

Solar energy - the basis for a sustainable global energy supply system

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Outline

- Towards a global sustainable energy supply system

Photovoltaic electricity generation

The Singapore perspective of photovoltaics

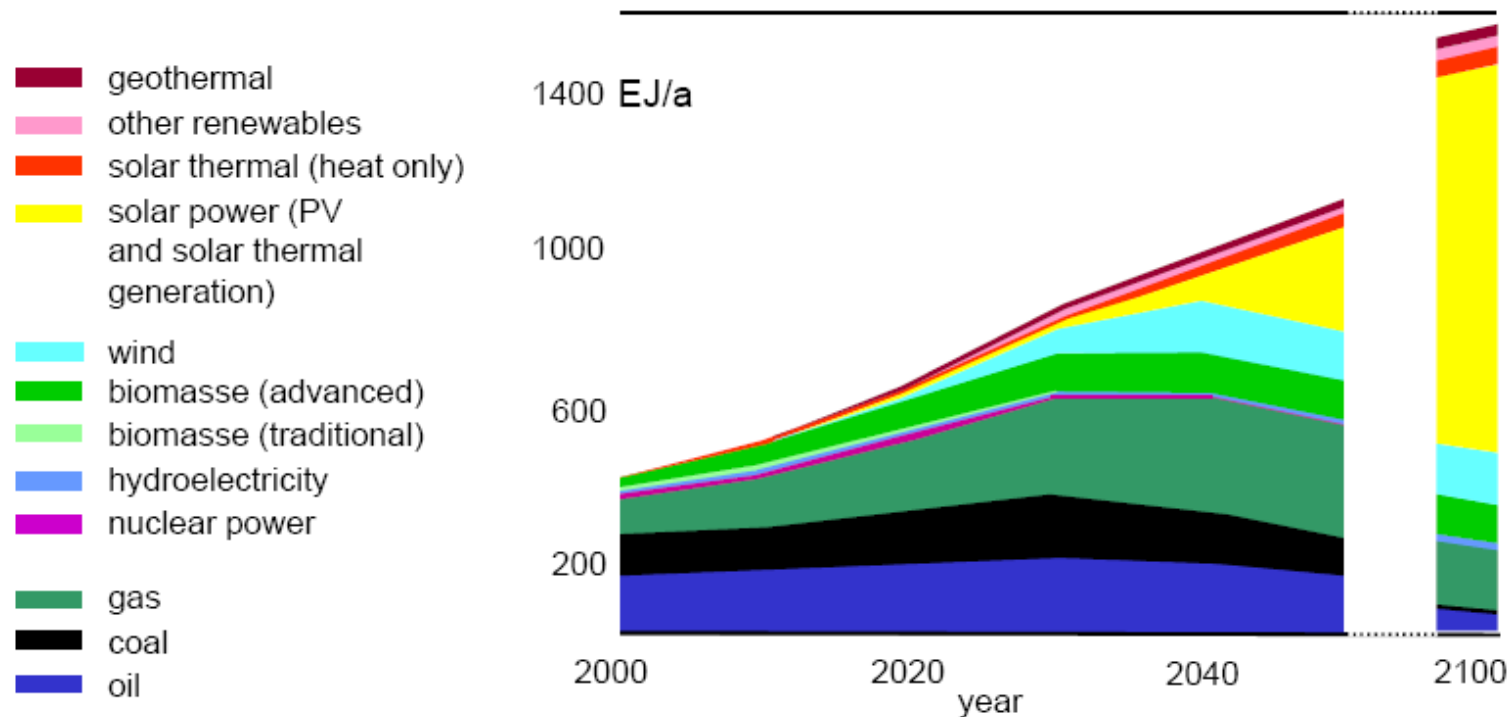
A global sustainable energy system, main benefits



- ❑ Protection of the natural life-support system
- ❑ Eradication of energy poverty in developing countries
- ❑ Promotion of peace by reducing dependence on regionally concentrated energy resources
- ❑ Increasing energy security

Future energy mix

Scenario



Source: German advisory panel on global change, 2003, www.wbgu.de

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Solar energy conversion, examples



- ❑ Electric power generation: Solar cells, solar thermal power plants
- ❑ Heat and cold generation: Solar thermal collectors, solar driven thermodynamic machines (cooling), solar and energy efficient building
- ❑ Fuels and equivalents: Bio-Fuels, electric energy from batteries, hydrogen (or H₂ - derivatives) from solar sources

Electricity from renewables,

main conversion paths



- Solar energy conversion
 - flat plate photovoltaics
 - PV under optical concentration
 - Solar thermal power plants
- Wind energy
- Biomass
- Hydro
- Ocean (waves, currents,...)
- Geothermal

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➤ Photovoltaic electricity generation

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Status of Photovoltaics 2009

