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Welcome

On behalf of the committee for the 45th Annual Conference of the Australian and New Zealand Solar Energy Society (ANZSES), it gives me great pleasure to welcome you all to Alice Springs in October 2007 for SOLAR07.

It is most appropriate that we are holding the conference in Alice Springs, as a newly announced Solar City. Being at the Centre of Australia, with an abundance of Sunshine, and minimal cloud cover, Alice Springs can be rightly called the Premier Solar City of Australia. There will be plenty of opportunities to find out what this "Solar City" status means to the residents of Alice Springs, as well as find out the technical details of the planned projects throughout the region.

During this first week of October, we have a great variety of very interesting Speakers, and I sincerely thank you all for your contributions and efforts.

This conference, like many of the previous ANZSES conferences, does rely heavily on Company and Corporate Sponsorship in order to operate successfully. We have been very fortunate this year to attract a reasonably large group of Sponsors, to help support us to reach our goals.

I would like personally like to thank our Gold Sponsor – "**CBD Energy**", for their magnificent contribution, and I also wish to thank "**Solar Systems**" for their fantastic contribution and extensive help. I also wish to express sincere gratitude to our other Sponsors: "**Northern Territory Government**", "**Australian Greenhouse Office**", "**Dyesol Group of Companies**", "**Alice Springs Town Council**", "**EcoEnergy**", "**Suntec**", "**BCSE**" and the "**Charles Darwin University**". I also would like to thank the "**Centre for Appropriate Technology**" for their help with this conference. Thank you all very much for your generous contributions.

I would also like to thank the small, but energetic volunteer team of people on the SOLAR07 organising committee, for their efforts in the preparation for what should be a memorable event. I assure you, that many sacrifices have been made in order to make this happen.

We all hope you enjoy your visit to Alice Springs and can attend as many of the programmed activities as possible: and we also hope you are able to join us on for our Conference Dinner at Ooraminna Station Homestead on Thursday evening for a relaxing evening under the stars. And finally don't forget to also join us for our Saturday Technical tour to the solar dishes at Hermannsburg which includes a visit to Standley Chasm as well as Simpson's Gap.

Have an enjoyable time.

Howard Pullen
Committee Chair
Solar07 Conference

TUESDAY, October 2, 2007

0900 - 1600	ANZSES Committee Meeting (in the Alice Springs Convention Centre – Boardroom) **(ANZSES Committee members only)**
1500 - 1745	**SOLAR07 Registration** at the Reception Desk of the Alice Springs Convention Centre Barrett Drive, Alice Springs
1800 - 1930	**Welcome Reception at the Alice Springs Council Chambers** (Corner of Todd St & Gregory Terrace) **1800 - 1930** (Shuttle Coaches will depart from the Convention Centre at 1745 returning approx 1930) **Proudly sponsored by the "Alice Springs Town Council & Australian Greenhouse Office, Canberra, ACT"**

WEDNESDAY, October 3, 2007 (Morning Session)

0900 - 1020	Keynote Addresses - Session (K1)
0900 - 0910	Welcome by Chair of SOLAR07 and President of ANZSES
0910 - 0930	**Simon Troman**, Australian Greenhouse Office, "RRPGP Achievements and Directions" (1)
0930 - 0950	**Grant Behrendorff,** Bushlight, Alice Springs "An Overview of renewable Energy Initiatives in Central Australia" (2)
0950 - 1020	**Barry Skipsey's "Red Centre Show"** – A kaleidoscope of Central Australian photography and song
1020 - 1045	Morning Tea & Coffee served in "Ghan" Foyer
1045 - 1230	Keynote Addresses - Session (K2)
1045 - 1120	**Steve Shallhorn,** "No coal and no need for Nukes – Towards a green energy scenario for Australia" (80)
1120 - 1145	**Aaron Fyke,** Starfish Ventures, "Solar Flares - Explosive Growth in Solar Energy Ventures" (3)
1145 - 1205	**Steven Peters,** Sustainability Victoria, "Smart Energy Zones" (74)
1205 - 1230	**Lyndon Frearson,** Centre for Appropriate Technology, "Solar Technology Demonstration Facility" (86)
1230 - 1330	Lunch is served in the "Ghan" Foyer Lunch today is **Proudly sponsored by "CBD Energy, Sydney, NSW"**

WEDNESDAY, October 3, 2007 (Afternoon Session)

1230 - 1330	Lunch is served in the "Ghan" Foyer Lunch today is **Proudly sponsored by "CBD Energy, Sydney, NSW"**	
1330 - 1510	**PHOTOVOLTAIC APPLICATIONS** **Session (1a) - chair:**	**RENEWABLE ENERGY POLICY** **Session (1b) - chair:**
1330- 1350	**Large scale grid connected solar in the future energy market (62)** G.Pollock and J. Birch **Solar Systems Pty Ltd, Hawthorn, VIC**	**Nuclear Energy for Australia; A solution to Climate Change or a new Problem (38)** A.Zahedi **Monash University,**
1350- 1410	**The Contribution of Photovoltaics to Commercial Loads (33)** M.Watt, R.Passey and M.Snow **University of New South Wales, Sydney, NSW**	**Adelaide's Transition to a Solar City (57)** M.Oliphant, A. Dwyer **University of South Australia, Adelaide**
1410- 1430	**Photovoltaics at CSIRO Energy Technology (61)** C.Fell **CSIRO, Newcastle, NSW**	**A Fair go for Future Generations (23)** T.C.Toomer **Whyalla, South Australia**
1430- 1450	**Towards a 55% efficient solar cell (60)** A.Blakers, K.Weber and C.Holly & V.Everett **Australian National University, Canberra**	**A tale of two Solar Cities (77)** D.Harries and A.Schlapfer **Murdoch University, Perth, WA**
1450- 1510	**King Island - Hydro Tasmania's Current Activities (87)** M.Rayner **Hydro Tasmania, Hobart, TAS**	**Making Hospitals Healthier (56)** F.McGain **Western Hospital, Melbourne**
1510 - 1535	Afternoon Tea & Coffee served in "Ghan" Foyer	
1535 - 1715	**SILICON SOLAR CELLS** **Session (2a) - chair:**	**SOLAR THERMAL -1** **Session (2b) - chair:**
1535 - 1555	**Silicon Nanocrystals in SiC Matrix for 3rd Generation PV Solar Cells (22)** D.Song, E.Cho, G.Conibeer, Y.Huang, C.Flynn **University of NSW, Sydney**	**Solar Assisted Reverse Cycle Air Conditioning (26)** M.Dennis and P.Atkinson **Australian National University, Canberra**
1555 - 1615	**Influence of corona charging on the Si-SiO_2 interface (20)** J.Hao, K.Weber, C.Dang and W.Jellett **Australian National University, Canberra**	**Application of Transpired Solar Collectors to Heat Air to Regenerate a Desiccant Bed Airconditioning (40)** G.Thorpe **Victoria University of Technology, Melbourne**
1615 - 1635	**Phosphorous doped Si QDs embedded in SiO_2 matrix for All-silicon Tandem Solar cell (24)** X.Hao, E.Cho, S.Park, G.Conibeer, M.Green **University of NSW, Sydney**	**Evaluation of a solar dryer in a high altitude area of Nepal (25)** R.Fuller, L.Aye and A.Zahnd **University of Melbourne, Melbourne**
1635- 1655	**Si QDs/Crystalline Silicon Heterojunction Solar Cells (31)** S.Park, E.Cho, X.Hao, G.Conibeer, M.Green **University of NSW, Sydney**	**Spectral Beam Splitter for Solar Hydrogen Production (50)** A.Imenes, W.Stein and J.Carras **CSIRO. Sydney**
1655 - 1715		**Baseload Solar Power for California (51)** R.Dunn, K.Lovegrove and G.Burgess **Australian National University, Canberra**
1730 - 1900	Public Discussion/Forum (Main Ellery Room)	

THURSDAY, October 4, 2007 (Morning Session)

0900 - 1020	Keynote Addresses - Session (K3)	
0905 - 0940	**Julia Judd, Solar Electric Power (USA)** "Solar Energy Markets and Trends – An American Perspective" (4)	
0940 - 1000	**Senator Christine Milne,** "Re-energising Australia" (5)	
1000 - 1020	**Dr Vernie Everett, ANU (Canberra),** "Sliver Cell: the low cost PV Electricity Alternative" (72)	
1020 - 1040	Morning Tea & Coffee served in "Ghan" Foyer Morning Tea & Coffee today is **Proudly sponsored by "EcoEnergy & Suntec, Alice Springs, NT"**	
1040 - 1240	**RENEWABLE ENERGY TECHNOLOGIES** **Session sponsored by "DYESOL, Sydney, NSW"** **Session (3a) - chair:**	**SOLAR THERMAL - 2** **Session (3b) - chair:**
1040- 1100	**Liquid Solar Array (48)** P.Connor **Sunengy Pty Ltd, Mt Kuringgai, NSW**	**Assessment of CSIRO Solar Tower Heliostats (73)** T.Richie, A.Burton, A.Imenes and W.Stein **CSIRO, Newcastle, NSW**
1100- 1120	**Blueberry Electricity:** **Fruit based Dye-Sensitised Solar Cells (41)** H.Smith and N.Ekins-Daukes **University of Sydney, Sydney, NSW**	**Solar Hot Water systems** **in Remote Australia (66)** D.de Vries and S.Hunt **Centre for Sustainable Arid Towns, Alice Springs,NT**
1120- 1140	**The evolving market for DSC in** **Building Integrated PV (58)** D.Ball, G.Evans, G.Tulloch and S.Tulloch **Dyesol, Queanbeyan, NSW**	**Large Payload Solar Tracking Frame** **for the Solar Boiler Project (65)** D.Caldwell **Hawera, New Zealand**
1140- 1200	**Sealed Test Cells;** **Using a Test Cell Assembly Machine (TCAM) (59)** T.Tran, R.Harikisun, G.Evans and S.Tulloch **Dyesol, Quenbeyan, NSW**	**Comparative Performance of Commercially** **available Solar and Heat-pump Water Heaters (64)** B.Lloyd and A.Kerr **Otago University, Dunedin, New Zealand**
1200- 1220	**The Bushlight approach to Designing** **and Implementing Renewable Energy (45)** P.Coull and M.Tuckwell **Centre for Appropriate Technology, Alice Springs, NT**	**ANU Micro-Concentrator Collector (30)** J.Smeltink and A.Blakers **Australian National University, Canberra, ACT**
1220- 1240	**Advanced Blades for** **Small Wind Turbines (18)** P.D.Clausen, P.Peterson, S.Wilson and D.Wood **University of Newcastle, Callaghan, NSW**	**Seasonal storage for Solar Thermal** **Systems in Australia? (35)** R.Fuller and L.Aye **Deakin University, Geelong, VIC**
1245 - 1345	Lunch is served in the "Ghan" Foyer	

THURSDAY, October 4, 2007 (Afternoon Session)

<table>
<tr><td>1245 - 1345</td><td colspan="3">Lunch is served in the "Ghan" Foyer</td></tr>
<tr><td>1345 - 1525</td><td>PVPS Workshop
Session (4a)</td><td colspan="2">SUSTAINABLE BUILDINGS - 1
Session (4b) - chair:</td></tr>
<tr><td>1345- 1405</td><td rowspan="5">PVPS Workshop

& Project Update

1. Welcome and Introduction to the PVPS Consortium

2. Recent Outcomes
• Update of the PV Market in Australia
• PV in Developing Countries
• PV in Mini Grids

3. PV Module and System Prices
• Australian and International Trends
• Issues Influencing Prices
• Strategies for Price Reduction in Australia

All Delegates Welcome</td><td colspan="2">Bond University Mirvac school -
Successful Sustainable Design in the Subtropics (47)
K.Healey, N.Groenhout, T.Fowler and D.Merrony
Bassett Consulting Engineers, Milton, QLD</td></tr>
<tr><td>1405- 1425</td><td colspan="2">The Use of Micro-encapsulated Phase-Change Material, and the development of the "Phase Change Chimney" .. (76)
D.Goodfield, M.Anda, R.Hammond and K.Mathew
Murdoch University, Perth, WA</td></tr>
<tr><td>1425- 1445</td><td colspan="2">Thermal Performance Studies at
the University of Newcastle (46)
H.Sugo, A.Page and C.Inglis
University of Newcastle, Newcastle, NSW</td></tr>
<tr><td>1445- 1505</td><td colspan="2">Exploring retrofit alternatives for
State Houses in Southern NZ (54)
M.Callau, B.Lloyd and T.Bishop
University of Otago, Dunedin, New Zealand</td></tr>
<tr><td>1505- 1525</td><td colspan="2">Cost Effectiveness of
a Carbon Neutral House (29)
S.Bambrook, A.Sproul and J.Copper
University of NSW, Sydney, NSW</td></tr>
<tr><td>1520 - 1540</td><td colspan="3">Afternoon Tea & Coffee served in "Ghan" Foyer</td></tr>
<tr><td>1540 - 1720</td><td>PVPS Workshop
Session (5a)</td><td>SUSTAINABLE BUILDINGS - 2
Session (5b) - chair:</td><td>SOLAR THERMAL - 3
Session (5c) - chair:</td></tr>
<tr><td>1540 - 1600</td><td rowspan="2">4. PV and Solar Cities
• International Synergies
• PV Monitoring Issues & Standardisation Options

All Delegates Welcome</td><td>Performance of a Solar pre-heater
for a commercial building (28)
P.Rogers, R.Fuller and M.Luther
Deakin University, Geelong, VIC</td><td>Sliver Cells in
Thermophotovoltaic Systems (21)
N.Lal and A.Blakers
Australian National University, Canberra</td></tr>
<tr><td>1600 – 1620</td><td>Energy Efficient &
Water Conserving Systems (42)
A.Sproul and B.Murray
University of NSW, Sydney, NSW</td><td>Unsteady effects in Direct Steam
Generation in the CLFR (78)
J.Pye, G.Morrison, and B.Masud
Australian National University, Canberra</td></tr>
<tr><td>1620 – 1640</td><td rowspan="3">PVPS Consortium
Meeting

