Title: An Analysis for Promoting Residential-Scale Solar Photovoltaic (PV) in Bangkok

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AN ANALYSIS FOR PROMOTING RESIDENTIAL-SCALE SOLAR PHOTOVOLTAIC (PV) IN BANGKOK, THAILAND

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Background

Energy Problems in Thailand

- The depletion of domestic energy
- The significant increase in electricity demand

→ The high dependence on imported non-renewable energy → *Thailand's Energy Crisis*

A Possible Solution: Solar PV

- The high urbanization growth rate in Bangkok
- Nearly a quarter of areas in Bangkok has been used for residential purpose.

→ *The significant potential for distributed residential-scale solar PV in Bangkok*

Thailand's Goal: 3000 MW Solar Capacity by 2021[1,8]

The Barriers of Promoting Solar PV in Bangkok

- The high capital costs
- The lower awareness of green energy

Approach

- We assume installation of 3,000 MW of solar PV
  - The goal of a renewable energy plan enacted by Ministry of Energy in Thailand
- For energy and financial calculations we use the PV Watts in the System Advisor Model (SAM) developed by the National Renewable Energy Laboratory

The Feasibility of solar PV in Bangkok

Technical Analysis
- Solar radiation
- Net electric load after PV installation

Economic Analysis
- Power generator cost
- LCOE of PV vs. grid electricity price
- Relate to consumer income/expense

Policy Analysis
- Net Present Value (NPV), Payback period (PBP)and Internal rate of return(IRR)
- Required policies to promote solar PV

Technical Analysis

System Advisor Model (SAM)

Weather File
(Solar Irradiance, Dry-bulb Temperature, and Wind Speed)

→ **Performance Model** → **PV System Output**

System Parameters
(Module type, DC to AC Ratio, Inverter Efficiency, Orientation, Tilt, Azimuth, and Losses)

Thailand's Goal: 3000 MW Solar Capacity by 2021

PV generation (assuming south-facing panels) aligns well with large-scale load (same as the US), but not residential load.

1-10 kW each: Residential PV — 130% of midday load

250-1,000 kW each: Large-Scale PV — 77% of midday load

Load Pattern versus Distributed Generation: Residential and Large-Scale loads

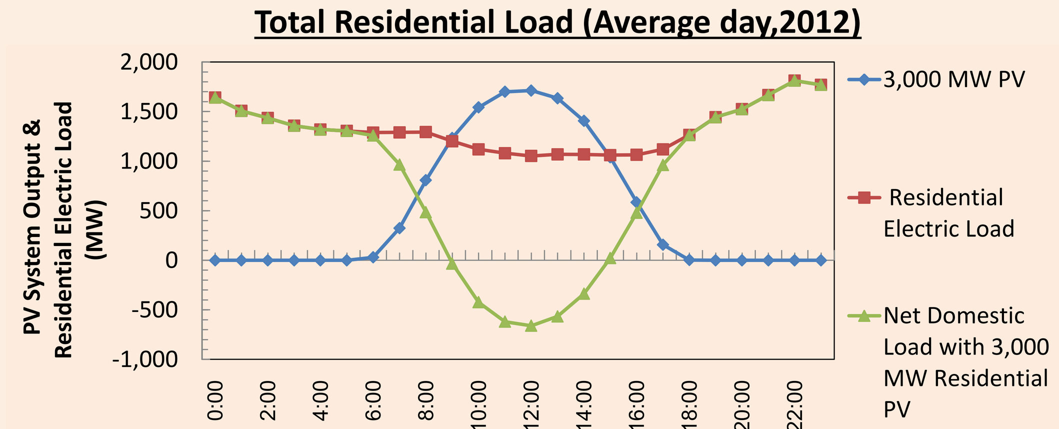

Fig.1 Residential Load and Distributed Generation patterns of the average day are not aligned [8-9].

