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Study of Grid-connect Photovoltaic Systems - Benefits, Opportunities, Barriers and Strategies

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Aims of project

- To characterise PV's ability to:
 - Offset large-scale conventional generation
 - Provide capacity
 - Defer network augmentation
 - Reduce line losses
 - Offset small-scale conventional generation

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Methodology

- Half hour load data
 - Perth, commercial load profile
 - Edge of Grid, diverse load/insolation, long feeders/high losses
 - Regional, diesel, good solar resource & good correlation
- Insolation
 - PvSyst used to simulate hourly PV output data
- PV data limited
 - used for peaks (defer network augmentation)
- Assessed PV's ability to
 - offset conventional generation
 - provide capacity
 - defer network augmentation
 - reduce system losses
 - reduce the cost of diesel supply

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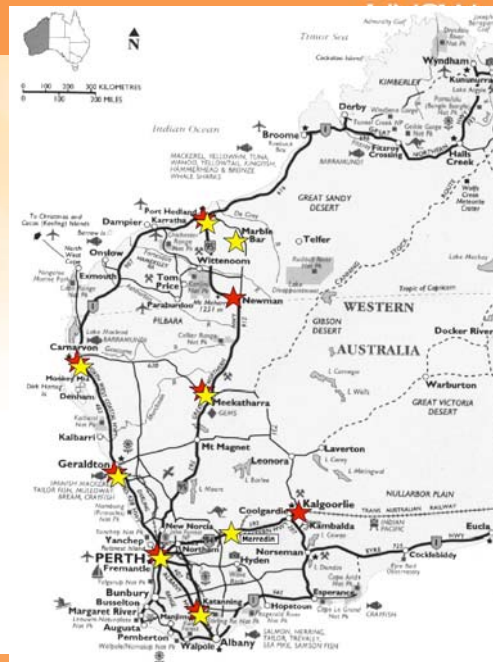


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Locations of load and insolation data

★ = Load

★ = Insolation



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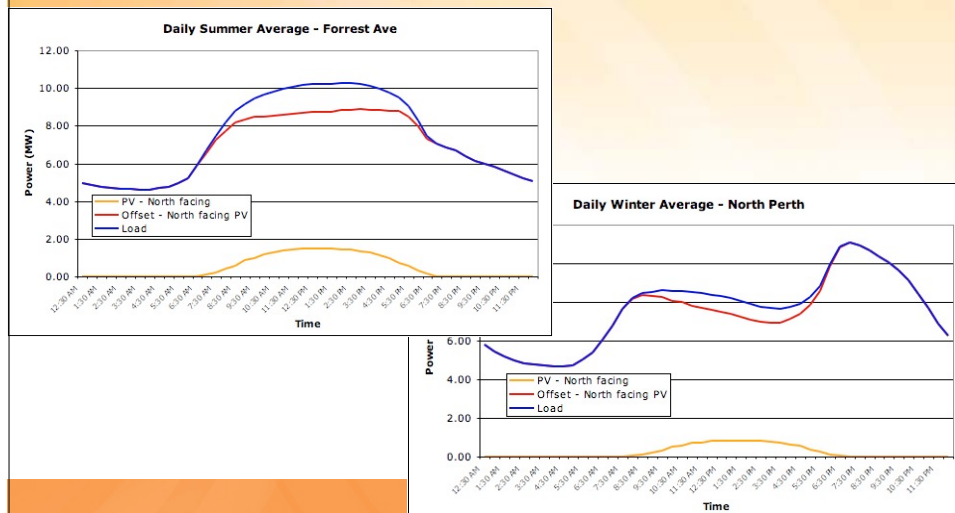


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Results - Perth

■ Offsetting large-scale conventional generation



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Results - Perth (cont.)