##################
Consortium
Members Only
##################</td><td>Non-uniform Temperature Distribution on PV field under Real Operating Conditions (44)
V.Benda, Z.Machacek and K.Stanek
Czech Tech University, Prague, Czechslovakia</td><td>A Prototype Liquid Desiccant
Dehumidification System (68)
K.Khouzam
Queensland University of Tech, Brisbane</td></tr>
<tr><td>1640 – 1700</td><td>BASIX 'DIY' Thermal Comfort Analysis -
Current Practice & Future Developments (70)
T.Lee and D.Howard
Energy Partners, Canberra, ACT</td><td>AC coupled Hybrid systems
and Mini Grids (34)
M.Wollny, M.Hermes and O.Chehab
SMA Technologie AG, Hanover, Germany</td></tr>
<tr><td>1700 – 1720</td><td></td><td></td></tr>
<tr><td>1745 - 2230</td><td colspan="3">Conference Dinner at Ooraminna Homestead - Coaches will pickup from Conference Centre

Conference Dinner is Proudly sponsored by "Solar Systems Pty Ltd, Melbourne, VIC"</td></tr>
</table>

FRIDAY, October 5, 2007 (Morning & Afternoon Sessions)

0900 - 1020	Keynote Addresses - Session (K4)	
0905 - 0935	**Alex Zahnd, Nepal** "Solar PV Systems in Himalayan Villages – Problems and Possible Solutions" (75)	
0935 - 1000	**Mark Diesendorf, UNSW (Sydney)** "Greenhouse Solutions with Sustainable Energy" (79)	
1000 - 1020	**Scott Frier, Abengoa Solar Power (USA),** "Solar Power is back, New Trough & Tower projects" (6)	
1020 - 1040	Morning Tea & Coffee served in "Ghan" Foyer	
1040 - 1220	**ENERGY - NATIONAL SCENARIOS** **Session (6a) - chair:**	**RENEWABLE & SUSTAINABLE EDUCATION** **Session (6b) - chair:**
1040 - 1100	**Scenario analysis of possible sustainable energy futures for Alice Springs (32)** J.Picton, M.Watt and I,MacGill **University of NSW, Sydney, NSW**	**Developments in the UNSW Photovoltaics and Solar Energy Engineering Degree Programs (19)** R.Corkish **University of New South Wales, Sydney, NSW**
1100 - 1120	**Economic evaluation of grid-connected solar photovoltaic energy systems in Australia (39)** A.Zahedi **Monash University, Melbourne, VIC**	**Education in the field of Photovoltaics in the Czech Republic (43)** V.Benda, Z.Machacek and K.Stanek **Czech Technical University, Prague, Chechslovakia**
1120 - 1140	**Maintaining Australia as an Energy Exporter (55)** K.Lovegrove and M.Munzinger **Australian National University, Canberra, ACT**	**Improving Community access to Australian Climate Data (36)** I.Muirhead **Bureau of Meteorology, Melbourne, VIC**
1140 - 1200	**Bushlight RE System Installation and Maintenance - Quality, Cost and Outcomes (49)** P.Rodden and M.McKay **Bushlight, Alice Springs, NT**	**Towards a new energy future: Lessons from the past (27)** D.Rudder **Powerhouse Museum, Sydney, NSW**
1200 - 1220	**Wider Renewable Energy Issues for Nepal (37)** P.Freere and A.Zahnd **Monash University, Melbourne, VIC**	**Creation of Ersatz Future Weather Data Files (69)** T.Lee and D.Ferrari **Energy Partners, Manuka, ACT**
1230 - 1245	Closing Ceremony (Main Ellery Room) Presentation to launch the 46th Annual ANZSES Conference in Sydney 2008	
1245 - 1345	Lunch is served in the "Ghan" Foyer	
1330 - 1630	Technical Tour to: **MET Bureau:** (View the Observation Room, Solar Radiation Monitoring Equipment & Radiosonde Balloon Launch. Staff on hand to explain technical aspects of equipment and communication network). **Desert Knowledge Precinct:** (Although currently under construction, this $60M development will be a National and International showcase of Desert knowledge including a Solar Technology Demonstration Facility). **Centre for Appropriate Technology:** (View display of Robust, Bush Hardy products developed by CAT, including a Bushlight RE system & energy Management system. Discuss Bushlight's unique Energy Planning model). Coaches will pickup from Conference Centre (1330) and will visit each of the Centres in Turn. The above Technical Tour is **Proudly sponsored by "CBD Energy, Sydney, NSW"**	
1630 - 1700	Afternoon Tea & Coffee served in "Ghan" Foyer	
1700 - 1800	ANZSES Annual General Meeting (in Breakout Room)	

SATURDAY, October 6, 2007

0830 - 1730	Technical Tour to Hermannsburg Solar Dishes Coaches will pickup from Convention Centre at **0830 Sharp** – Coaches will return to Alice Springs at around 1700. (Lunch can be purchased at Hermannsburg and also at Standley Chasm at delegates own cost). Includes visits to Standley Chasm (entrance fee of $8pp extra) and Simpson's Gap. Delegates are advised to take a Hat, Sunscreen, water bottle and Camera.

ABSTRACTS

NOTE:

1. **The Abstracts are printed in numerical order.**
2. **The Abstracts are printed one Abstract per Page.**
3. **Refer to the Programme (shown previously) to obtain the Abstract Number shown in brackets at the end of each paper title.**

   E.g. "ANU Micro-Concentrator Collector" (30) refers to Abstract 30.
4. **There is provision for note taking at the bottom of each Abstract page.**
5. **Additional note pages are provided at the end of this booklet.**

Keynote - 01

"RRPGP Achievements and Directions"

Simon Troman

Renewable Energy Deployment
Australian Greenhouse Office
Department of the Environment and Water Resources
E-mail: Simon.Troman@environment.gov.au

Abstract Not Available at time of publication

NOTES: ____

Keynote - 02

"An Overview of renewable Energy Initiatives in Central Australia"

Grant Behrendorff

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Alice Springs NT 0871
Australia
E-mail: grant.behrendorff@bushlight.org.au

Abstract Not Available at time of publication

NOTES: ____

Keynote - 03

"Solar Flares – Explosive Growth in Solar Energy Ventures"

Aaron Fyke

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Jolimont VIC 3002
Australia
E-mail: aaron@starfishvc.com

With incentives for solar energy growing in many markets around the world there has been a tremendous outburst from solar energy technology companies. Increased production capacity, growing potential markets, and increased installed capacity is driving spectacular valuation growth. However, the investment community has seen this type of exuberance many times before and it is important to learn from the past to avoid experiencing the same type of disappointment. Nevertheless, investors are still very interested in supporting new solar technology and venture capital has an important role to play. Details of how to raise funding will also be discussed.

Aaron Fyke has dedicated his career to the success of clean technology companies, and joined Starfish in 2007 to focus on cleantech investments.

With both engineering and management expertise he has led a number of key initiatives relating to new product development, manufacturing, and commercialization in the energy, automotive, and aerospace industries. Prior to joining Starfish, Aaron led the redesign for manufacturability of a solar concentrator for an early stage start-up, Practical Instruments. Previous to that, he managed the start-up of a new factory, led the formation and growth of a logistics, training, and customer support division, and developed the business plan to develop and commercialize a new ocean power technology for AeroVironment, a leading clean technology and aerospace company. Aaron provided consulting services to Visteon, a large automotive supplier, to respond to new business conditions, and was a key engineer in the development of direct methanol fuel cell technology for Ballard Power Systems.

Aaron earned his MBA from the Leaders for Manufacturing program at the MIT Sloan School of Management, his MS in Mechanical Engineering from the MIT School of Engineering, and his BEng in Mechanical Engineering from the University of Victoria, as the Canadian Society for Mechanical Engineering Gold Medal recipient for graduating first in his class. He is registered as a Professional Engineer in Mechanical Engineering both in California and British Columbia.

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Keynote - 04

"Solar Energy Markets and Trends – An American Perspective"

Julia Judd

Solar Electric Power
1341 Connecticut Avenue, NW, Suite 3.2
Washington, DC 20036
USA
E-mail: jjudd@solarelectricpower.org

Abstract Not Available at time of publication

Ms. Judd has served as a Solar Electric Power Association executive director since January 2004 and worked for an additional 4 years as a program manager for the association. Prior to running SEPA, she worked as a senior associate at ICF International, a leading consulting firm in the areas of energy and environment, where she supported the US Environmental Protection Agency with the implementation of the ENERGY STAR program. Her career has focused on developing tools to communicate the value of renewable energy and energy efficiency to electric utilities, municipal governments, and product manufacturers.

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Keynote - 05

"Re-energising Australia"

Senator Christine Milne

Office of Senator Christine Milne
Australian Greens Senator for Tasmania
GPO Box 896
HOBART TAS 7001
E-mail: Wendy.McLeod@aph.gov.au

Abstract Not Available at time of publication

Senator Christine Milne, Australian Greens spokesperson on climate change, was elected to represent Tasmania in the federal parliament at the 2004 election after a distinguished career in the Tasmanian state parliament where she served as Leader of the Greens from 1993-1998. Christine is a leader in the environment movement in Australia and overseas. She was appointed to the United Nations Environment Programme's Global 500 Roll of Honour in 1990 and was elected at the World Conservation Congress in Amman, Jordan, to the Global Council of the World Conservation Union (IUCN) and is currently one of four global vice presidents. She represented the IUCN at the Conference of the Parties to the Climate Change Convention at Montreal, Canada, in December 2005. Christine initiated the Senate Inquiry into Australia's future oil supply and alternative transport fuels which was completed in February this year. Her private members bill on climate change, setting a minimum 80% reduction on 1990 levels of greenhouse gasses by 2050, has been introduced into the senate and she has recently launched a report "Re-Energising Australia" which is available from her website www.christinemilne.org.au

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Keynote - 06

“Solar Power is back, New Trough & Tower projects”

Scott Frier

Abengoa Solar Power USA
E-mail: sdfrier@msn.com

Abstract Not Available at time of publication

I was the CEO of Solargenix Operating Services, which had just built the one MW Saguaro parabolic trough plant in Arizona and the construction of Nevada Solar One parabolic trough plant was in its mature phases.

I have now since moved and am the COO of US operations for Abengoa Solar Power (called Solucar for the PS-10 and PS-20 projects in Spain. PS-10, as you might well know is now the world’s first commercial solar power tower (10 MW as the name suggests) and PS-20 is in full construction at this time. Solar Nova One, a 50 MW trough plant has also broken ground at the base of the towers near Seville and two Integrated Solar Combined Cycle Systems (ISCCS) have begun construction by Abengoa in Morocco and Algeria respectively.

I was recruited away from Solargenix (now Acciona Solar) to spear head the US developments, that, as my introductory sentence suggests is going at great speed with significant project opportunities popping up like mushrooms (not mushroom clouds mind you… I could not resist the temptation of the word play on this year’s conference tag phase.)

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RET - 18

Advanced Blades for Small Wind Turbines

Philip Clausen, P. Peterson*, S.V.R. Wilson* and D.H. Wood*

School of Engineering
The University of Newcastle
University Drive Callaghan NSW 2308
AUSTRALIA
*and Aerogenesis Australia
E-mail: Philip.Clausen@newcastle.edu.au

This paper describes the important aspects of the evolution in the design and manufacture of a 2.5 m long fibreglass composite blade for a 5 kW wind turbine.

The first generation blade was aerodynamically efficient and light but suffered from structural problems in the transition region between the attachment block and working section which inspired a redesign.

Extensive field testing with the second generation blade improved our understanding of blade dynamics and allowed us to develop a detailed fatigue loading procedure to predict the blade's lifespan. The aerodynamic design of the current blade has been further improved using an evolutionary strategy; aspects of this strategy and the effects on the blade shape are discussed in this paper.

Detailed structural modelling of all generations of blade designs has been used to determine the amount and lay of glass within the blades. The current design blade is some 45% lighter than the first generation blade with the level of strain some 45% lower at design conditions. Aspects of the manufacturing process for the current blade are also discussed.

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RSE - 19

Developments in the UNSW Photovoltaics and Solar Energy Engineering Degree Programs

Richard Corkish

School of Photovoltaic and Renewable Energy Engineering
University of New South Wales
Sydney, NSW 2052
AUSTRALIA
E-mail: r.corkish@unsw.edu.au

The Bachelor and Masters programs in photovoltaics and solar energy engineering at UNSW are attracting significant sponsorship support for Asia-Pacific students and the focus of the Masters program has been narrowed to service the burgeoning need for engineers in photovoltaic manufacturing.

The paper will outline the substantial sponsorship obtained for undergraduate and postgraduate education from the Australian Government through the multinational Asia-Pacific Partnership on Clean Development and Climate program and through industry sponsorship from China.

Photovoltaic manufacturing is of particular interest to prospective students from the region and the postgraduate coursework program will now focus on that interest. The postgraduate program has also been revised, as part of recent Faculty-wide changes, to include engineering management and manufacturing engineering subjects. The undergraduate student sponsorship will bring to UNSW students who have already completed two years of study at Chinese partner universities.

Recent changes to the undergraduate and postgraduate coursework programs are also discussed.

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SSE - 20

Influence of corona charging on the Si-SiO2 interface

Jin Hao, K. Weber, C. Dang and W. Jellett

Australian National University
FEIT, #32, North RD, ANU, Canberra 0200
AUSTRALIA
E-mail: hao.jin@anu.edu.au

Corona charging has been acknowledged as a non-invasive method for temporary Si surface passivation by means of varying the surface femi level. The deposition of corona charges is extensively used for device reliability characterisation as well as for fundamental studies on many types of devices and structures, including solar cells.

However, Stesmans et al showed that at least 5 EPR active defects, including the Pbx, were generated with corona charging process. Dautrich et al argued that the generation of EPR active defects only occur at high (>4MV/cm) electrical field.

A combination of capacitance-voltage (CV) and lifetime decay measurements are used in our investigation to show that both positive and negative corona biasing of oxidised samples result in the generation of additional interface defects and an increase in surface recombination in oxide/Si structure. The onset of interface degradation occurs at relatively low electric fields, estimated to be less than ~ +/-1.2MV/cm. About 3 orders and 40 orders of magnitude higher defects are generated by 26 minutes positive and negative corona charging, respectively. The majority of the defects generated by corona biasing can be removed by a short anneal at 400^{o}C in N2 and further reduced by annealing in forming gas. The results are consistent with the hypothesis that atomic hydrogen is chiefly responsible for the observed degradation.

