fostering collaboration
- ASI will transfer by 1 January 2013



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