■ Offsetting large-scale conventional generation (cont.) – Marginal Cost Administrative Prices, 20 years

Table 1 Commercial value of electricity generated by 1MW simulated PV

Discount rate	PV Orientation	Value in year 1	Discounted Value ^a	Disc Value per Watt ^b	ROI ^c
6%	North-25	\$137,430	\$1,968,40 0	\$2.00	0.76%
	West-25	\$143,803	\$2,059,66 0	\$2.05	0.79%
12%	North-25	\$137,430	\$1,230,93 0	\$1.25	0.47%
	West-25	\$143,803	\$1,287,99 0	\$1.30	0.50%

a: Over 20yrs

b: Values rounded to nearest 5c

c: The Return on Investment (ROI) = (discounted total returns / years invested) / initial investment.

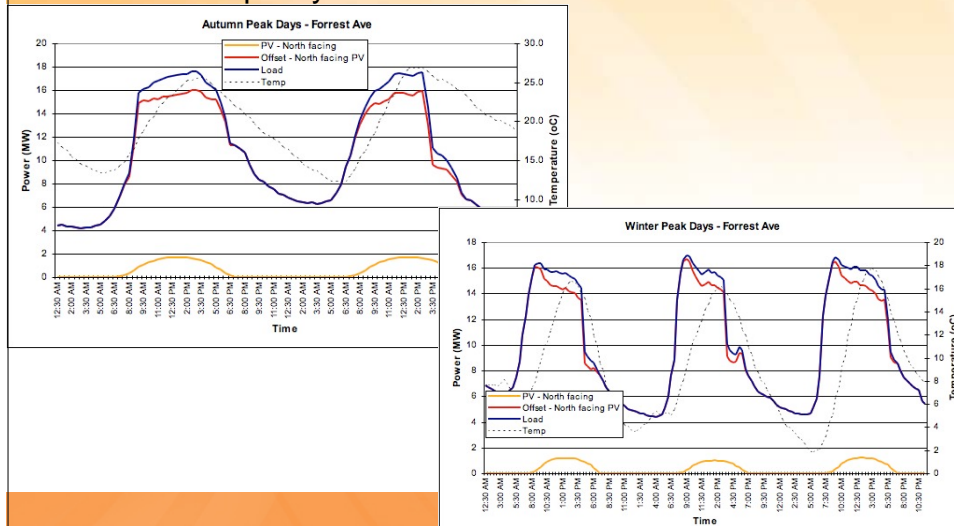


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Results - Perth (cont.)

■ Provide capacity



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Results - Perth (cont.)

- Value of providing capacity
 - RCM, PV assumed to reduce retailer's IRCR

Table 1 SWIS^a Capacity Credit Outcomes: Methodology 3, 1MW Simulated PV

	1MW Simulated North-facing PV		1MW Simulated West-facing PV	
Reduction in IRCR	0.66		0.94	
Value in year 1 ^b	\$66,000		\$94,000	
Discounted NPV ^c	6%	12%	6%	12%
	\$946,000	\$591,000	\$1,340,000	\$838,000
Disc Value per Watt	\$0.95/W	\$0.59/W	\$1.34/W	\$0.84/W
ROI ^d	0.36%	0.23%	0.52%	0.32%

a: Simulated PV for Perth only

b: Assuming a RCC price of \$100,000/MW/yr

c: Net present value over 20yrs at a 2.5% inflation rate

d: The Return on Investment (ROI) = (discounted total returns / years invested) / initial investment.



Results - Perth (cont.)

Value of conventional generation + providing capacity

Table 1 Commercial value of electricity generated by 1MW simulated PV: Offsetting conventional generation and providing firm capacity

PV Orientation	Disc Value per Watt ^a		Total ^b	ROI ^c
	Conventional generation	Firm capacity		
North-25	\$1.25	\$0.60	\$1.85	0.71%
West-25	\$1.30	\$0.85	\$2.15	0.82%