Our results indicates that corona charging, even at low electrical field, could be invasive to the surface passivation of Si solar cells by generating additional defects.

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RET - 21

Sliver Cells in Thermophotovoltaic Systems

Niraj Lal, and A. Blakers

Australian National University
Centre for Sustainable Energy Systems
Building 32, ANU, ACT, 0200
AUSTRALIA
E-mail: pilularis@gmail.com

A new model was created that enables examination of the effect of solar cell structure and composition on Thermophotovoltaic (TPV) system efficiency. Thermophotovoltaic systems use solar cells to generate electricty from the light emitted by a heated object. Potential sources for this heat include solar radiation, natural gas, industrial waste heat, vehicle engine heat and radioactive decay

Sliver Cells - thin, bifacial solar cells developed at the ANU, were investigated in Thermophotovoltaic systems. These cells were compared against state-of-the-art back contact conventional cells.

Thickness of the cell, temperature of the TPV emitter, distance from the emitter, antireflectance coating, mirror reflectivity, and temperature of the cell were considered and optimised.

Initially an idealised system was investigated to validate the model and examine the effect of each system component. Key components were identified to be the antireflectance coating and spectral control - as indicated in the literature, and also temperature of the cell.

For the comparison of Sliver cells and conventional cells, the key differences were thickness of the cell and cell contact geometry; Sliver cells have their contacts at the edges of the cell giving lateral resistance losses, and back contact cells have vertical resistance losses.

Conventional geometries were found to perform better than Sliver geometries - returning higher efficiencies at optimum emitter temperatures of ~3000K. Systems considerations however, such as cell shading, non-uniform light distribution, parallel circuitry and thermal sinking, favour Sliver cells. The modelled cells were composed of Silicon; a material unlikely to be used in TPV systems. However using Silicon allowed a detailed investigation of the effect of cell structure and thickness in TPV systems. The model can readily be extended to an analysis of Ge and GaAs cells, and also to multijunction structures.

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SSC – 22

Silicon Nanocrystals in SiC Matrix for Third Generation Photovoltaic Solar Cells

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Silicon nanocrystals (Si-NCs) embedded in a silicon carbide (SiC) matrix (abbreviated Si-NC:SiC) were prepared by alternating deposition of substoichiometric and stoichiometric silicon carbide ($Si_{1-x}C_x$/SiC) mutilayers by magnetron co-sputtering followed by a post-deposition anneal.

Transmission electron microscopy and Raman spectroscopy revealed that the Si-NCs are clearly established in annealed films, with sizes in the range of 3-5 nm. X-ray photoelectron spectroscopy (XPS) analysis of depth profile for annealed films showed a uniform chemical composition. Optical studies showed an increase in the optical band gap after films were annealed, from ~1.4 eV (as-deposited) up to 2.2 eV (annealed at 1100 $_{o}$C). Heterojunction (HJ) devices were fabricated from p-type Si-NC:SiC on n-type crystalline silicon (c-Si) substrates to evaluate the suitability of Si-NC:SiC for photovoltaics applications.

The electrical and photovoltaic properties of Si-NC:SiC/c-Si HJ devices were characterized by current-voltage (I-V) and quasi-steady-state open-circuit voltage (Suns-V_{oc}) measurements. The external quantum efficiency (EQE) and internal quantum efficiency (IQE) were measured also.

Factors limiting the cell's performance are discussed. This study indicates that Si- NC:SiC materials are promising for third generation Si-based photovoltaic cells.

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REP - 23

A Fair Go for Future Generations

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If it is argued that global warming is the greatest threat to the world this century, then a solution to global warming would be the greatest opportunity. Technically, the problem can be solved; present difficulties are cost and lack of political vision. People who believe in a "fair go" should expect to pay an honest price for any goods they receive, and also expect that those who are disadvantaged by supplying those goods should be fairly compensated.

This proposal is for the establishment of a perpetual trust fund to fairly compensate future generations for the consequences of unavoidable global warming, while providing interest free finance to make renewable energy competitive with fossil fuels. For a cost of about five cents per kWh, or one dollar per day for a typical Australian household, such a trust fund would be able to finance enough renewable generation capacity to replace the output of all existing coal fired power stations over a period of less than twenty years.

With improving technology, and mass production of modular systems, a combination of Wind Turbines, Solar Thermal Power Stations, Concentrating Photovoltaic Systems, and Hot Rock Power Stations, could eventually meet all future electricity needs. When renewable energy becomes cheaper than coal, coal fired power stations would no longer be needed. When the loans are paid back, (without interest, but indexed to inflation) the funds will be available to meet the costs of relocating future climate change refugees.

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SSC - 24

Phosphorous doped Si QDs embedded in SiO2 matrix for All-siliconTandem Solar cell

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In this study, silicon-rich oxide (SRO and SiOx, 0 < x < 2) films containing phosphorus (P) were prepared by co-sputtering of Si, SiO2 and P2O5 at room temperature, which formed Si nanocrystals upon subsequent high temperature annealing. P concentrations ranging from 0.1 at% to 3.0 at% were varied by changing deposition rates of three targets.

The chemical compositions of as-deposited phosphorus doped silicon-rich oxide sample were then investigated by X-ray photoelectron spectroscopy (XPS). The composition of as-deposited SRO was obtained by a curve fitting of the Si 2p peak by using XPSpeak, which is compared with the optical absorption of the films by using UV-Vis- NIR spectrophotometer. Both the peaks of Si-P and/or free phosphorus (peak around 129 eV) and PO (peak around 135 eV) were observed in P2p peak, which indicates that the phosphorus may exist inside Si nanocrystals. Phosphorus doped Si QD superlattice was prepared by alternating depositions of phosphorus doped silicon-rich oxide and stoichiometric silicon oxide.

From the XRD together with TEM, it is showed that Si nanocrystals embedded in the SiO2 matrix has been formed. The dark conductivities of P-doped Si QD superlattices were increased a lot compared with undoped Si QD superlattices. Both the effective phosphorus doping and other factors have an influence on the dark conductivity.

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ST - 25

Evaluation of a solar dryer in a high altitude area of Nepal

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Nepal is a poor country and is ranked 143 out of 177 countries in terms of standard of living, with approximately 38% of the population earning less than US$1 per day. Of the 75 provinces in Nepal, Humla has been judged to be one of the poorest (UNDP, 1998). Using a ranking of 1 (best) to 75 (worst), Humla was ranked 69th in terms of poverty and deprivation, and 73rd in terms of socio-economic and infrastructure development. Humla is also a food deficient area and to improve general food security, a small number of solar dryers have been produced for increased and improved crop preservation.

This paper describes the evaluation of one of the solar dryers located at the High Altitude Research Station (HARS) in Simikot, the main town of the Humla Province. The purpose of the evaluation was to determine the effectiveness of the current design and suggest possible design improvements. The paper first presents a description of the solar dryer and its location. This is followed by an outline of the methodology used to evaluate the dryer in technical, financial, practical and social terms. The results of the evaluation are then presented and discussed, followed by some possible design improvements and the impact that these may have. Some general comments about the prospects for solar drying in remote areas of Nepal are made in the conclusions of the paper.

Dr Bob Fuller is a Principal Fellow at the International Technologies Centre (IDTC), The University of Melbourne. He holds PhD.(Melbourne), M.Eng.Sc.(Melbourne), Dip.Mech.Eng.(Swinburne), and Dip. Auto. Eng.(UK). Dr Fuller has been research active in solar energy field since 1978 and published numerous papers on solar dring. He also has publised three books/booklets on solar drying.

Dr Fuller also contributed an invited article "Solar drying - a technology for sustainable agriculture and food production" in "The Encyclopedia of Life Support Systems".

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ST - 26

Solar Assisted Reverse Cycle Air Conditioning

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About 70% of Australian households now have air conditioners with annual sales reaching one million units in Australia during 2006. These units are predominantly reverse cycle, meaning that they can operate as heat pumps in heating or cooling mode. Despite increasing performance and mandatory energy efficiency requirements, household energy demand is growing stubbornly and this is attributed in part to installation of these air conditioners. Furthermore, these units contribute to peak demand and this is placing severe strain on electricity networks.

This paper outlines a method under investigation to use solar energy to unload the air-conditioning compressor and thus improve the coefficient of performance of the unit. A refrigerant ejector system is proposed as the solar cooling mechanism as it is very simple and has no moving parts. Although the solar subsystem alone is capable of producing solar cooling, a systems design approach indicates far greater benefits if the ejector subsystem is combined with a conventional air-conditioner. The design lends itself to retrofitting to existing reverse cycle air-conditioners, providing solar assistance to winter heating as well as summer cooling.

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RSE - 27

Towards a new energy future: lessons from the past

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Energy is a major theme at the Powerhouse, which has significant engine and transport collections; electricity generators, batteries, meters and appliances; engineering models; and solar cells and evacuated tubes. Its main building was Sydney's first public power station.

We seek to increase visitors' understanding of the future in the context of the past. Our working steam engines serve as a hook to get people interested in energy: they are visually interesting, easily explained, and tell stories of innovation, disruptive social change, continual search for energy efficiency, and the shift to dependence on fossil fuels.

In 2001 we opened the exhibition 'Ecologic: creating a sustainable future'. It discusses energy issues via: a quirky 3D representation of the carbon cycle; a huge tree slice re-interpreted as a carbon sink; models of renewable energy devices; solar and heat-pump hot water systems and other features built into a full-scale 'house'; interactive access to current and cumulative information on the output of our rooftop CSG solar system; a vanadium redox cell and models of the Austrans vehicle and Solar Sailor; and the popular 'Long hot shower' interactive where visitors can select systems and duration and see money going down the drain and carbon into the air.

My next challenge is to redevelop our 'Steam Revolution' exhibition, immersing visitors in the wider story of energy, from renewables to the fossil fuel age and back to renewables. There will be significant new object and image content about current energy ideas. One new interactive will allow visitors to access data from our (planned) cogeneration system; another will allow them to 'play' the National Electricity Market; a third will help demystify the hydrogen economy, with visitors able to power an electrolysis unit that feeds hydrogen to a fuel cell, which powers a kinetic toy.

NOTES: ____

SB - 28

Performance of a solar pre-heater for a commercial building

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In 1999, a study commissioned by the Australian Greenhouse Office found that the greenhouse gas emissions from the commercial buildings sector were expected to increase by nearly twofold from 32 Mt of CO2 per annum to 63 Mt of CO2 between the years of 1990 and 2010 under the BAU scenario. The specific operational energy applications responsible for the majority of these greenhouse gas emissions were cooling (28%), air handling (22%), lighting (21%) and heating (13%).

Solar air heating has the potential to reduce the emissions associated with heating. Large scale systems have been installed on various commercial buildings in various northern hemisphere countries. A solar air heating system is normally designed to contribute up to 50% of heat to the space and compliment the conventional fossil fuelled space heater.

In 2004, two 60 m2 solar air heaters were constructed on the roof of a Deakin University building to preheat the air entering a large design studio located on the top floor. This paper reports the measured performance of this solar air heater over a one-year period. In addition, a validated mathematical model of the studio, the solar air heater, and heating, ventilation and air conditioning systems serving it, was used to investigate performance improvement strategies and these simulation results are also reported in the paper.

The measured solar contribution of the heaters was found to be less than 5%. In some instances the solar air heaters actually contributed to the space heating load. A different control strategy and recommissioned control sensors was found to substantially improve the solar air heater performance.

Dr Bob Fuller is a Principal Fellow at the International Technologies Centre (IDTC), The University of Melbourne. He holds PhD.(Melbourne), M.Eng.Sc.(Melbourne), Dip.Mech.Eng.(Swinburne), and Dip. Auto. Eng.(UK). Dr Fuller has been research active in solar energy field since 1978 and published numerous papers on solar dring. He also has publised three books/booklets on solar drying.

Dr Fuller also contributed an invited article "Solar drying - a technology for sustainable agriculture and food production" in "The Encyclopedia of Life Support Systems".

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SB - 29

Cost Effectiveness of a Carbon Neutral House

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The cost effectiveness of building a carbon neutral house in Sydney is investigated. Currently all new residential dwellings in NSW must comply with the BASIX requirements of a 40% reduction in energy consumption compared to the current average energy usage. While this requirement reflects progress towards sustainable housing, there is further potential for energy savings in new buildings. This paper seeks to answer the question: Is it possible that the combined cost of energy efficiency measures and renewable energy can be incorporated into a home loan in a cost effective manner? An important factor that assists in the cost effectiveness of these measures is the ability to secure a "green home loan", at a lower interest rate.

Two renewable energy options to achieve a carbon neutral house are explored: installation of a photovoltaic system and the purchase of GreenPower. A higher initial home loan amount is required to pay for the energy efficiency measures, and also for the photovoltaic system. However, the energy savings arising from all measures are used to increase the loan repayments and typically mean that the loan period is reduced. Initial results indicate that the combination of lower interest rates and energy savings from energy efficiency is a very attractive financial option paying out the home loan 5 years earlier than a loan for a conventional house without energy efficiency. The financial savings generated in this way mean that energy efficiency in combination with a photovoltaic system or GreenPower results in paying out the home loan 1 to 4 years earlier. What this work shows is that a carbon neutral home has a lower life-cycle cost than a conventional home with high energy costs.

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ST - 30

ANU Micro-concentrator Collector

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The Australian National University, Centre for Sustainable Energy Systems has developed a panel-mounted, tracking, concentrator solar collector. This Micro-concentrator collector is similar in size to existing solar thermal panels, so is suitable for domestic residential application. Unlike existing products this concept lends itself to the integration of photovoltaic cells. A single unit will have the capability to produce both electricity and hot water.

The prototype collector of dimensions 1.7 by 1.5 by 0.2 m has recently been completed. It incorporates seven parabolic mirrors that focus light onto receiver tubes. The mirrors are made of polished aluminium and measure 0.15 metres wide by 1.25 metres long. The mirrors are moved by a motor driven tracking mechanism. This assembly is mounted on a support frame and housed in an enclosure.

The Micro-concentrator solar collector is intended for installation in a split domestic solar water heater system. The heat generated by the concentrated light is transferred to a fluid pumped through the receiver. This heat is then transferred to the tank via the heat exchanger.