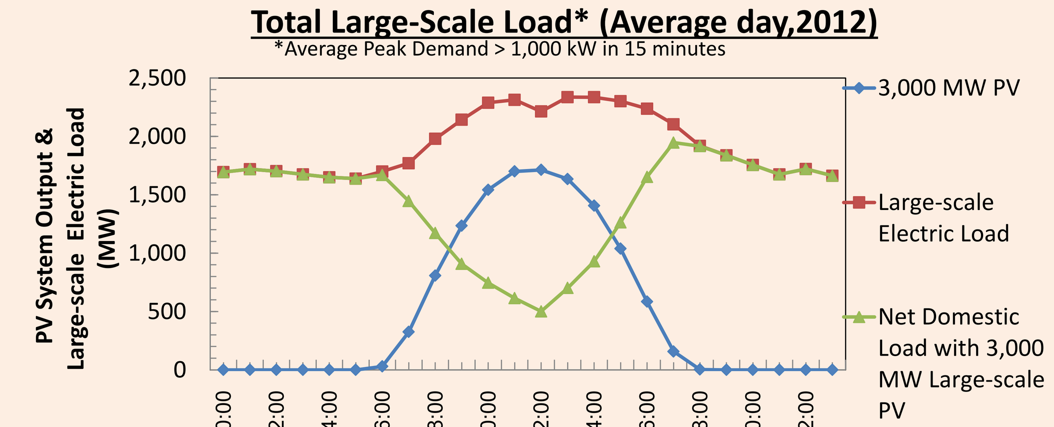

Fig.2 Large-Scale Load and Generation patterns of the average day are better matched [8-9].

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Economic Analysis

Power Generator Cost

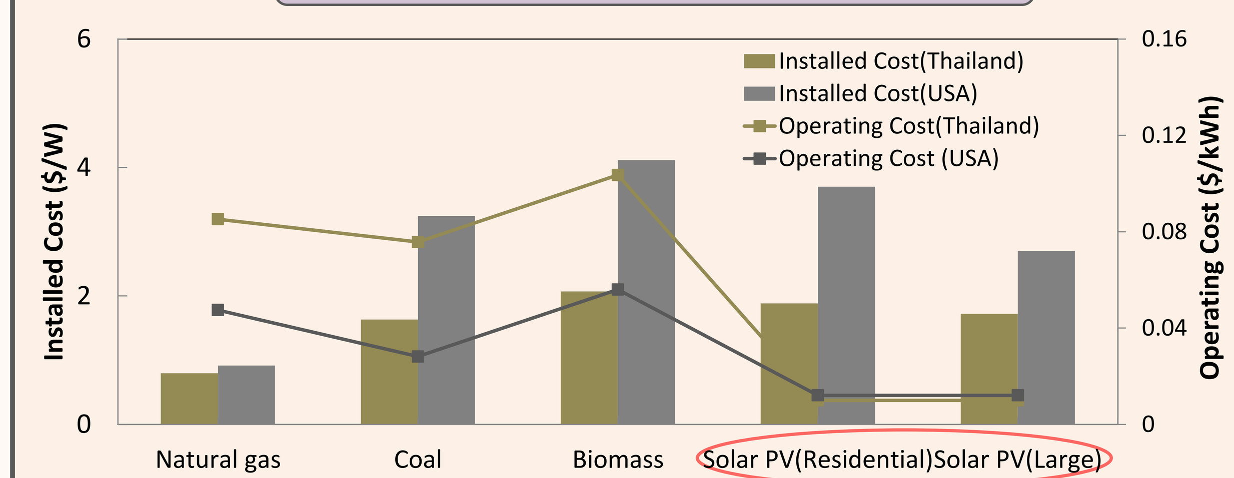

Fig.3 The Difference of Power Generator Cost between Thailand and the U.S [3-6].

