Solar Retrofit – Sydney, Australia

PV grid connected system

UPGRADE Solutions & IEA SHC Task 47
Renovation of Non-Residential Buildings towards Sustainable Standards

1. INTRODUCTION

PROJECT SUMMARY
The following presentation summarizes a research project into the technical and economic feasibility of using a grid connected PV system to increase the NABERS Energy rating (ie decrease GHG emissions) of a case study commercial building, located in Sydney, Australia.

The project was undertaken using computer simulation tools to assess and determine the optimal size and arrangement of the PV panels. In addition, future economic conditions were assessed as well as alternative solutions to reduce the GHG emissions.

RESEARCHER: Brett Pollard

SOFTWARE:
HOMER (US) – technical feasibility modelling
RETScreen (Canada) – economic feasibility modelling
eQuest – energy consumption and load profile
NABERS rating calculator and NABERS energy rating
Sunny Design – inverter selection
Panel Shading – panel arrangement & self shading assessment.

Acknowledgements
This summary is based upon 'Solar Retrofit' a chapter, in the book, Sustainable Retrofitting of Commercial Buildings: Warm Climates, edited by Hyde, R, Groenhout, N, Barram, F, Yeang, K. 2012 published by Rutledge.

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

2. CONTEXT AND BACKGROUND

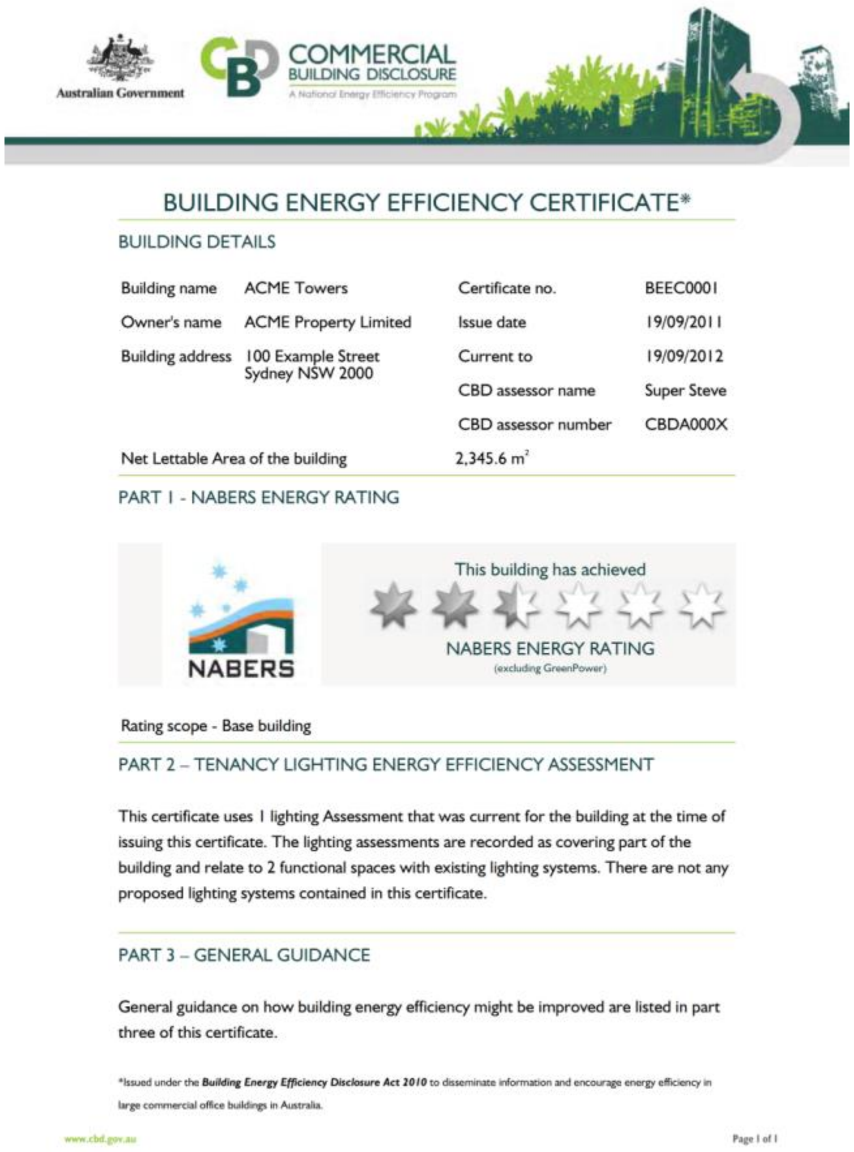
Despite Australia having one of the highest available solar resources in the world ,over 90% of Australia's electricity (in 2012) is generated using fossil fuels, predominately coal.