Initial work has been focused on developing the mechanical aspects. For simplicity the prototype Micro-concentrator is a thermal unit that employs black painted copper tube as the receiver. At a later stage photovoltaic cells will be fitted to the receivers to generate electricity as well as useful heat. It is envisaged that a very narrow PV cell would be used. Operating under intense illumination the PV cell coverage is reduced to about 5% of the equivalent flat PV plate area.

Development of the Micro-concentrator is continuing. This paper will

- *Describe the Micro-concentrator collector.*
- *Show prediction of performance based on a TRNSYS model.*
- *Provide test results for the thermal performance of the prototype Micro-concentrator unit.*
- *Describe steps in the development of the photovoltaic receivers.*

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SSC - 31

Si QDs/Crystalline Silicon Heterojunction Solar Cells

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One of the approaches for improving efficiency beyond that of a standard pn junction cell is to use a tandem stack of cells, with a stack of a different bandgap material. Silicon quantum dot superlattices have been proposed for all-silicon tandem cells. By restricting at least one dimension of silicon less than the Bohr radius of the bulk crystalline silicon (around 5 nm), quantum confinement cause its effective bandgap to increase.

In this study, we have investigated heterojunction solar cells on p-type crystalline silicon (c-Si) substrate by depositing a phosphorus-doped n-type silicon quantum dots (Si QDs) in silicon oxide matrix which is around 3 ~ 5 nm in radius.

We describe the fabrication steps of (n-type) Si QDs/(p-type) c-Si devices and analyse the electrical properties by quantum efficiency, current-voltage characterisation, and capacitance-voltage measurements. Our best cell without high efficiency features such as back-surface field or surface texturing has an efficiency of 10.5 % at 1-sunillumination condition. Open-circuit voltage and short circuit current density are 520 mV and 28 mA/cm^2 over a 1 cm^2 area, respectively. High frequency capacitance-voltage measurements show good junction characteristics.

This study indicates the silicon quantum dots can be a good candidate for all-silicon tandem solar cells.

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ENS - 32

Scenario analysis of possible sustainable energy futures for Alice Springs

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Global concern about the impacts of climate change and future energy security has sparked debate in over the role renewable energy technologies could play in achieving a more sustainable energy future. Availability, costs and intermittency issues have all been argued to limit renewable energy's possible future potential. Clearly these issues are largely context specific.

This paper presents the results of a scenario study exploring future options for high renewable energy penetration in the Alice Springs power system. Wind energy, photovoltaics, solar thermal, municipal waste gas and energy storage options are modelled to illustrate their combined potential to contribute to Alice Springs' future electricity needs.

The scenarios also explore the role of improved energy efficiency, fuel switching and load shifting to facilitate renewable energy integration and sustainability outcomes. Past load data has been extrapolated for future growth and modified for demand side measures. Based on the modified load data, scenarios with varying renewable energy targets have been used to demonstrate potentially advantageous combinations of renewable technologies. Supply/demand matching is examined over 24 hours for seasonal high, low and average load days. Economic outcomes consider uncertainties including the future price of natural gas, learning curves for renewables and varying possible degrees of carbon taxation.

I'm currently completing my undergraduate degree in Photovoltaic Engineering at UNSW and this paper is based on my final year thesis.

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RET - 33

The Contribution of Photovoltaics to Commercial Loads

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Whilst photovoltaics (PV) is an increasingly popular technology for residential application, PV output is often better matched to commercial load patterns. This has ramifications for both placement of PV and for support policies.

Commercial buildings provide the potential for larger scale PV installations which in turn can be valuable in stimulating market growth, developing new financial arrangements and driving price reduction through economies of scale. Market entry by the commercial sector has been instrumental in the rapid market increase experienced in countries such as Germany, while the Japanese PV industry and government, which previously focussed support on residential applications, has now moved to development of this larger scale market.

Through the Australian Government Renewable Energy Commercialisation Program (RECP), a number of commercial scale projects were completed as showcase examples, notably in Sydney (Kogarah Town Square), Melbourne (Melbourne University Research Building) and Brisbane (Hall Chadwick Centre). These projects focused on whole building design outcomes and demonstrating PV integration technologies.

This research takes an important step further by investigating the value of PV electricity generation to the commercial sector in the Australian context. Specifically, this paper examines PV output and load profiles from a number of substations which service areas with a significant portion of commercial load. The cost-effectiveness of PV is then examined for commercial customers, based on current tariffs, depreciation allowances and Renewable Energy Certificates. Possible strategies to stimulate commercial sector uptake of PV are discussed.

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PVA - 34

AC coupled Hybrid systems and Mini Grids

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Distributed supply based on renewable energy sources is one main element in all scenarios for the worldwide energy supply in the future. Solar energy, wind energy, bio fuel and hydro power will be basic essentials of a long-term sustainable energy supply.

The recent developments of the inverter technology for photovoltaic and battery systems allow to built up supply structures in stand alone grids today, that are very similar to the large interconnected public grids. The modular AC-coupled hybrid systems and mini grids have brought a completely new quality to standalone energy supply systems and has closed the gap between grid connected and the previous common off-grid systems, like solar home systems or small DC-coupled hybrid systems. Modular AC coupled mini grids and hybrid systems have proven their efficiency in very different applications and with all kind of renewable energy sources. It is the ideal way to build up distributed energy supply systems for grid connected, off grid and back up applications and is therefore the appropriate technology for rural electrification with renewable energy sources. The innovations and developments from the very fast growing market for grid connected PV-technique can be applied in systems in a power range from 3 kW to 100 kW or even more that can easily be designed, installed and operated with standard components. The control principles are compatible to that of conventional power plants and therefore it is easy to integrate these systems into public networks. The manager of the AC-coupled mini grids is the battery inverter that utilizes voltage and frequency control and the operational control of the energy supply system. The droop control in combination with the power control of the generators via frequency shift makes it possible to built up distributed system without a fast communication system.

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ST - 35

Seasonal storage for solar thermal systems in Australia?

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Seasonal storage systems have been operating in various European countries since 1985. Combined with solar collectors, these systems are known as 'central solar heating plants with seasonal storage' (CSHPSS). While these systems have been shown to be technically feasible, their cost is still too high to make them competitive with fossil fuels.

In Australia, we have quite different conditions to those countries where CSHPSS have been trialled. In general, we experience higher radiation levels, ambient temperatures and cooling loads. Our heating loads and energy prices are also usually lower. As a result, any evaluation of CSPSS operating in a European context may not be valid for Australian conditions. To the authors' knowledge, no evaluation of these systems has been carried out for Australia.

This paper therefore attempts an initial assessment of these systems and their viability for Australia. The paper first describes the various types of CSHPSS and then reviews their current status. The performance of one type of CSHPSS operating in several locations of Australia has been predicted using a TRNSYS model. The simulations indicated that the design guidelines for Europe are inappropriate for Australia and would result in greatly over-sized systems.

An indication of the financial viability of the system was determined by calculating a simple payback period for a variety of fossil fuels. This type of seasonal storage systems appears to be financially attractive in areas of southern Australia where the solar system is displacing LPG.

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RSE - 36

Improving community access to Australian climate data

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Along with the increased recognition of climate change, there has been an increase in the number of associated mitigation policies, many of which involve changes to our present approaches to energy generation and consumption. Improving access to climate data will assist in the implementation of these policies, particularly the smaller-scale initiatives.

The Bureau of Meteorology's new Climate Data Online project expands the previous climate statistics and related information on the Bureau's website, and will provide more efficient public access to climate data via staged development of web-based tools. The initial phase of the project has introduced a greater number of climate statistics, with a focus on providing supporting metadata, educational material, and interactive exploratory features. Global solar exposure has been included for the first time, as have 9 am and 3 pm wind roses. First and ninth deciles of temperature provide a quick guide to temperature distributions for more than 1000 Australian locations. In addition, the range of climatological maps available on the Bureau of Meteorology website has continued to grow. Average daily global solar exposure on a horizontal surface, based on improved satellite-derived data, is now available, as are climatologies of Heating Degree Days and Cooling Degree Days.

Future developments are likely to include an improved spatial navigation and data viewer, new climate statistics and free access to basic climate data files such as daily solar exposure records for a location. A web-accessible database, which will manage and provide information from more than 500 Gbyte of gridded data files, is currently being established. The public will have access to interpolated daily data for any point on mainland Australia and Tasmania, with a spatial resolution as fine as 5 km, and a continuous daily record back to 1900 for some products. Daily solar exposure will be available from 1989 to present; however, daily wind analyses are not planned at this stage.

Ian has been employed within the National Climate Centre of the Bureau of Meteorology since 1998. Major areas of work include providing consultative advice on the application of climate data, web content development, and enhancing metadata resources and their use. Prior to this he spent 13 years at Telstra Research Laboratoriies in the field of new PV technologies and remote area power systems.

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ENS - 37

Wider Renewable Energy Issues for Nepal

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The principle of renewable energy for a near bankrupt and developing country like Nepal is well accepted, but its success in filling the needs and aspirations of the development workers and the country is low. The reasons for this include culture, poverty, language, lack of land titles, ancient rights, inadequate education, civil war, civil strife, hunger, greed, business practices, retaliation, infrastructure, bureaucracy and corruption.

Examples of how these effects operate are given, together with some possible short term solutions.

Possible long term solutions are discussed and the likely ramifications on the society as a whole.

Trigger factors are identified which may effect a complete collapse of the intended outcomes, whether via the collapse of the projects, or collapse of the complete society. Given a complete collapse of the renewable energy project or society, a range of possible least worst (or best) outcomes are presented.

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REP - 38

Nuclear Energy for Australia; A Solution to Climate Change or a new Problem

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Without any doubt Australia has a huge amount of uranium Australia has, indeed, more than 1/3 of the world's uranium [1]. There are enough evidences suggesting that Australia has more sun & wind than uranium. Australia is blessed with high level of sun radiation that makes Australia the sunniest continent on the earth. The average rate of the sun radiation in Australia is about 5.1kWh/m_2 per day.

This is about 100% more than sun radiation level of the Western European countries. Australia has also sites with very high quality wind resources with wind speed of more than 8 m/s. These are the facts that make Australia a country with more renewable energy resources per person than any other country in the world.

Being so rich in some renewable sources of energy make us to ask ourselves if Australia really needs nuclear energy? Nuclear energy is a type of energy that is associated with some problems including waste disposal and the threat of accidents.

This paper summarizes some important issues need to be considered before deciding in including nuclear energy into Australia's energy system. The issues discussed here are related to economical, technical and environmental aspects of nuclear power.

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ENS - 39

Economic evaluation of grid-connected solar photovoltaic energy systems in Australia

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This paper summarizes the cost issues of roof-top grid-connected photovoltaic (PV) systems and will presents the results of a study recently conducted on the electricity cost of solar PV systems for residential applications in Australia considering both the old (A$4000/kW) and the recently announced (A$8000/kW) government's subsidies.

Although the installation of solar PV systems in most countries is subsidized by country's government, but unit price of solar PV electricity in some countries including Australia is still expensive when compared with the electricity price of the electricity produced by conventional power plants. The wide gap between the cost of PV electricity and conventional plant electricity is relatively high, and probably this is the main barrier hindering the development of solar photovoltaic electricity.

This paper presents the detailed solar PV electricity cost. To determine the PV electricity price a number of parameters have been considered. These parameters include sun radiation data of location of PV installation, PV system's capital cost, interest on the loan obtained to pay for the installation cost, period of the loan, and maintenance cost, which is in the case of roof-top PV system is negligible. These parameters have direct as well as indirect effects on the price of electricity of the solar PV system. In this study we are using analytical tools and simulation program to determine the PV electricity price.

The results show that, although the new government subsidy program make grid-connected PV more affordable, but in terms of electricity price it is still higher than conventional electricity price specially in the states with lower sun radiation such as Melbourne.

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ST - 40

The Application of Transpired Solar Collectors to Heat Air to Regenerate a Desiccant Bed Air Conditioning System for Cooling Grains

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Food grains must be stored in good condition for prolonged periods of time. One of the most effective methods of achieving this is to cool the grain which has the effect of reducing the growth of insect populations and moulds, and cooling maintains desirable quality attributes. In temperate climates adequate cooling of grains can be achieved by ventilating them with cool ambient air. In sub-tropical and tropical climates this may not be sufficient and the air used to ventilate, or aerate, grain must be conditioned. One method of conditioning the air is to dry it isothermally using a desiccant during the night, and using warm air to regenerate the desiccant during the day. An analysis of the requirements of a desiccant bed grain cooling system has shown that during the day ambient air must be heated by about 30°C. By calculating the transmittance of the atmosphere to solar radiation and by making use of published performance data it has been shown that the area of a transpired solar collector required to cool one tonne of stored grains is about 0.1 m^2. The corresponding flow rate of air drawn through the perforations of the collector is 0.01 $m^3/s/m^2$ of collector area. Supplementary heating may be required during times that are cloudy or particularly humid.

Circular silos that are up to about 12m high may be cooled if all of the roof area is used to collect solar energy. Grain storage sheds have a high surface area to volume ratio and they are good candidates for solar cooling, even if only one side of the shed roof is used as a collector. A transpired solar collector perforated with holes with a diameter of 1 mm located on a 20 mm pitch results in a pressure drop of about 25 Pa which is commercially acceptable.

Professor Thorpe applies the principles of engineering science to solving a range of problems in post-harvest technology and water re-use. He has developed new methods of using heat to disinfest food grains of insects, and he has designed and built a system for refrigerating 15000 tonnes of stored grains. He uses contemporary engineering techniques in his work, such as advanced computational fluid dynamics and his work on porous media is informed by the methods of volume averaging. Professor Thorpe has a PhD from the University of Nottingham and a DEng from the University of Melbourne.

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RET - 41

Blueberry Electricity: Fruit based Dye-Sensitised Solar Cells

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There is great promise for low cost solar power generation using Dye-Sensitised Solar Cell (DSSC) technology. The best solar cells achieve 11.1% efficiency which is sufficient for practical implementation. Laboratory produced DSSCs use carefully synthesised ruthenium bipyridyl–based dyes, but for the purposes of demonstration, natural anthocyanin fruit dyes can be used instead.