- High installed cost, but low operating cost for Solar PV
- Residential-scale cost > Large-scale cost
- Solar PV costs are cheaper in Thailand than in USA

LCOE versus Electricity Price

System Advisor Model (SAM)

$$LCOE = \frac{C_0 + \sum_1^N \frac{C_n}{(1-d_{nom})^n}}{\sum_1^N \frac{Q_n}{(1-d_{real})^n}}$$

Q_n = Electricity generated by the system in year n
N = Analysis period (25 years)
C_0 = The project's initial cost
C_n = The annual project's cost in year n
d_{real} = The real discount rate without inflation (3% for Thailand and 10 % for the U.S.)
d_{nom} = The nominal discount rate with inflation (5.9% for Thailand and 10.9 % for the U.S.)

Country	Residential PV ($/kWh)	Large-scale PV ($/kWh)	Grid ($/kWh)
Thailand	0.14	0.13	0.12[9]
The U.S.	0.18-0.27[5]	0.13-0.18[5]	0.10[2]
	0.14-0.20*	0.096-0.14*	

* Subsidized price from [5]

Table 1. LCOE versus Electricity price of Thailand and the U.S [2,3,5,9].

- Residential-scale LCOE > Large-scale LCOE
- LCOE > grid electricity price
  - but much closer in Thailand
- Need incentives/policies to decrease costs of energy

Relate to Income and Expense

	Expenses and Savings as a % of Income	Residential scale	Large scale (Mfg.)	Large scale (Hotel)
	Monthly Income or Revenue (USD)	1,153	43,038	59,689
Grid	Expenses (%)	72	78	50
Grid	Saving or Profit (%)	*28*	*22*	*50*
Grid	Elec. Expenses (%)	4	2	12
PV	Expenses (%)	74	79	54
PV	Saving or Profit (%)	*26*	*21*	*46*
PV	Elec. Expenses(%)	6	3	19

Higher Savings · Higher Profits · Fund Solar PV · Lower Savings · Lower Profits

Table 2. Only 2% of household income, out of 28% saved, is needed to fund residential PV [10]

Policy Analysis

System Advisor Model (SAM)

System Cost
(Installed cost and Operating cost)

Incentives → **Financial Model** → **Cash Flow**

Financial Parameter
(Loan Parameters, Discount rate, Tax and Insurance Rates)

Thailand's Current Solar PV Rooftop Feed-in Tariff (FIT)

Capacity (kW)	FIT ($/kwh)
Residential Rooftop (0-10 kWp)	*0.20*
Commercial Rooftop (10-250 kWp)	0.19
Large-scale Rooftop (250-1,000 kWp)	*0.18*

Table 3. Thailand's Current Solar PV Rooftop FIT [7]

- Changed from Adder to FIT
- Started FIT scheme in 2013
- Residential-scale FIT > Large-scale FIT

Financial Analysis

	NPV ($/kwh)	LCOE ($/kwh)	PBP (Years)	IRR (%)
Residential scale (W/O Incentives)	0.01	0.14	12.16	7
Residential scale (W/ Incentives)	*0.10*	*-0.04*	*4.89*	*27*
Large scale (W/O Incentives)	0.02	0.13	11	9
Large scale (W/Incentives)	*0.10*	*-0.04*	*4.76*	*28*

Table 4. The effect of current incentives on solar project's feasibility. [3,4,7]

- The current incentive levels make PV electricity cheaper than grid electricity at 0.12 $/kwh (e.g., LCOE < 0)
- For LCOE = 0, the FIT could be reduced to 0.14 and 0.13 $/kWh for residential scale and large scale, respectively
- Although LCOE for residential PV is higher than for large scale (e.g., industrial), Thailand's FIT makes PV equally attractive to both types of customers.

Future Work

- Investigate the best PV incentives for Thailand: direct cash incentives or tax credits.
- Policy/ Incentive Suggestion

- Renewable Portfolio Standard (RPS), Net Metering, and Solar Renewable Energy Credit (SERC)