a: Over 20yrs at 12% discount rate

b: Values rounded to nearest 5c

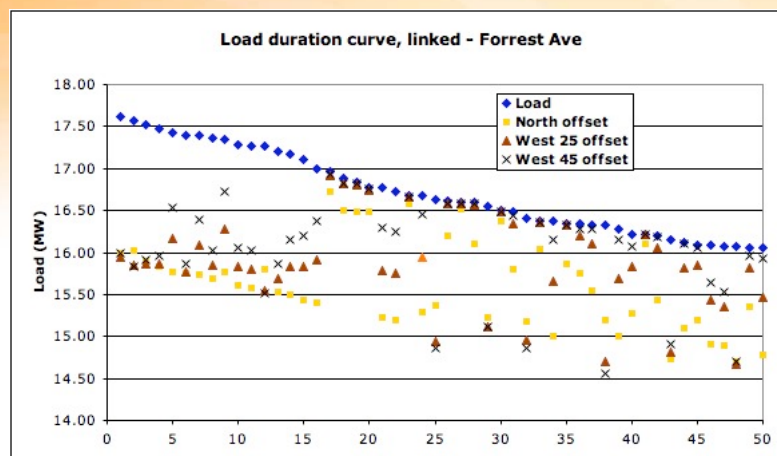
c: The Return on Investment (ROI) = (discounted total returns / years invested) / initial investment.

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Results - Perth (cont.)

Deferring network augmentation



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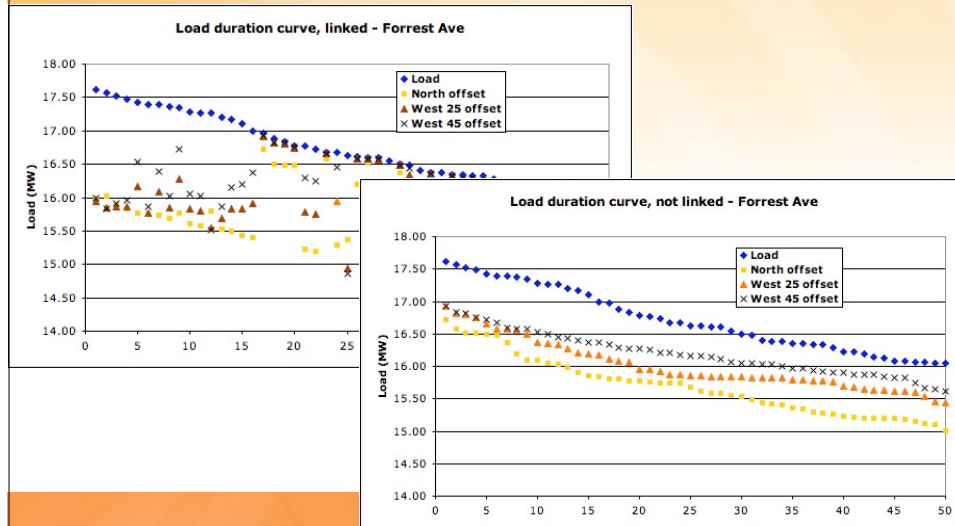


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Results - Perth (cont.)

■ Deferring network augmentation (cont.)



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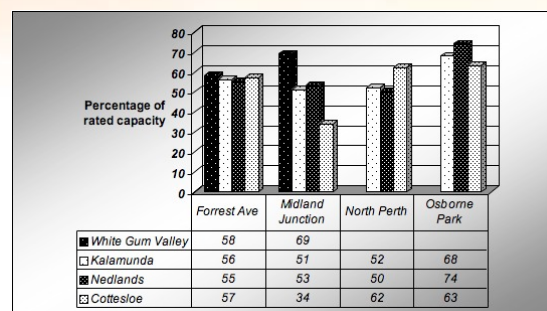
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Results - Perth (cont.)

Deferring network augmentation (cont.)

Table 1 Summary of PV contribution in peak periods at SWIS locations

Location	Linked	Not linked
Forrest Ave TX2	81%	45%
Osborne Park TX1	33%	33%



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Edge of SWIS

- Offset conventional generation & provide capacity

Table 1 Commercial value of electricity generated by 1MW simulated PV: Offsetting conventional generation and providing firm capacity

PV Orientation	Disc Value per Watt ^a			
	Conventional generation	Firm capacity	Total ^b	ROI ^c
Perth				
North-25	\$1.25	\$0.60	\$1.85	0.71%
West-25	\$1.30	\$0.85	\$2.15	0.82%
Edge of SWIS				
North-25	\$1.15	\$0.50	\$1.60	0.61%
West-25	\$1.15	\$0.65	\$1.80	0.69%

a: Over 20yrs at 12% discount rate

b: Values rounded to nearest 5c

c: The Return on Investment (ROI) = (discounted total returns / years invested) / initial investment.