DSSCs of area 1cm2 were tested under a halogen lamp with power output of 500W/cm2. Raspberry cells performed best followed by blackberries then blueberries (Fig. 2): Raspberries produced a SCC of 77.3μA, VOC of 0.427V, and FF of 49.3%. Although the power output of fruit based DSSCs is not commercially viable, it is sufficient for demonstration purposes.

The anthocyanin pigments which give fruits their distinct colour have a network of alternating single and double bonds. These orbitals can delocalize, stabilise the structure, and have strong absorption bands in the visible regions of the spectrum. The majority of light received at sea level is at ~400-600nm (Solar Spectrum, see Fig. 3). In this region, raspberries absorb more photons than blueberries (Fig. 3). The anthocyanin molecules in red fruits like raspberries absorb short wavelength photons and reflect red light (long wavelength photons) and so appear red. Blueberries reflect mostly short wavelength photons and so appear blue. Therefore, in blueberry DSSCs, fewer photons are available for absorption and cell performance is inferior to the DSSCs made using red fruits.

The fruit based DSSC is ideal for introducing the concepts of artificial photosynthesis because it has a simple construction design; it does not need ultra-pure substances; and it uses low-cost materials and processes that have little environmental impact. For maximal cell efficiency, the fruit must be well matched to the energy levels of the titanium diode and electrolyte, and absorb strongly at the peak output of photons in the solar spectrum.

I am an advanced science undergraduate student at the University of Sydney. I began working on fruit based DSSC in my first year through the Talented Student Program. I have done two further summer vacation scholarship projects on solar cell technology. Last year, Ned and I presented a poster on the educational merits of the DSSC. This year, we would like to present additional work done on the spectral properties of fruit dyes.

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SB - 42

Energy Efficient & Water Conserving Systems

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The recent water shortages in Australia, especially in the capital cities, have meant a greater focus on water conserving technologies. Technologies such as drip irrigation, and rainwater systems for domestic use are being increasingly implemented in both urban and rural settings. Typically such water conserving technologies rely on conventional grid connected pumps to transfer water from the source to point of use. Such pumps are typically designed to operate with total dynamic heads of the order of 20 – 30 metres, whilst the static head requirement, may typically be of the order of 0 – 10 metres. In terms of energy these pumps may be small. Domestic systems may only require motors of the order of 0.2 – 0.5 kW, whilst drip irrigation systems may be considerably larger (> 1 kW). However in terms of the hydraulic power actually required to deliver water in these types of applications, the systems are typically of low efficiency.

This paper examines how little energy is really required for such technologies to deliver water. The basis for highly energy efficient water delivery systems is low pressure. For example rainwater tanks typically deliver water into a home with a static head of a few metres, yet typical pumps develop heads of say 25 meters and deliver flow rates of say 15 litres/min.

Example: Rainwater tank supplying toilets: static head = 4 m, pump pressure = 25 m, flow rate = 15 litres/min. That is the frictional losses in the pipes/valves/bends are equal to 21 m of head. The hydraulic power in this case is ~ 61 W and with a 30% efficient pump this requires an electrical power input of ~200 W. However if the pipe delivery system were simply designed with say a pipe diameter of 25 mm instead of the typical 12 mm, then the fractional losses could be reduced from 21m to essentially zero. With a suitable low pressure, high flow rate pump, the same flow rate could be delivered. In this case the required hydraulic power is reduced to ~10 W and again with a 30% efficient pump this requires an electrical power input of only ~33 W, a reduction in power and energy of ~85%. Typical energy usage in terms of kWh per ML for a conventional 240 V pump and high pressure design can exceed the energy used (kWh/ML) by the local water authority. The low pressure option allows water to be supplied with less energy per ML than the supply authority is capable of delivering.

Conclusions: *Water efficiency appears to be something that is achieving greater and greater awareness in Australia. Many businesses are getting into the market of delivering water saving technologies to Australian homes and businesses. Unfortunately in many instances opportunities of utilising low pressure and therefore low energy pumps to deliver this water are being missed at present. Further details of water and energy efficient systems including drip irrigation suitable for powering by photovoltaics will be included in the final paper.*

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RSE - 43

Education in the field of photovoltaics in Czech Republic

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The rapidly growing European PV industry is willing to strengthen the European efforts on sustainable solar electricity by increasing its commitment in market, research and industry development considerably.

There is expected a demand for specialists in this area in a relatively near future. Education and training specialists in the field of photovoltaics are essential to establish and maintain a market and its infrastructure.

One of problems with teaching photovoltaics is that the field of photovoltaics is relatively very broad and interdisciplinary. The education may be done on different levels – from very basic information of public to training of users and preparing specialists. Education specialists in the field of photovoltaics may be realised by different ways from short courses and professional training up to graduate programs of relatively high level.

In the Czech Republic the education has several levels.

For basic and secondary schools, a state supported programme "Sun into schools" took place in period 2000 – 2006. At basic schools it is just information about a possibility to generate electrical energy using a PV system, preparing a general consciousness. At several hundred schools were built small on-grid connected PV demonstration systems and basic information included into lessons in Physics. Education of teachers has been a part of this activity.

On the level of secondary schools, bigger systems with data collection were built at more specialised schools. Photovoltaics has been included in lessons in Physics in more details.

Specialists are prepared at the university level. At the CTU Prague, the course "Photovoltaic systems" oriented on PV system technology (28 hours of lectures, 28 hours of exercises) is a part of Master study programme on Electrical Engineering and Information Technology. Another course on Photovoltaic systems (the same size) has been included in Master study programme on Intelligent Building. This course is more oriented on practical application in energy efficient buildings.

Details about both courses will be given in the paper.

Prof. Vitezslav Benda, PhD., FIET - Professor in Materials and Technology for Electrical and Electronics Engineering at the Czech Technical University in Prague, Czech Republic. He specialises in electronic materials and devices, especially in physics, technology and diagnostics of power semiconductor devices and photovoltaics. In the framework of project Socrates he gave lectures also at Bristol University, Swansea University and Aalborg University. He also took part in the Renewal PV programme coordinated by TEI Patras. He has been also co-ordinator of several research projects. He was awarded with the State Premium for technology in 1980 and with the Merit Award for inventors in 1989. He is author or co-author of 11 textbooks, 19 Czechoslovak patents and more than 80 papers. He is a Fellow of the IET and he serves as Chairman of the IET Czech Network.

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SB - 44

Non-Uniform Temperature Distribution on Photovoltaic Field under Real Operating Conditions

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The paper is focused on the issues concerning the photovoltaic system efficiency drop with increasing temperature, namely the temperature of each single solar cell and the temperature of the whole photovoltaic field. When the temperature of the photovoltaic field is not homogenously distributed, the differences of the V-A characteristics between single photovoltaic cells become more distinct. When series-parallel connected, the cells with lower efficiency will negatively affect the colder cells with higher efficiency.

The temperature distribution on the photovoltaic field was measured using a contact-less pyrometer and thermal imaging camera. Differences in the temperature distribution can be also due to the local shading of cells, e.g. owing to the biological pollution. In this case, the temperature of the shaded cell increases and the inhomogeneity in the temperature distribution on the photovoltaic field is brought in.

In our experiments, the temperature distribution was measured on PV systems installed at the CTU, i.e. on the open-rack PV arrays and on the back ventilated facade PV array. Both arrays are made from 110Wp c-Si PV modules. In both cases there were found non-uniform temperature distributions. In the case of the open-rack PV array the experimentally found difference in temperature was up to 10°C, temperature difference found in the case of the back ventilated PV façade array was higher then 25°C. The situation at the facade was simulated for the case of two vertical parallel plates with applied uniform heat flux where the temperature difference between the PV modules and the air in the ventilated gap remains constant along the height. Results of simulation are compared with experimental data.

The results can be used for optimising the performance of building integrated PV systems.

Prof. Vitezslav Benda, PhD., FIET - Professor in Materials and Technology for Electrical and Electronics Engineering at the Czech Technical University in Prague, Czech Republic. He specialises in electronic materials and devices, especially in physics, technology and diagnostics of power semiconductor devices and photovoltaics. In the framework of project Socrates he gave lectures also at Bristol University, Swansea University and Aalborg University. He also took part in the Renewal PV programme coordinated by TEI Patras. He has been also co-ordinator of several research projects. He was awarded with the State Premium for technology in 1980 and with the Merit Award for inventors in 1989. He is author or co-author of 11 textbooks, 19 Czechoslovak patents and more than 80 papers. He is a Fellow of the IET and he serves as Chairman of the IET Czech Network.

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ENS - 45

The Bushlight approach to Designing and Implementing Renewable Energy

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The Bushlight project represents an new and innovative approach to improving livelihood choices for indigenous people, through the access to sustainable Renewable Energy services. Bushlight is a project of the Centre for Appropriate Technology (CAT) initiated to address the twofold challenges of providing a reliable energy service to remote indigenous communities while addressing identified shortfalls in Australia's Renewable Energy (RE) industry.

This paper will look at the Bushlight approach to the design and implementation of Renewable Energy systems in remote indigenous outstations. A key part of Bushlight's approach is to involve community members in the planning, design and establishment of appropriate community Renewable Energy systems. This involves extensive community consultation, training and the creation of a three tier technical service provider network involving community members, community essential service provider staff and qualified electrical personnel. This process is supported by the development of robust, modular and well-tested technology which is notable for its reliability, intuitive user interface and operational credentials.

The Bushlight project has also developed a range of technical solutions to Demand Side Management issues including energy management units that enable the equitable sharing of available energy between households within a community based on community agreed household energy budgets.

Bushlight's installations range from individual houses to communities of a dozen or more houses. As a mark of the success of the project, Bushlight will install their 100th Renewable Energy system by late 2007.

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SB - 46

Thermal Performance Studies At The University Of Newcastle

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Over the last six years an extensive research program has been underway at the University of Newcastle in conjunction with Think Brick Australia aimed at investigating the thermal performance characteristics of masonry. This is being done at a full-scale level with purpose built test modules and has been extended to include the development of building simulation energy models.

This report gives a brief overview of the project and outlines the thermal performance of the test modules in terms of heat flow through the building envelope. The difference in behaviour for the four wall types (cavity brick, brick veneer, insulated cavity brick and lightweight) are reported in conjunction with the influence of the heat gained/lost via the window and slab for various times throughout the year.

I am a materials science graduate with a PHD in masonry. I have extensive experience in materials characterisation and recently have been working on the area of thermal performance. I have been responsible for the development of the thermal performance facilities at the University of Newcastle.

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SB - 47

Bond University Mirvac School of Sustainability - Successful Sustainable Design in the Subtropics

Kathryn Healey, N. Groenhout, T. Fowler and D. Merrony

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The new Mirvac School of Sustainability at Bond University on the Gold Coast has been designed to be world's best practice with regard to environmentally sustainable design. In order to benchmark the building, the design will be assessed against the pilot Educational Green Star design tool developed by the Green Building Council of Australia. The School is expected to be Australia's first building accredited under the Educational tool and Queensland's very first six-star building, representing an important milestone for building design in the subtropics. Not only is the building designed to be comfortable and efficient, its educational value is amplified by the fact that sustainable development students and staff will inhabit it on a daily basis.

Bassett Consulting Engineers played a central role in this innovative design, incorporating several measures of interest, including:

Individual thermal control of academic offices, Mixed mode ventilation, Extensive passive solar design, Intelligent daylighting control

Building integrated renewable energy sources including;

- *20kW BIPV array, Vertical axis wind turbine*

Extensive monitoring, sensing and data acquisition technology to enhance educational outcomes.

The building design including these innovations is presented as it currently stands going into construction phase, subject to possible changes during final design and implementation. As well as detailing the technical solutions, the paper presents how the building will work with its occupants – the Bond staff and students. Both groups tend to forge an intimate relationship with University buildings they inhabit and are therefore pivotal to the successful operation of the building. The design process has integrated sustainable design from the earliest planning stages to ensure that energy conservation was a cornerstone of the design. The process began with enthusiastic workshopping of ideas, and via an iterative process incorporating detailed modelling, simulation and testing, the team arrived at an optimum solution with confidence. The path from the initial concept to the final design is illustrated and reflected on. The building is expected to be completed in late 2007.

This paper will be of interest to anyone involved in bringing sustainability to the building industry.

Kathryn Healey (BE(HonsI) BSc) is a mechanical and renewable energy engineer based in Brisbane, having gained her qualifications at Edith Cowan and Murdoch Universities in Perth. Kathryn has worked in the wind energy industry both in a research role at Darmstadt University in Germany and in wind farm development with Wind Prospect Australia, UK and China. Previous conference publications have been in this field. For the last two years Kathryn has been a mechanical building services engineer at Bassett Consulting Engineers, most notably involved in the design of sustainable transport facilities for the Brisbane CBD.

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RET - 48

Liquid Solar Array

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The LSA system is based on floating solar concentrating collectors made mostly of plastic. Each has a very small area of silicon photovoltaic cells at the water surface with a large, thin plastic focussing lens rotating slowly above to track the sun. The water cools the silicon cells, and in bad weather the lens is protected by rotating it fully under the water to avoid damage in high winds.

•Almost all the structure is low-mass plastic so costs per square metre are extremely low.

•Only a very small area of silicon is needed (2% of the collector area) so Silicon shortages and the cost of refined silicon are not limitations. Other materials can also be used.

•The large lens can be as little as one millimetre thick but still survive winds over 100mph, because of its' unique method of weather protection, using water as part of the structure.

•All the major specialised components required are available off-the-shelf now, most at mass production levels, so commercial sales could begin in one to three years.

•The estimated system embodied energy payback period is under 15 months.

Phil Connor is a scientist and engineer based in Sydney, Australia who conducts research and development in a variety of fields including solar energy.

Background:

•Electrical Engineering degree, Sydney University, 1973. •Masters Degree in Electrical Engineering and Computer Science (ME), University of New South Wales, 1982. •Seven years at Macquarie University conducting research into speech and music using Fourier analysis and development of a fast digital signal processor. •Fifteen years with the Commonwealth Scientific and Industrial Research Organization (CSIRO) developing spectroscopic electro-optical instruments for the remote sensing and classification of minerals for the mining industry.