In 2010 the Australian Government introduced the Commercial Building Disclosure (CBD) scheme as an initiative to reduce GHG emissions from building energy use. The scheme is applied to office building and tenancy spaces over 2,000sqm when leased or sold. The scheme uses the NABERS Energy rating system which rates buildings on their GHG emissions associated with their actual energy use. NABERS uses 0 to 6 stars to rate performance levels with 6 stars representing excellent performance and average performance between 2.5 – 3 stars.

OBJECTIVES OF THE PROJECT

Critical points:

- Determine **technical feasibility** to utilize a grid connected PV system,
- Determine **economical feasibility** to utilize a grid connected PV system
- **Decrease GHG emissions** by Increasing the NABERS Energy rating (from 4.5 stars to 5 stars)


Australian Government

CBD COMMERCIAL BUILDING DISCLOSURE
A National Energy Efficiency Program

BUILDING ENERGY EFFICIENCY CERTIFICATE*

BUILDING DETAILS

Building name	ACME Towers	Certificate no.	BEEC0001
Owner's name	ACME Property Limited	Issue date	19/09/2011
Building address	100 Example Street Sydney NSW 2000	Current to	19/09/2012
		CBD assessor name	Super Steve
		CBD assessor number	CBDA000X
Net Lettable Area of the building		2,345.6 m²	

PART 1 - NABERS ENERGY RATING

NABERS

This building has achieved

NABERS ENERGY RATING
(excluding GreenPower)

Rating scope - Base building

PART 2 – TENANCY LIGHTING ENERGY EFFICIENCY ASSESSMENT

This certificate uses 1 lighting Assessment that was current for the building at the time of issuing this certificate. The lighting assessments are recorded as covering part of the building and relate to 2 functional spaces with existing lighting systems. There are not any proposed lighting systems contained in this certificate.

PART 3 – GENERAL GUIDANCE

General guidance on how building energy efficiency might be improved are listed in part three of this certificate.

*Issued under the ***Building Energy Efficiency Disclosure Act 2010*** to disseminate information and encourage energy efficiency in large commercial office buildings in Australia.

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Page 1 of 1

NABERS ENERGY

6 Star – Market Leading
5 Star – Exceptional
4 Star – Excellent
3 Star – Very Good
2 Star – Average
1 Star – Poor

3. RESEARCH METHODOLOGY, TECHNICAL FEASIBILITY, INFORMATION AND TARGETS

SUMMARY OF THE CASE STUDY BUILDING
NLA: 5,770sqm
GFA: 11,700sqm
HVAC: VAV with high efficiency chillers + gas-fired boiler system
Lighting: High efficiency T5 fluorescent fittings
PV Panels: BP Solar 175W/ 13.9% efficiency
Inverters: Sunny Range, SMA Australia

TECHNICAL FEASIBILITY
NABERS requirements,
Energy use information in three different cases:
- Tenancy
- Base building
- Whole building

SOLAR AND ENERGY INFORMATION
Data sources for solar information obtained from softwares (HOMER and RETscreen)
Building energy use from simulation using eQUEST and comparing results with NABERS calculators.

ELECTRICITY TARGETS
5 stars NABERS Energy:

4. TECHNICAL FEASIBILITY ANALYSIS

PRELIMINARY ANALYSIS

First Steps
- Determine roof area required for targeted PV electricity
- Compare to available roof area