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Edge of SWIS (cont.)

- Reduction of line losses

Table 1 Total Loss Factors and estimated electricity losses avoided and financial values for three 'Edge of SWIS' locations

		Total Loss Factor	Losses avoided (kWh)	Annual value of avoided losses	Discounted value of avoided losses ^a
Geraldton TX1	N	1.2165	369,836	\$0.029/W	\$0.26/W
	W		364,171	\$0.031/W	\$0.28/W
Katanning TX2	N	1.1559	263,733	\$0.021/W	\$0.19/W
	W		248,546	\$0.021/W	\$0.19/W
Merredin TX1	N	1.1740	293,457	\$0.023/W	\$0.21/W
	W		225,510	\$0.019/W	\$0.17/W

a: Over 20yrs at a 12% discount rate

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Summary of benefits (Perth & Edge of SWIS)

Table 1 Summary of approximate benefits provided by PV in the SWIS and Edge of SWIS

Benefit	Approximate average value /W ^a		Approximate average value /kWh		Who benefits
	North	West	North	West	
Offsetting convent. gen.	\$1.20	\$1.20	7.8c	8.6c	Retailer
Providing firm capacity ^b	\$0.55	\$0.75	3.5c	5.1c	Retailer
Deferring network aug ^c	\$0.12	\$0.12	0.8c	0.8c	Retailer ^d
Reducing line losses	\$0.22	\$0.21	1.4c	1.6c	Retailer
Total	\$2.09	\$2.28	13.5c	16.1c	

Note that these values are indicative averages only. The actual values will vary from system to system and will be influenced by a number of factors including orientation, location, temperature, shading and maintenance of the panels and balance of system equipment.

a: Over 20yrs at a 12% discount rate. A 6% discount rate increases the totals to \$3.34 and \$3.64 for north and west-facing PV respectively

b: The ratio of the /W to the /kWh values will not be the same for the conventional generation and firm capacity values because the /W conventional generation values are proportional to electrical output whereas the /W firm capacity values are proportional to the reduction of IRCR.

c: The north-facing and west-facing values are identical because both north-facing and west-facing PV are assumed to provide 50% of their rated capacity to meeting peak network loads.

d: Assuming full pass through of savings to the retailer

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Regional

■ Offsetting small-scale diesel generation

Table 1 Value of electricity generated by 1MW simulated PV: Generation cost

Location	Generation cost ^a	Value in year 1	Discounted Value ^b	Disc Value per Watt	ROI ^c
Carnarvon	\$0.1339	\$190,974	\$3,012,12 0	\$3.00	1.15%
Carnarvon Solar Farm	\$0.1339	\$221,287	\$3,489,80 0	\$3.50	1.35%
Marble Bar	\$0.3911	\$548,626	\$8,652,46 0	\$8.65	3.35%
Meekatharra	\$0.3550	\$498,071	\$7,853,81 0	\$7.85	3.00%
Port Hedland	\$0.0707	\$102,663	\$1,618,94 0	\$1.60	0.65%

a: Generation cost for Horizon Power

b: Over 20yrs at a 12% discount rate

c: The Return on Investment (ROI) = (discounted total returns / years invested) / initial investment.

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Conclusions

- Residential: average value paid = average value provided
- Business: average value paid < average value provided
- Diesel residential: average value paid << average value provided
- Residential 1kW PV: \$8,000 rebate + \$500 RECs + net metering = 20yrs
- Business 1kW PV: \$500 RECs + 6c/kWh = >100yrs
- Diesel residential: \$6,000 rebate + \$500 RECs + net metering = 25yrs
- Diesel residential: \$6,000 rebate + \$500 RECs + FiT = 15yrs

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Thank you... and *questions*

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