•Twenty-five years research and experimentation in solar energy techniques, including development of a low-cost solar thermal water pump and a variety of novel photovoltaic and thermal solar electricity-generation techniques, culminating in the formation of Sunengy Pty Ltd. to commercialise these developments

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RET - 49

Bushlight RE System Installation and Maintenance – Quality, Cost and Outcomes

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The Bushlight project has been installing renewable energy systems in indigenous communities since 2003. To date over 100 systems have been installed that range in size from stand alone household systems right up to large scale community hybrid systems. These installation sites cover a huge area across central and northern Australia. Site conditions vary from Central Australian deserts to remote tropical islands.

Bushlight awards all installation contracts through a competitive tendering process. A host of different installation contractors have completed installation work for Bushlight. Bushlight free issues to all installation contractors key equipment which ensures standardization of equipment across all our systems. All installations are completed to the Bushlight Technical Specification which is based on the Bushlight energy supply model and ensure a high quality of installation work. The ongoing maintenance of Bushlight systems is also a key aspect of our overall energy supply model and is delivered by electrical contractors who provide scheduled and unscheduled maintenance services to Bushlight technical standards.

Over this period Bushlight has been able to gather a lot of data on the cost of our installations, maintenance and breakdown call outs and make a useful assessment of the costs of building quality renewable energy installations in remote indigenous communities and in installing and maintaining renewable energy systems in general. An assessment of costs and cost trends for individual system components, total system costs, regional differences, impacts of distances and system maintenance and call outs provides an interesting insight into RE system installation in remote Australia.

We believe that the Bushlight project has been on the whole a great success, but as with all such projects we have constantly tried to improve on the quality of the service we deliver, adapt to a changing industry and learn from our mistakes. Ongoing feedback from the communities in which we have installed systems, the installation contractors and our own field experience have been the core source of our learning.

Paul Rodden - Capital Works Program Manager - Bachelor Photovoltaic Engineering (UNSW). Paul has worked with Bushlight Project since 2004 where his primary responsibility has been in managing the Bushlight system installation program.

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ST - 50

Spectral Beam Splitter for Solar Hydrogen Production

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Australia's abundant natural resource of solar energy has the potential to become a main driver for sustainable production of renewable hydrogen. In order for solar technologies to play a significant part in the future energy budget, there is a need to develop more efficient solar energy conversion and storage methods that can bring down the cost. Solar beam splitting is a method of making optimum use of the incident solar radiation and thereby improve the efficiency of the energy conversion process. An application for beam splitting technology is proposed here, combining the solar thermal production of hydrogen from a well-proven methane steam reforming process with the production of electricity from concentrating photovoltaic cells. The electric output can be used directly or converted to hydrogen by means of electrolysis. This paper discusses the initial stage of a feasibility study that includes the design, manufacture and testing of a spectral beam splitter. Results are presented for the filter design process of a beam splitter to be integrated with the CSIRO Solar Tower system in Newcastle.

Academic qualifications: PhD (Science), MSc (Hons).

Current position: Postdoctoral Fellow at the National Solar Energy Centre (NSEC) in Newcastle, NSW. The centre functions both as a demonstration and research facility for new solar technologies. My role has mainly been concerned with optical modelling, characterisation, and commissioning of a high concentration solar tower array. Currently, I am also working on the design and optimisation of a spectral beam splitting filter that is aimed at integration with a solar process for hydrogen production.

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ST - 51

Baseload Solar Power for California

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For several years, the group at ANU has worked on Thermo-chemical Energy Storage, using ammonia as a storage medium. This involves decomposing ammonia into nitrogen and hydrogen gas during the day, using a solar concentrator. Then at night, the gases are used to re-synthesise ammonia, releasing heat which creates steam to generate electricity.

Previous work has centred on optimising the process for parabolic dish concentrators. However, a large existing market of solar concentrators is the LS-2 parabolic troughs, prominant in the SEGs plants of California. These concentrators are now also being used in Spain, Israel and other locations world wide, backed by companies such as Solel, ACCIONA and Solargenix.

The ultimate goal of this project is to optimise the ammonia reactor design for use with LS-2 concentrators. While dish concentrators feature high operating temperatures (~700 degrees celsius) and a point focus, trough concentrators pose the challenge of lower operating temperatures (~390 degrees), and a linear focus (with a greater area for heat loss).

Therefore, the first step in this process was to model the heat losses from the trough reactor. Initial experiments involved the use of a small-scale model receiver containing heating elements. This resulted in the formulation of equations for the radiation, conduction and free convection heat losses from the receiver. Thes e were then applied to the data from solar dissociation experiments with a trough concentrator, to see if the experimental results could be predicted by theory.

A Fortran simulator for the chemical reaction also aided in this prediction.

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SB - 54

Exploring retrofit alternatives for State Houses in Southern New Zealand

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Most houses in NZ were built before energy efficiency regulations came into force with little being done over the years to improve thermal performance. A government sponsored, residential energy efficiency upgrade program has been put in place to improve the existing situation in terms of state houses across the country over a 7 year period. Unfortunately, our previous study has suggested that the basic insulation Housing NZ Corporation (HNZC) upgrade program will provide little improvement in terms of raising the minimum indoor temperatures towards those accepted by the WHO for a healthy indoor environment, particularly in the cooler parts of the country.

The present paper presents the results of an investigation exploring ways of investing in energy efficiency by improving the building fabric performance to a much greater extent than that undertaken in the basic HNZC upgrade program. Two state houses were retrofitted with wall, ceiling, underfloor insulation and double glazing in order to increase the thermal resistance of the building envelope. Several combinations of materials and components were trialled. Intensive monitoring took place during each stage of the upgrade, including using the house as a calorimeter to measure total R values. Using this technique the R value of the building envelope (fabric only) was found to have increased from about 0.8 m²K/W for the non insulated house to about 1.6 m²K/W for the fully insulated house. The upgrade process was also modelled using a dynamic computer program showing good agreement with the monitoring data. The model suggested that if houses were heated to minimum levels of comfort, a reduction of 2/3 of the space heating energy requirements would be achieved. Finally a cost benefit analysis was performed in order to assess the different alternatives presented in the retrofit.

Maria Callau, is an architect from Argentina, currenly working in housing enrgy efficiency research project in the Physics Department (University of Otago) and undertaking a masters degree by thesis.

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ENS - 55

Maintaining Australia as an Energy Exporter

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Australia's biggest single current source of export income is Coal, with an annual value of approximately $24billion. Australia is also the worlds biggest exporter of coal. In a carbon constrained world, this situation places the Australian economy at some risk.

With recent talk of an expanded nuclear industry, it might be thought that enhanced uranium exports could fill the gap. However the $/J value of Uranium is many times less than coal, so a global shift to Uranium would disadvantage us. In addition, conventional supplies of Uranium would only last a few decades if nuclear became the dominant power generation technology.

This paper will argue that Australia's best opportunity lies in the use of large scale solar thermal concentrator technologies to produce solar derived fuels for export. In the first instance this could be the solar thermal gasification of biomass or even coal to produce syngas for methanol production. In the longer term, thermochemical water splitting is suggested.

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REP - 56

Making Hospitals Healthier

Forbes McGain

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Hospitals use an enormous amount of energy and water and produce vast amounts of waste. Efforts to reduce hospital consumption have not been considered important thus far by the great majority of medical and other hospital employees. State and Territory Health bodies have however made non-binding commitments to reduce their energy and water consumption to which most staff remain ignorant.

Central Australia is predicted by the CSIRO to suffer the greatest climate change of our continent. The indigenous people of the Red Centre are amongst the most marginalised in the nation and least able to cope with climate alterations. I recently completed 6 months at Alice Springs' Hospital in the Intensive Care, Anaesthetics and Flying Doctor Units.

I would like to present a slide show detailing the general energy and water expenditure of the Alice Springs' Hospital and the timeline of unfulfilled attempts to alter this situation.

A group of committed staff have donated funds for a small PV system to be installed on the hospital to serve as an icon for other energy and water initiatives. Despite Alice Springs becoming the ultimate Australian Solar City the response from the NT Government has been muted.

Forbes McGain. Doctor i.e. anaesthetist and intensive care physician. Recently appointed to the Alice Springs Hospital. Now working at the Western Hospital.

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REP - 57

Adelaide's Transition to a Solar City

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By 2008, when the 3rd International Solar Cities Congress is held in Adelaide, the city will be well on its way to becoming a solar city. The paper will include an invitation to all delegates to come to the Adelaide Congress to see how Adelaide is implementing its solar cities program and share learnings from around the world on the role of sustainable energy in the urban environment.

Adelaide has particular attributes and drivers that make the search for a means of transitioning to a more renewable and distributed generation future an obvious pathway for the State. The paper will address these attributes and drivers. It will present a strategy for developing Adelaide as a solar city through Government leadership and policy, industry leadership, demonstration projects, capacity building and community engagement strategies. The paper will demonstrate that South Australia is highly engaged in the search for a new energy future which includes wholesale integration of renewable energy technologies. It will validate that South Australia has both a natural competitive edge for the update of these technologies plus sound economic drivers and constraints to existing energy networks that compels the South Australian Government to engage with industry and the community to find new solutions

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PVA - 58

The evolving market for DSC in Building Integrated Photovoltaics, within Australia

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This paper is a review and elaboration of the Dyesol submission 'for the case study into renewable energy sectors in Australia', written for the House of Representatives June 2007. The purpose of the Dyesol submission was to present a general overview of DSC research activities, information about dye solar cells (DSC) relative to other photovoltaic (PV) technologies and give a forecast to the market for DSC technology, specifically the evolving building integrated photovoltaic (BIPV) market.

When discussing the evolving market for DSC it is important to compare the advantages of this technology relative to alternate PV technologies, primarily silicon PV. To date silicon based technologies have dominated the PV market, however DSC technologies are able to provide an alternative; with partial transparency, lower manufacturing cost and improved performance when subject to shading or low light conditions. Some key beneficial features of DSC for BIPV are;

The range of available colours and transparency;

Reasonable performance at low light levels or partial shading;

Performance retention for greater angles of solar incidence;

Easier manufacturing processes than silicon;

No toxic gas emissions in manufacture;

Capacity to build tandem products such as UV protection using electro chromic windows.

The concept of BIPV design is relatively new to many people within the building industry. The technical capabilities of onsite electricity generation and the unusual nature and benefits of the technology are still being realised. With new flexibility in designs and the reduced manufacturing costs for DSC, this technology is expected to play a significant role in the energy sector, architectural designs and other engineering applications. DSC technology could be integrated into facades or in BIPV systems of commercial buildings available across CBD landscapes, and reduce the electricity demand from grid.

DSC BIPV can assist with the daytime electricity load of that building and also reduce the peak electricity load of an electricity grid. As cities continue to grown and electricity infrastructure moves towards full capacity, widespread implementation of alternatives such as DSC BIPV will be an essential consideration for city planners, and potentially critical for electricity demand throughout a CBD. DSC technology is on the verge of commercialization and quickly becoming a focus of attention for research institutions and businesses around the world.

NOTES: ____

RET - 59

Sealed Test Cells; Using a Test Cell Assembly Machine (TCAM)

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Research in Dye Solar Cell (DSC) technology at Dyesol began using open or unsealed cells. In many organisations, open cells are still the only cells used in DSC research, but there are clear problems in this approach. Open cells can only provide useful test results for a very short time, and measured results for DSC are intrinsically time dependent. Therefore understanding the set of results from an open cell experiment is inherently difficult and often misleading. For this reason, Dyesol moved to sealed cell experiments, and developed a prototype piece of equipment – the TCAM (Test Cell Assembly Machine) to make manufacture of sealed test cells a standardised procedure.

In this paper, some examples of different time variation patterns which have been seen at Dyesol will be used to illustrate the importance using sealed cells which can be measured over an extended period.

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PVA - 60

Towards a 55% efficient solar cell

A. Blakers, Vernie Everett, K. Weber and C. Holly

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ANU is joining a consortium of mostly US companies and Universities that aims to develop a 55% efficient tandem concentrator solar cell. The tandem cell will comprise six individually wired solar cells fabricated from different semiconductors. Sunlight with power of 20 suns (2W/cm2) will be incident on the top of the package. The cells will be ordered with decreasing bandgap from top to bottom. Each cell will absorb a slice of the solar spectrum and transfer light with energy less than its bandgap to the underlying cell.

ANU will be responsible, with others, for developing a suitable silicon cell. Light of energy <1.42eV will be transferred to the Si cell. The power of this light will be about 0.7W/cm2. Most of the light of energy <1.1eV must pass through the Si cell to an underlying InGaAs cell. By the end of the 3 year program the silicon cell should contribute >140mW/cm2 to the electrical output of the package. This is a challenging and interesting target.

The Si cell must make good use of long wavelength, weakly absorbed E>1.1eV infra red light. It can only absorb this light by ensuring a long path length of light within the Si. However, it is a requirement that the Si cell not compromise transmission of sub-bandgap light to underlying cells. This precludes the normal use of texturing. Parasitic free carrier absorption of sub bandgap light must also be minimised. Other important factors include the necessity of maintaining near-unity internal quantum efficiency, low surface and bulk recombination rates, n=1 operation (for high fill factor) and low parasitic resistance losses.

The paper will describe the design and fabrication of the silicon cells, and the compromises and tradeoffs required. Progress of the whole package towards a target efficiency of 55% will be reviewed.

Vernie spent a number of years long distance trucking and contracting before establishing a small earthmoving business. Leaving earthmoving after ten years he moved to Armidale and worked through a Bachelor of Computing Science (1992), Bachelor of Science (1994), BSc (Hons) 1995 and PhD (2002) at UNE. He was actively involved with student, management, and academic interests, serving as postgraduate student representative on policy and advocacy, three terms as postgraduate representative on the UNE University Council, two terms as president of the UNE Postgraduate Association, and tutoring maths, applied maths, physics, optoelectronics, astronomy, and electronics, as well as part time lecturing. During this time he also established a small computer business employing up to ten staff with branches in Armidale, Brisbane, and Gladstone.

