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**Potential Electricity Generation from Small Scale  
Solar Photovoltaic Systems -**

**Case Study 1: Solar Harvesting Potential from  
roofs of Invercargill Homes**

**And**

**Case Study 2: Model Validation using Existing  
Data from PV Generation on Selected New  
Zealand Schools**

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## ABSTRACT

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Solar energy is abundant, free and non-polluting. Solar energy can offset the consumption of fossil fuels, greenhouse gas emission reduction targets and contribute to meeting the fast-growing energy demands. The use of solar energy for electricity generation from photovoltaic (PV) panels has increased but is still not a widely utilised technology in New Zealand. This research approximated the potential solar energy that could be harvested from the rooftops of existing residential buildings in a case study city.

This research is divided into two work strands, each involving a case study. The first strand investigated if a model could be developed, using existing data sources to determine the solar harvesting potential from the rooftops of existing residential buildings. The second strand involved the validation of the solar PV prediction model proposed in the first strand of the research, to test the reliability of the modelling outcomes.

Invercargill City was selected as the study city for case study 1. Invercargill is the southernmost city in New Zealand so represents a worst case scenario. The method involved merging computer-simulation of solar energy produced from PV modelling and mapping incoming solar radiation data from north facing residential rooftop area. The work utilised New Zealand statistical census map of population and dwelling data, as well as digital aerial map to quantify the efficient roof surface area available for PV installations. The solar PV potential was calculated using existing formulas to investigate the contribution of roof area to the solar PV potential in buildings using roof area and population relationship.

The estimated solar PV potential was 82,947,315 kWh per year generated from the total solar efficient roof surface area of 740,504 m<sup>2</sup>. This equates to approximately 60.8% of the residential electricity used in Invercargill's urban

area, based on the 7,700 kWh typical annual electricity consumptions per household. The result represents an immense opportunity to harvest sustainable energy from Invercargill's residential rooftops.

To verify the accuracy of the developed method for predicting the PV outputs, the model was applied to actual generation data from grid-connected solar photovoltaic (PV) systems that are installed in New Zealand schools under the Schoolgen programme (Case Study 2). A total of 66 Schoolgen PV rooftop models were incorporated in the analysis. At this stage, the actual system parameters including size, panel type and efficiency were included in the analysis. The performance prediction and analysis outcome showed the parameters and operating conditions that affect the amount of energy generated by the PV systems. This part of the research showed the area where the PV model can be improved.

The predicted generation from the model was found to be lower than the actual generation data. Schoolgen systems operating at over 0.75 performance ratio were found to be underestimated. This indicated that most Schoolgen PV systems were operating at higher capacities than predicted by the default value of system losses. The analysis demonstrated the effects of PV technology type, site orientation, direction and tilted angle of the panels on the ability to generate expected amount of potential capacity based on solar resource availability in different site scenarios. This in turn has provided more in depth analysis of the research and served to expand the area for improvements in the design of the model.

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## ABBREVIATIONS

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AC:	Alternating Current electricity
BIPV:	Building Integrated Photovoltaics
BOS:	Balance of System
CAD:	Computer Aided Design
COP:	Coefficient of Performance
DC:	Direct Current electricity
DEM:	Digital Elevation Model
DHI:	Diffuse Horizontal Irradiance
DNI:	Direct Normal Irradiance
FIT:	Feed-in Tariff
GIS:	Geographic Information System
GHI:	Global Horizontal Irradiance
GW:	Gigawatts ( $10^9$ Watts)
GWh:	Gigawatt-hour
HEEP:	Household Energy End-use Project
kW:	Kilowatt ( $10^3$ Watts)
kWh:	Kilowatt-hour
kWp:	Kilowatt-peak
LCOE:	Levelized cost of electricity
LiDAR:	Light Detection and Ranging technology
MJ:	Megajoule ( $10^7$ Joules)
MPP:	Maximum Power Point
MPPT:	Maximum Power Point Tracking
MWh:	Megawatt-hour ( $10^7$ Watt-hours)
OECD:	The Organisation for Economic Co-operation and Development
PV:	Photovoltaics
PJ:	Petajoule ( $10^{15}$ Joules)
RPS:	Renewable Portfolio Standards
SVF:	Sky View Factor
UHI:	Urban heat island