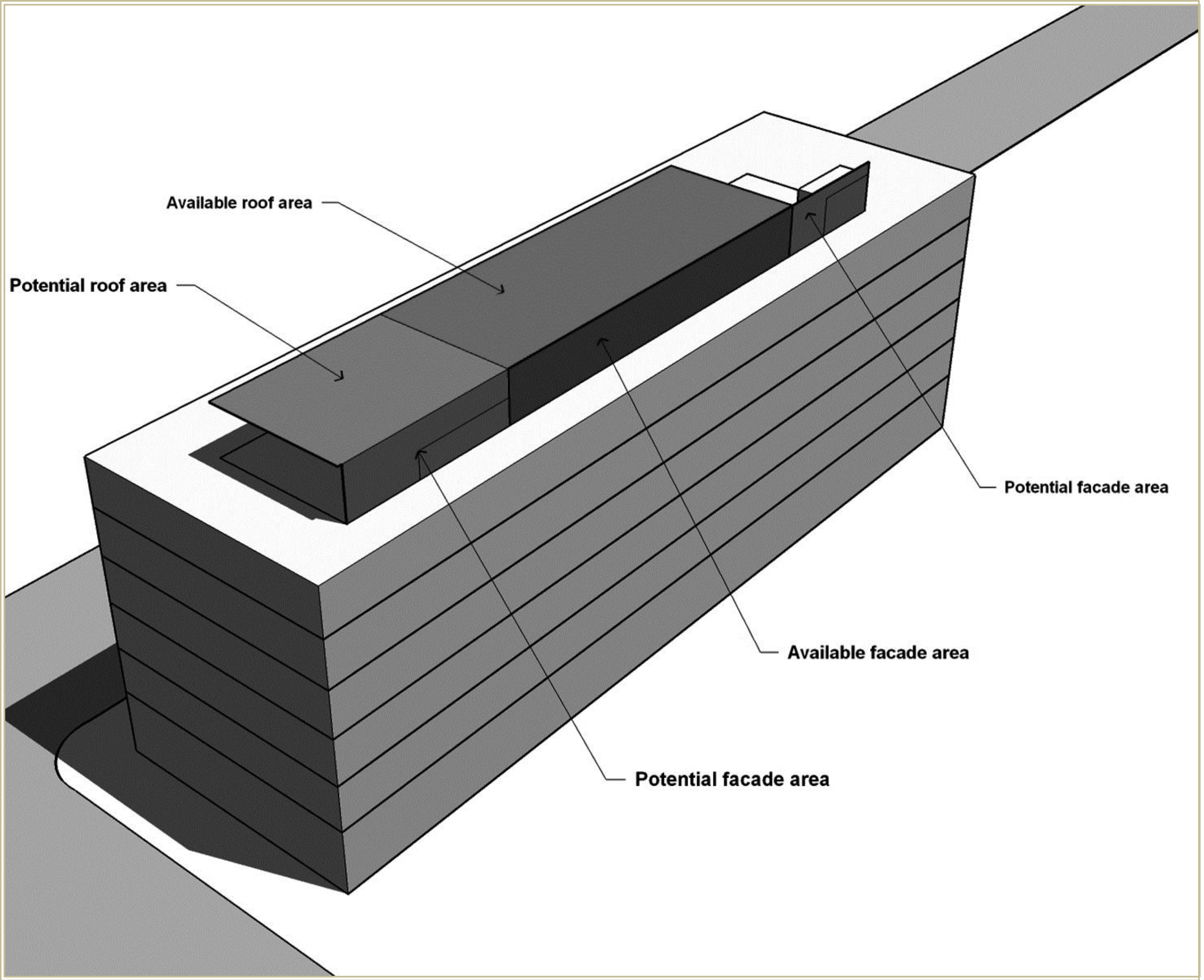
Total Roof Area :
1,250sqm

Residual Roof space (discount services) :
321sqm (discontinuous, potentially shaded)
+ 151sqm (over lift overrun)

Potential available unshaded space :
- 105 sqm Plant room northern façade
- 84 future expansion and cooling towers space

DETAILED ANALYSIS

- Determine precise area and number of PV panels, locating them in hierarchy from available spaces then into potential spaces if needed
- Determine capacity for the PV system according to number of panels installed
- Size inverters
- Determine PV panels orientation and tilt
- Compare results to PV and electricity targets



5. OPTIMISATION ANALYSIS AND GHG EMISSION REDUCTION

OPTIMISATION

PV panels orientation :
North facing (southern hemisphere)

Optimal tilt angle :
= latitude angle of location
30% less efficiency when mounted vertically

Avoid Panel shading:
Computer simulation tool (Panel shading)

GHG EMISSIONS REDUCTION

Reduction in grid electricity consumption :
8.4% - 11.6%

Reduction in GHG emissions :
< than electricity due to gas emissions included in the building

Exclusions :
GHG reductions associated with PV electricity exported to grid is not considered.