In 2001 he commenced work on the Sliver Project at ANU, developing automated handling, assembly, electrical interconnection, and module design solutions for Sliver solar cell technology. He is the author or co-author of more than ten patent applications, six refereed journal articles, sixteen refereed conference papers, and more than thirty other scholarly publications; the majority of these in the field of plasma physics and Sliver Technology. He recently won the Institute of Engineers Australia (Canberra Division) Innovation and Excellence in Engineering Award 2007. He was a finalist in the Institute of Engineers (Australia), Innovation and Excellence in Engineering Award, 2006; Joint winner, ACT Sustainable Cities 2006 Environmental Innovation Award; Joint winner, ACT Sustainable Cities 2006 Overall Award; Joint winner, Banksia Award 2005, Environmental Leadership in Infrastructure & Services; Joint winner, Aichi World Expo Global Eco-Tech 100 Award, 2005; Joint winner, Australian Institute of Energy Innovation in Energy Science & Engineering Award, 2005; and Joint Finalist, Sherman Eureka Prize for Environmental Research, 2005.

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PVA - 61

Photovoltaics at CSIRO Energy Technology

Chris Fell

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In late 2005 CSIRO Energy Technology commenced a research program in photovoltaics with an emphasis on organic-based technologies that have the potential to dramatically reduce the cost and enhance the applications of photovoltaic solar power. Whilst the world's best research scale organic devices are close to achieving marketable power conversion efficiencies, there are still significant barriers to large scale implementation of this new technology. Lab scale fabrication methods are fundamentally not scalable to manufacturing volumes and device durability is still inadequate for practical applications.

CET's program aims to address two clear needs of the Australian photovoltaics community; i) to work with universities to demonstrate promising organic-based technologies on a manufacturing scale, and ii) to provide a base of expertise and infrastructure for accurate characterisation of PV devices. The latter has presented a particular challenge for organic photovoltaics, where key advances are often made by synthetic organic chemists, whilst the expertise to monitor these advances is dominated by groups working in traditional inorganic PV technology.

The vision is to expand the existing National Solar Energy Centre at Newcastle to include a world-class photovoltaics characterisation facility, catering for the special requirements of organic photovoltaic devices, whilst working to standardise measurements across the entire Australian PV community. We report on our progress toward this goal.

Dr. Fell holds a degree in Applied Physics from UTS and a PhD in experimental physics from the University of Newcastle. He is a specialist in optics and photovoltaics and has been involved in technology development for the both the semiconductor and telecommunications industries, including an important role in developing the thin-film silicon technology now commercialised under the name CSG Solar.

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PVA - 62

Large scale grid connected solar in the future energy market

Graeme Pollock and J. Birch

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Define large scale solar concentrator technology

o Compare the market segment separation between Flat Plate Solar and Solar Concentrators (Performance & Design Distinction)

o Define Solar Systems' current technology and its current Central Australian applications

o Describe the current cell efficiency status for concentrator systems

o Describe the pros and cons of solar concentration - complication vs conversion efficiency.

o Describe the potential scale-up of solar generation using concentrators in a power station format.

o Describe the four proposed Alice Springs Solar Cities concentrator sites

o Describe the 154MW Northern Victorian project, and it's differentiator to the Central Australian and Alice Springs power stations.

o Discuss the possible Australian and International Market potentials for Solar Concentration in Mainstream Grid Connected Electricity Markets and Regional Areas.

o Describe the potential for Hydrogen production - currently at R&D stage - as a by-product of Solar Power to develop 24hr base load generation power stations.

The presentation will include descriptions of the Solar Concentration concept and process, utilising photographs that allow ease of understanding at all levels of technical knowledge.

Graeme Pollock has over 20 years electricity industry experience in network design & construct, energy management, energy conservation, and energy retailing.

Graeme has a unique view of, and insight into the electricity market, having worked extensively in Network Management, Retailing in the National Energy Market, and also having a background as a customer advocate for large and small business electricity consumers.

As National Sales Manager for Solar Systems, Graeme now leads Solar Systems' bid to develop a range of moderate to mega scale solar concentrator power plants throughout Australia, in both regional and National Grid connected locations.

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ST - 64

Comparative Performance of Commercially available Solar and Heat-pump Water Heaters

Bob Lloyd and A. Kerr

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In-situ performance data for solar and heat pump hot water systems are not copious in the literature. Otago University has been testing some systems available in NZ for a number of years. The results obtained are compared to international studies of in-situ performance of solar hot water systems and heat pump hot water systems, by converting the results from the international studies into a single index suitable for both solar and heat pump systems (COP). Variability in the international data is investigated as well as comparisons to model results.

The conclusions suggest that there is not too much difference in performance between solar systems that have a permanently connected electric boost backup and heat pump systems over a wide range of environmental temperatures.

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ST - 65

LARGE PAYLOAD SOLAR TRACKING FRAME for the Solar Boiler Project

David Caldwell

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This paper explores aspects of the design and development of a solar boiler. The system incorporates a number of perhaps unique features based on a dual axis tracking frame.

The concentrators are 1m square, modular panels. This allows the collector deck structure to be essentially planar and the structural system has been designed to support up to a 10m x 10m configuration. The characteristics of the spherical collector surface used for these panels are outlined in comparison with a paraboloid form.

The concentrator panels are piped in series up the slope of the deck and a water drum and steam drum are positioned at the bottom and top, in much the same way as a conventional water tube boiler. The design is developed around direct steam generation. Each riser pipe incorporates a series of high temperature receivers. The dual axis tracking system is formed with an Azimuth deck and an Altitude rack. The structure for the rack incorporates a small, 2m square enclosure to house the controls and steam vessels. The drive mechanism uses a ratchet principle with pneumatic over hydraulic system with rams and pins to position both the altitude and azimuth drives. The positional control system is primarily open and is trimmed with a direct beam solar sensor.

The controls for each boiler comprise a single board PLC supervised by a remote personal computer. The PC uploads positional tables and data logs each PLC connected to it. The digital electronics have provision for remote access and control via the internet. The accuracy requirements are discussed and the relative characteristic requirements of spherical vs parabolic dishes are examined. Finally a basis of evaluating thermal performance relative to a standard site (we have selected Daggett CA) is discussed.

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ST - 66

Solar hot water systems in remote Australia

David de Vries and S. Hunt

Centre for Sustainable Arid Towns
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AUSTRALIA
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Detailed monitoring has been conducted on sixteen commercial solar hot water systems installed on residences in remote small communities and in Alice Springs suburban settings. Booster current, tank water temperature, tank over-temperature discharge temperature and water volumes were logged. Scale buildup was also examined.

Results identified numerous potential inefficiencies. Where AC boosters were left on, very significant power usage was identified even on days of very high solar gain. As there is no provision of off-peak electricity or hot water meters in the region, the booster power consumption may be high and undetected. Other high external power demands were generated by hot water draw being far greater than the systems were designed for. Water inefficiencies were identified by frequent overtemperature discharge events in older systems resulting in the majority of the tank being lost to waste. Scale accumulation was identified and is thougt to underlie some of the maintenance and efficiency problems encountered.

One cause of these inefficiencies is the design of commercial systems is optimised for temperate, high water quality settings. Strategies to optimize solar hot water system performance in remote Australia will be presented.

David de Vries is the Director of the Centre for Sustainable Arid Towns in Alice Springs. CSAT conducts research on a commercial basis for a range of clients in the fields of energy, water, built environment and food production. See csat.com.au

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ST - 68

A PROTOTYPE LIQUID DESICCANT DEHUMIDIFICATION SYSTEM

Kame Khouzam

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School of Engineering Systems
2 George St., Brisbane, Queensland 4001, Australia
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The objective of the project is to develop a low temperature crop drier as a viable alternative to the conventional systems currently in use. Typically Queensland summers are relatively humid resulting in a higher air temperature requirement for the crop drying procedure when compared with less humid climate. The increase in temperature required for successful drying due to this humidity can reduce the quality of these products. By using a suitable desiccant however, the air can be dried. The use of dehumidified air allows drying at much lower temperatures and preserve product quality. The desiccant once saturated with moisture can then be regenerated for reuse using a solar energy driven system. The prototype development consists of a crop batch bin, air-drying system, regeneration system, and solar thermal collector. Various pumps, air blowers, heat exchangers, and instrumentation and control are used. The packed bed tower structure was adopted in both the dehumidification and regeneration modules. Lithium chloride was used essentially but trials included calcium chloride. A solar water heater coupled with a heat exchanger provided thermal energy for desiccant regeneration.

Several parameters are investigated including regeneration temperature, liquid desiccant concentration, and airflow rate.

Tests were conducted with air at a wide range of relative humidity (RH 28% - 100%) and temperatures (4 - 32°C). The airflow rate was in the range 200 to 300 litres/sec and the desiccant flow rate ranged from 2 to 6 litres/min. A wide range of desiccant concentration was investigated. Results show that a desiccant concentration of 52% to 64% (W/V) is suitable running at low flow rate. At high concentration, air of very low RH was achieved regardless of ambient air intake. The packed bed was found to be adequate especially for the air dehumidification process; however, it was less efficient for the regeneration process.

The system offers many benefits in relation to drying, energy and cost savings. The use of solar energy has the potential to replace fossil fuels for drying purposes as well as to enhance the quality of produce in a reasonable processing time. The proposed system would make drying grain and other agricultural products more viable in the tropics, where high ambient humidity makes heated-air dryers expensive to operate. The system would also have appeal in the colder parts of the country (such as in Victoria and Tasmania) where high humidity and low temperatures also make drying more expensive.

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RSE - 69

Creation of Ersatz Future Weather Data Files

Trevor Lee, and D. Ferrari

Energy Partners
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Predicted climate change is often reported as the mean seasonal change between climate variables averaged over a given period, while thermal and other energy engineering simulations often require hourly representation of climate variables (elements). This paper describes a method of combining seasonal increments with hourly data representing the present climate. The resulting hourly data is representative of future climate estimates.

An architect by initial training, Trevor is a consultant on energy conservation in the built environment through his multi-disciplinary firm Energy Partners. He is the lead author of the Australian Solar Radiation Data Handbook (ASRDH, 2006) and team leader for developing the current Australian Climate Data Bank (ACDB, 2005), the basis of all building and energy system simulation programs in current use in Australia. Subsequently, he worked on a project for the Australian Greenhouse Office (as yet unpublished) to project the impact on the built environment of "inevitable climate change".

His interests include solar energy applications and ethical investment and, in pursuit of these, he has served as the Chairman of the Australian and New Zealand Solar Energy Society and as a director of the Sustainable Energy Industry Association (forerunner of the Business Council for Sustainable Energy, BCSE) and of the Canberra-based funds manager Australian Ethical Investment Ltd.

Currently a doctoral student in the Faculty of Engineering and Information Sciences at the Australian National University, Dave is an engineer working part time for Energy Partners.

NOTES: ____

SB - 70

BASIX 'DIY' Thermal Comfort Analysis - Current Practice and Future Developments

Trevor Lee, and D. Howard

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BASIX is the web-based planning approval system recently introduced for housing in the state of NSW and presented as a model to other jurisdictions for adoption.

This paper analyses the DIY method for the thermal comfort section of the BASIX program. The thermal performance of a basic house was compared using both the NatHERS method and the BASIX DIY method for three different climates. The effects of varying different building characteristics such as glazing and external wall surface were also tested. It was found that there were significant variations in the results from the simulation method (NatHERS) compared to the DIY results. In most cases it was found that the DIY method was considerably less responsive to changes in the building characteristics than the simulation method. These results suggest that there is considerable modification work to be done on the BASIX DIY method in order to improve the accuracy of its predictions.

In addition to this analysis, consideration is given to the impending adoption of the 2nd Generation NatHERS software packages which will widen the disparity between the simulation and DIY methods both in terms of the accuracy of the energy predictions and in the range of climate zones offered for the simulation option.

An architect by initial training, Trevor is a consultant on energy conservation in the built environment through his multi-disciplinary firm Energy Partners. He is the lead author of the Australian Solar Radiation Data Handbook (ASRDH, 2006) and team leader for developing the current Australian Climate Data Bank (ACDB, 2005), the basis of all building and energy system simulation programs in current use in Australia. Subsequently, he worked on a project for the Australian Greenhouse Office (as yet unpublished) to project the impact on the built environment of "inevitable climate change".

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Currently a doctoral student in the Faculty of Engineering and Information Sciences at the Australian National University, Dave is an engineer working part time for Energy Partners.

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Keynote - 72

Sliver cells: the low cost PV electricity alternative

E.T. Franklin, A. Blakers, K. Weber and Vernie Everett

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Acton, ACT 0200
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Sliver® cells are long, thin single-crystal silicon solar cells fabricated using novel processing methods based on standard fabrication technology Sliver® modules are highly efficient and can be low cost, bifacial, transparent, flexible, shadow-tolerant and lightweight. Compared with current industry standard PV technology, a mature Sliver® technology will need less than 10% of the pure silicon and only around 5% of the wafer starts per MW of factory output. In this respect they represent a very large cost saving via major reductions in demand on two of the dominant PV module cost factors: expensive ultra-pure silicon, and labour, equipment and consumables intensive wafer processing. An important feature of Sliver technology is that a single 15cm diameter host wafer can contain enough Sliver cells to populate a module with a rating of up to 100W. This means that a longer wafer process and good process control can generally be afforded.

The Sliver research team at the Australian National University has been steadily advancing the Sliver® technology. The focus has largely been on the challenge of providing a mature, optimised and robust Sliver cell fabrication method which produces a high yield of highly efficient Sliver cells, and which is suitable for transfer to industry. In addition, considerable work on the challenge of turning wafers full of sliver cells into sliver modules has been conducted and it has been demonstrated that the billions of Sliver® cells that would be produced annually by a 100MW Sliver cell factory can be extracted from the host wafer and encapsulated at low cost without vision systems or robotics, and using entirely conventional PV module materials. Consideration of cell fabrication and module production cannot be made independently, since the most cost-effective module production methods also rely upon a cell fabrication sequence which delivers high-efficiency cells with high yield (to avoid the necessity of measuring and binning each cell).

An optimised Sliver cell processing sequence that is capable of producing 20%+ cells, when coupled with a robust, low-cost Sliver module construction method [5], can be expected to significantly reduce the costs of commercial PV modules. Much skilled engineering work is still required to translate the exceptional promise of Sliver technology into commercial reality. However, we believe that the essential building blocks are now in place.