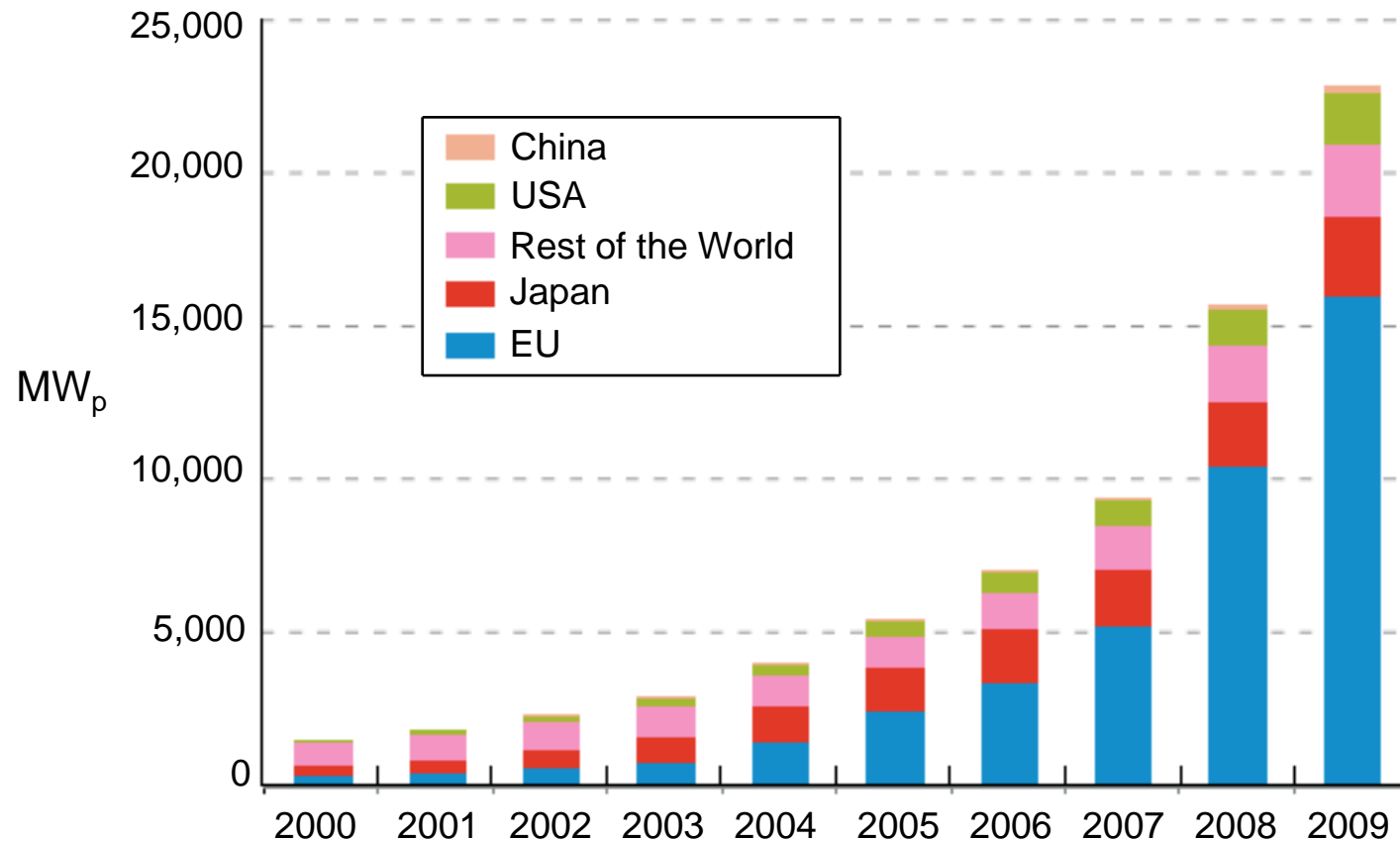
Cumulative PV capacity globally installed	22 GW _p
PV fraction of global electricity generation	0.1 %
PV fraction of German electricity generation	1.0 %

PV power installed in 2009	7.1 GW _p
Global market volume	22 billion €

Source: EPIA; Clean edge; SERIS market research 2010

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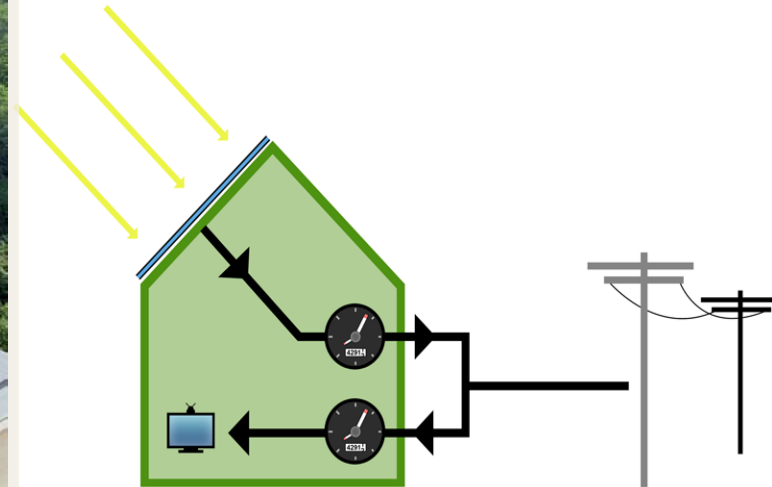
PV power installed, cumulated