ENERGY TARGETS

NABERS category	PV production kWh/yr	Grid Electricity kWh/yr	NABERS Rating	Gas GJ/yr
Tenancy	50,229	536,665	5	
Base Building	62,127	447,002	5	299.357
Whole Building	109,933	986,056	5	299.357

OPTIMISED PV SYSTEMS

NABERS category	No. of PV Panels	PV capacity kW	Tilt & Azimuth of PV panels	PV production kWh/yr
Tenancy	148 (s)	25,9 (s)	25ºx180º (s)	50,276
	46 (v)	8,1 (v)	70º x 180º (s)	
Base Building	185 (s)	32,4 (s)	10º x 180º (s)	66,276
	82 (v)	14,4 (v)	70º x 180º (s)	
Whole Building	330 (s)	57,8 (s)	10º x 180º (s)	106,031
	101 (v)	19,5 (v)	85º x 180º (s)	

GRID ELECTRICITY CONSUMPTION

NABERS category	Grid electricity without PV kWh/yr	Grid electricity with PV kWh/yr	Reduction in grid electricity %	PV electricity exported kWh/yr
Tenancy	586,894	537,336	8.4	718
Base Building	509,528	450,300	11.6	7,048
Whole Building	1,095,989	995,558	9.2	5,600

GRID ELECTRICITY CONSUMPTION

NABERS category	GHG emissions without PV kgCO2e/yr	GHG emissions with PV kgCO2e/yr	Reduction in GHG emissions kgCO2e/yr	Reduction inGHG emissions %
Tenancy	551,680	505,096	46,584	8,4
Base Building	497,706	442,407	55,299	11,1
Whole Building	1,049,355	954,949	94,406	9,0

6. ECONOMIC FEASIBILITY

- Equity Payback
- Net Present Value (NPV)
- Rate of Return (IRR)

IEA calculated Capital Cost for a 10kW system :
$6,000 – $7,000.

Values for the study:
Capital Cost = $6,500
Maintenance = $20/kW/year

REBATES, SUBSIDIES AND FEED TARIFFS
- Small Scale Technology Certificates (STCs)
- Solar Credits (SC)
- Green Building Fund (GBF)

CURRENT ECONOMIC FEASIBILITY
Parameters for economic modelliing
- Inflation rate: 3%/yr
- AER (tenancy): AUD$0.1602/kWh
- AER (base building): AUD$0.1419/kWh
- AER (whole building): AUD$0.1340/kWh
- Electricity cost increase: 3%/yr (as per inflation)
- Discount rate: 7%
- Project life: 25 years
- GHG emissions factor: 1.063kgCO2e/kWh of grid supplied electricity

IMPACT OF SUBSIDES ON CAPTIAL COST

NABERS category	Base Capital Cost	Capital Cost after STC	Capital Cost after STC+SC	Capital Costafter STC+SC+GBF
Tenancy	221,000	206,920	190,320	190,320
Base Building	304,200	284,800	262,920	131,460
Whole Building	502,450	470,410	435,890	217,945

NABERS TENANCY ECONOMIC FEASIBILITY

Rebate/Grant	Simple Payback (yr)	Equity Payback (yr)	NPV ($)	IRR (%)	GHG reduct cost $/ tCO2e
No rebates	29.9	21.2	-104,137	1.6	167
STC	28	23.4	-90,057	2.1	145
STC + SC	25.8	22.1	-73,457	1.2	118
STC + SC + GBF	NA	NA	NA	NA	NA

NABERS BASE BUILDING ECONOMIC FEASIBILITY

Rebate/Grant	Simple Payback (yr)	Equity Payback (yr)	NPV ($)	IRR (%)	GHG reduct cost $/ tCO2e
No rebates	36.5	24.5	-172,515	0.2	210
STC	34.2	23.4	-153,115	0.7	186
STC + SC	31.6	22.1	-131,235	1.2	160
STC + SC + GBF	15.8	12.8	225	7.0	0

NABERS BASE BUILDING ECONOMIC FEASIBILITY

Rebate/Grant	Simple Payback (yr)	Equity Payback (yr)	NPV ($)	IRR (%)	GHG reduct cost $/ tCO2e
No rebates	39.4	>25	-300,984	-0.3	228
STC	36.9	24.7	-268,944	0.1	204
STC + SC	34.2	23.44	-234,424	0.6	178
STC + SC + GBF	17.1	13.7	-16,479	6.3	12