Vernie spent a number of years long distance trucking and contracting before establishing a small earthmoving business. Leaving earthmoving after ten years he moved to Armidale and worked through a Bachelor of Computing Science (1992), Bachelor of Science (1994), BSc (Hons) 1995 and PhD (2002) at UNE. He was actively involved with student, management, and academic interests, serving as postgraduate student representative on policy and advocacy, three terms as postgraduate representative on the UNE University Council, two terms as president of the UNE Postgraduate Association, and tutoring maths, applied maths, physics, optoelectronics, astronomy, and electronics, as well as part time lecturing. During this time he also established a small computer business employing up to ten staff with branches in Armidale, Brisbane, and Gladstone.

In 2001 he commenced work on the Sliver Project at ANU, developing automated handling, assembly, electrical interconnection, and module design solutions for Sliver solar cell technology. He is the author or co-author of more than ten patent applications, six refereed journal articles, sixteen refereed conference papers, and more than thirty other scholarly publications; the majority of these in the field of plasma physics and Sliver Technology. He recently won the Institute of Engineers Australia (Canberra Division) Innovation and Excellence in Engineering Award 2007. He was a finalist in the Institute of Engineers (Australia), Innovation and Excellence in Engineering Award, 2006; Joint winner, ACT Sustainable Cities 2006 Environmental Innovation Award; Joint winner, ACT Sustainable Cities 2006 Overall Award; Joint winner, Banksia Award 2005, Environmental Leadership in Infrastructure & Services; Joint winner, Aichi World Expo Global Eco-Tech 100 Award, 2005; Joint winner, Australian Institute of Energy Innovation in Energy Science & Engineering Award, 2005; and Joint Finalist, Sherman Eureka Prize for Environmental Research, 2005.

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ST - 73

Assessment of CSIRO Solar Tower Heliostats

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The National Solar Energy Centre at CSIRO's Newcastle headquarters is home to the first solar tower in the Southern Hemisphere. The field comprises nearly 200 mirrors, which in total can deliver over 500kW of solar energy at the receiver aperture with average fluxes of around 1000 times, and much higher peak fluxes.

The field is presently set up to be used for SolarGas production, a gas produced by using solar energy to reform natural gas resulting in solar energy embodied in chemical bonds of the gas. The field will also be used for many other high temperature applications such as high temperature steam production, and beam splitting. Much of the work to date has been on assessing and modelling the optical performance of the heliostats as they represent a fundamental part of the whole system. Improving performance, while maintaining low cost, is crucial to the cost effectiveness of the technology. The heliostat assessment procedure has involved photogrammetry, surface contour plots, ray tracing, assessment of astigmatism and cosine factors, and actual flux measurements using specialised flux measurement equipment.

The results of this work will be presented, including analytical procedures and results.

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Keynote - 74

Smart Energy Zones

Steven Peters

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AUSTRALIA

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Finding solutions to the rising demand for energy with the need to cut greenhouse gases requires a radical shift in the way we develop our urban areas. Smart Energy Zones, a $4 million Victorian Government initiative managed by Sustainability Victoria, was launched in February 2007 to demonstrate that by combining supply and demand solutions and developing local energy opportunities, communities can dramatically and cost-effectively reduce their greenhouse intensity.

In response to the Federal Government's Solar Cities initiative, a number of Victorian proposals were developed to address local energy needs in a sustainable way and avoid the need for electricity system infrastructure augmentation.

The Smart Energy Zones program is intended to support the Victorian Government's active involvement in these projects and to support the development of further integrated, locally developed and applied sustainable energy solutions. The Solar Cities program, although aligned with Victoria's energy objectives, constrains support for micro-generation to solar technologies. Smart Energy Zones creates an opportunity to utilise the momentum Solar Cities has developed to deliver outcomes which more closely meet Victoria's particular needs.

Through Smart Energy Zones, Sustainability Victoria is working with developers, local governments, industries and community groups to implement appropriate sustainable solutions in both greenfield and existing urban sites.

In these Zones, communities will trial the effectiveness of combining micro-generation, emerging technologies, market measures and demand-side solutions to:

> *> reduce the rate of growth in energy demand*
>
> *> provide a cost-effective alternative to large infrastructure investment; and,*
>
> *> drive consumer uptake of more sustainable energy alternatives through the integration of distributed generation, microgrids, energy efficiency, smart meters, energy storage and cost-reflective pricing.*

As part of the Renewable and Distributed Energy team at Sustainability Victoria, Steven currently manages the Smart Energy Zones program, a $4 million Victorian Government initiative to show how communities can cut greenhouse emissions with a combination of energy solutions. Previously responsible for the commercial building programs at Sustainability Victoria, Steven managed the regional administration of the Australian Building Greenhouse Rating (ABGR) scheme in Victoria, and sat on the Green Building Council of Australia's technical working group for the development of new Green Star *rating tools. Steven holds a Bachelor of Engineering in Building Engineering from Victoria University.*

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Keynote - 75

Solar PV Systems in Himalayan Villages: Problems and Possible Solutions

Alex Zahnd

Assist. Prof. Department of Mechanical Engineering
Kathmandu University, Nepal
& RIDS-Nepal Project Director, P.O. Box 126, Kathmandu, Nepal
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K. McKay

Assoc. Prof. Department of Anthropology,
University of Montana, USA
& *The ISIS Foundation* Nepal Humla Project

Over the last decade Nepal has experienced a steady growth in solar photovoltaic (PV) system installations in remote mountainous communities. The reason for this is the growing understanding that grid connected infrastructure will never be feasible for these inaccessible parts of the country. Government subsidy programs, funded by foreign governments and INGOs, have caused a mushrooming of solar PV companies in the country's capital, Kathmandu. However, while the development of a renewable energy industry is to be welcomed, the standard of the majority of the solar PV systems installed is questionable from a sustainability point of view. The designers, manufacturers and policy makers' view of rural village electrification through solar PV systems is driven and biased by an urban, academic and business oriented perspective. Their perception does not take account of the end users' local context and needs. Likewise the end users lack awareness and education about the use of renewable energy systems, which results in inappropriate and unrealistic expectations.

These two mismatched worldviews threaten the long term relevance of the local renewable energy industry and the improvement in living standards of these remote mountain communities. The major problems fall into two categories, technical and non-technical. This paper explores the range of these problems and suggests some possible remedies. Through the examples of installed solar PV system projects these remedies are reflected in practice in one of the most remote and impoverished areas of Nepal. The case studies are from three villages, in each of which a different solar PV system approach has been followed, according to differing geographical and cultural conditions. Each village has one system-specific data monitoring system, recording data for detailed, long-term understanding of the solar PV system's performance and interaction with the users.

This paper reflects on monitoring results and the practical experience gained over 10 years of installing solar PV systems. It provides recommendations for improved and context related solar PV village system projects.

ZAHND Alex has a mechanical engineering degree from Switzerland, and a Masters in Renewable Energy from Murdoch Australia. His industrial experience ranges from development projects in extrusion technology for the food and plastic industry, to pharmaceutical production plants. He lived and worked from 1996 - 2000 in one of the remotest and poorest mountain communities in the Nepal Himalayas, in Jumla, as director of a holistic community development (HCD) project. Since 2001 he has been a member of expatriate staff of Kathmandu University, involved in teaching Renewable Energy courses as well as in applied research of renewable energy technologies. Since 2002 he combined his extensive field experience and applied academic research projects by developing and leading a long-term HCD project and a High Altitude Research Station (HARS), in the very remote and impoverished north western district of Humla through the established NGO RIDS-Nepal (www.rids-nepal.org). The HCD projects are designed, implemented and followed-up in close partnership with the local village communities and local manufacturing companies. He is currently working on his PhD in rural village electrification systems and a new HCD approach for Himalayan villages.

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SB - 76

The Use of Micro-Encapsulated Phase-Change Material, and the development of the "Phase Change Chimney," in improving the thermal performance and energy efficiency of lightweight solar housing.

David Goodfield, M. Anda, R. Hammond and K. Mathew

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This paper describes the latest developments in a research program focused on the application of a recently marketed product from Germany called Micronal Smartboard, a 15mm plasterboard containing micro-encapsulated phase-change material.

The application is designed to improve the thermal performance and energy efficiency of lightweight low cost steel-framed transportable housing under both summer and winter conditions in a warm temperate climate such as Perth, Western Australia.

An options study was carried out to determine affordable methods and systems to achieve this end and two technologies selected for incorporation into a single prototype funded by National Lifestyle Villages Ltd.

Occupation is anticipated in late June 2007, following which a comprehensive monitoring program will be carried out in order to evaluate the effectiveness of the new systems of which there are four main elements:

use of plasterboard impregnated with phase-change material within the fabric of the building;

the use of a ducted heating and cooling fan system;

a "phase-change chimney" augmented by natural gas heating system; and

a system which combines the use of all three technologies.

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REP - 77

A Tale of Two Solar Cities

D. Harries, August Schläpfer and S. Rawnsley

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and School of Electrical, Energy and Process Engineering
Murdoch University
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Western Australia is the only state or territory in which Solar City project proposals were developed and submitted, but no projects were selected. Due to the competitive nature of the bidding and the commercial-in-confidence nature of the bids, as well as the in camera selection process, there will always be speculation over why some proposals were successful and others were not.

Two cities, Perth and Kalgoorlie, were two competing solar city consortia in WA. A number of possible reasons can be put forward to explain why neither of the proposals submitted by these two city consortia was successful. Rather than being a case of sour grapes, there is value in asking what went wrong as the advancement of renewable energy, and photovoltaics in particular, in Western Australia will continue to be frustrated so long as a number of issues that are serving to inhibit the growth of the industry in Western Australia remain unquestioned and unchallenged.

The failure of either Perth or Kalgoorlie to succeed in the quest to have a Solar City project should be used as an opportunity to identify and to understand these issues.

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ST - 78

Unsteady Effects in Direct Steam Generation in the CLFR

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The Compact Linear Fresnel Reflector (CLFR) is a concept for a large-scale line-focus solar concentrator for use in thermal power stations. A linear analogue of the 'central receiver' concept, it incorporates novel single-axis-tracking mirrors together with a line-focus direct-steam-generation thermal receiver. A transient model of two-phase flow in the CLFR absorber is presented.

The model uses Friedel pressure drops, and the simplifying assumptions of homogeneous flow and a stationary momentum equation. Dynamics are modelled using the numerical method of lines and a backwards difference formula DAE solver, and is performed using the free/open-source ASCEND modelling environment. During a step change in solar irradiation, a highly non-linear variation in exit flowrate is predicted and an explanation sought.

We also present an investigation into the Ledinegg pressure/flowrate instability in the CLFR prototype. This instability arises from inflexion in the pressure-drop-versus-flowrate relationship during flow-boiling, but is seen to be stabilised by the addition of orifice plates upstream of the absorber. A methodology for sizing these orifice plates is provided.

A revised system model is presented incorporating the results of the above analysis. It is found that when the CLFR is run at a high exit steam quality, it gives only a slightly greater system efficiency, while increasing the risk of entry into the undesired superheat region.

John Pye completed his BE/BSc (Mechanical Engineering and Mathematics) at the University of Melbourne in 1997, and commenced his PhD at UNSW in 2002. His thesis is currently with examiners. He has been working at the ANU in the Solar Thermal Group since 2006. His research interests are system-modelling of solar thermal energy systems, including two-phase flow in long pipes and convective and radiative losses, and system-level mathematical modelling using open-source process engineering tools. His publications and conference papers to date have all been on the topic of thermal modelling for the CLFR arising from doctoral work at UNSW.

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Greenhouse Solutions with Sustainable Energy

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Global warming and its impacts are accelerating. Therefore the developed countries must urgently set and implement short-term greenhouse gas reduction targets, policies and instruments for achieving them. Unfortunately, vested interests and their parliamentary representatives are disseminating the misinformation that sustainable energy, namely efficient energy use and renewable energy, cannot do the job. Federal and State Governments are delaying real action until their chosen unproven technologies, coal power with geosequestration and a new generation of nuclear power stations, have been developed.

However, given the political will, Australia could cut its GHG emissions to 30% below the 1990 level by 2020 by means of sustainable energy, with natural gas as a transitional fuel. To achieve this will require concerted actions by all levels of government to set a framework for business, industry and the community at large.

To get governments moving, supporters of sustainable energy must help to build a social movement, raising their voices in the media, public meetings, lobbying politicians and professional and community groups.

Dr Mark Diesendorf teaches and researches sustainable energy and sustainable development at the Institute of Environmental Studies, University of New South Wales. He is also Director of the private consultancy Sustainability Centre Pty Ltd. At various times he has been a principal research scientist in CSIRO, vice-president of the Australia New Zealand Society for Ecological Economics, a member of the Committee of ANZSES, and Professor of Environmental Science at University of Technology Sydney. He is author of the new book "Greenhouse Solutions with Sustainable Energy", UNSW Press, 2007.

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No coal and no need for nukes, Towards a Green Energy Scenario for Australia

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Steve Shallhorn took up the post of Chief Executive Officer of Greenpeace Australia Pacific in December 2005, having served two years as Executive Director of Greenpeace Japan prior to coming to Sydney. He has also worked for Greenpeace in Washington, London, Ottawa and Toronto (his home town), and has taken part in Greenpeace actions all over the world.

Mr Shallhorn's Greenpeace career began in 1987 as a disarmament campaigner for Greenpeace Canada. In 1989, he took part in a Nuclear Free Seas campaign which revealed that the US Navy lost a nuclear weapon from an aircraft carrier near the coast of Okinawa during the Vietnam War. In Canada he took part in a successful campaign which stopped the Canadian government buying nuclear powered submarines.

In 1990, Mr Shallhorn led a ship expedition to the secret site of a nuclear weapons test conducted by the former Soviet Union. Mr Shallhorn was detained in a dramatic sequence of events that was broadcast around the world. While the Soviets went ahead with the nuclear tests, it was the last one they ever did.

In 1993, he was involved in several Greenpeace actions which led to a significant global treaty banning the dumping of nuclear waste at sea. A few years later, as campaign Director for Greenpeace Canada, he was actively protecting the Great Bear Rainforest in British Columbia, Canada, from destructive logging.

Mr Shallhorn holds two degrees from McMaster University in Hamilton, Ontario: a BA in History and a BA in Economics.

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