7. FUTURE ECONOMIC FEASIBILITY AND ALTERNATIVE STRAETEGIES

FUTURE ECONOMIC FEASIBILITY

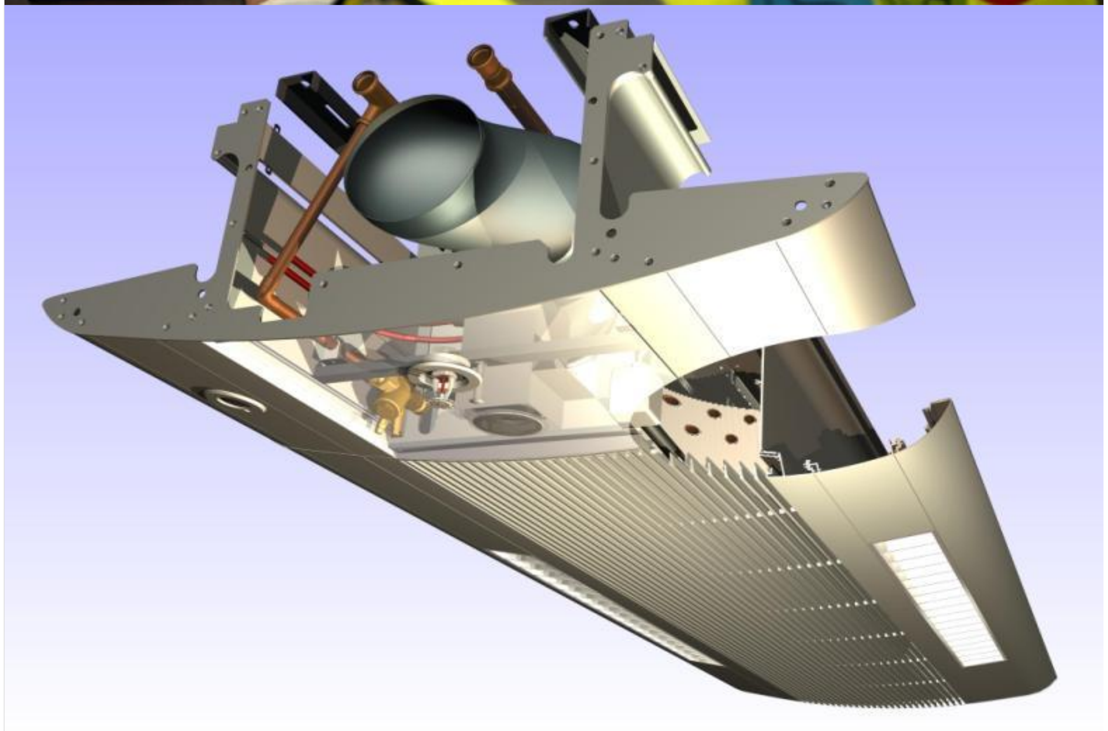
PV systems lifespan : 25 years

Factors for future economic conditions:
- Rising electricity costs
- Introduction of an emission trading scheme (ETS) or carbon tax
- Feed in tariffs (FiT)

Scenarios:
i. 3% above inflation rate:
Not enough to be commercially viable
ii. 7% above inflation rate:
equity paybacks between 11.3 and 12.4 years (not viable yet)
iii. 3% above inflation rate + Fit ($0.20/kWh 15 years):
Equity payback between 8.8 to 10.9 years

ALTERNATIVE STRATEGIES FOR IMPROVING NABERS RATING

- Chilled beams HVAC system;
- Cogeneration/ tri-generation plant;
- Purchase of Accredited Green Power;
- Improve building management



8. CONCLUSIONS

TECHNICAL

- It is technically feasible to increase NABERS rating (reduce GHG emissions) by using PV panels.
- For this specific case ±10% of reductions can be achieved by placing PV panels on available roof area.
- PV panels optimum performance when facing north and tilted at around 35º (=latitude)

ECONOMICAL

- At current energy prices is not economically viable to reduce GHG emissions and energy consumption by means of using only a PV panel system, even applying existing subsidies.
- To make PV panels economically viable high levels of subsidy would be needed, combining rebates, grants and uncapped Gross FiT.
- Dramatic rises in electricity would make PV systems viable.
- Mass production of PV technology could lower capital costs, making them economically viable.