Source: EPIA

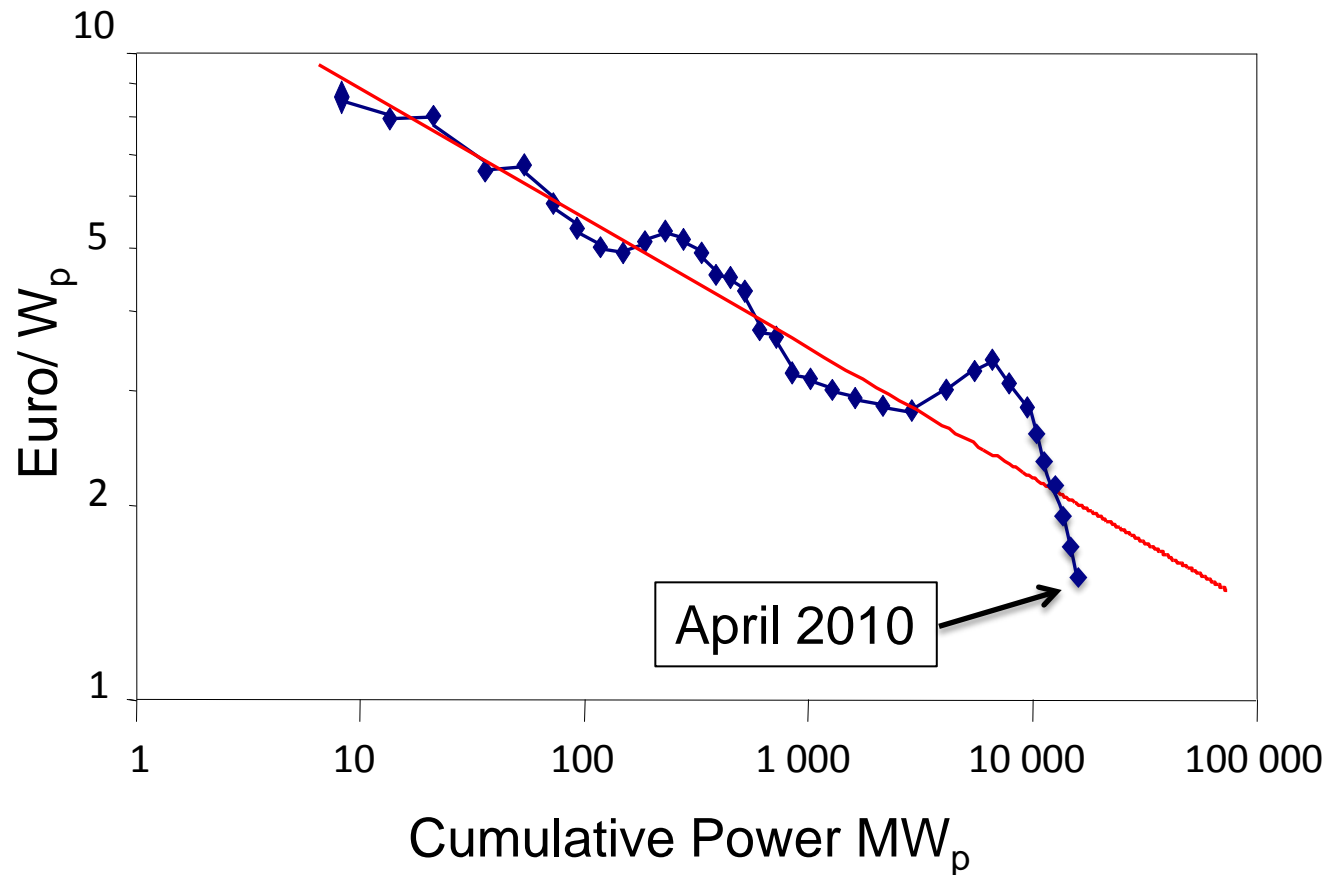
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Feed-in tariff, photovoltaics



Different tariffs (prices) for selling and buying of electricity - the difference in prices is distributed over the electricity bills of electricity consumers. They pay for the installation of a sustainable electricity system

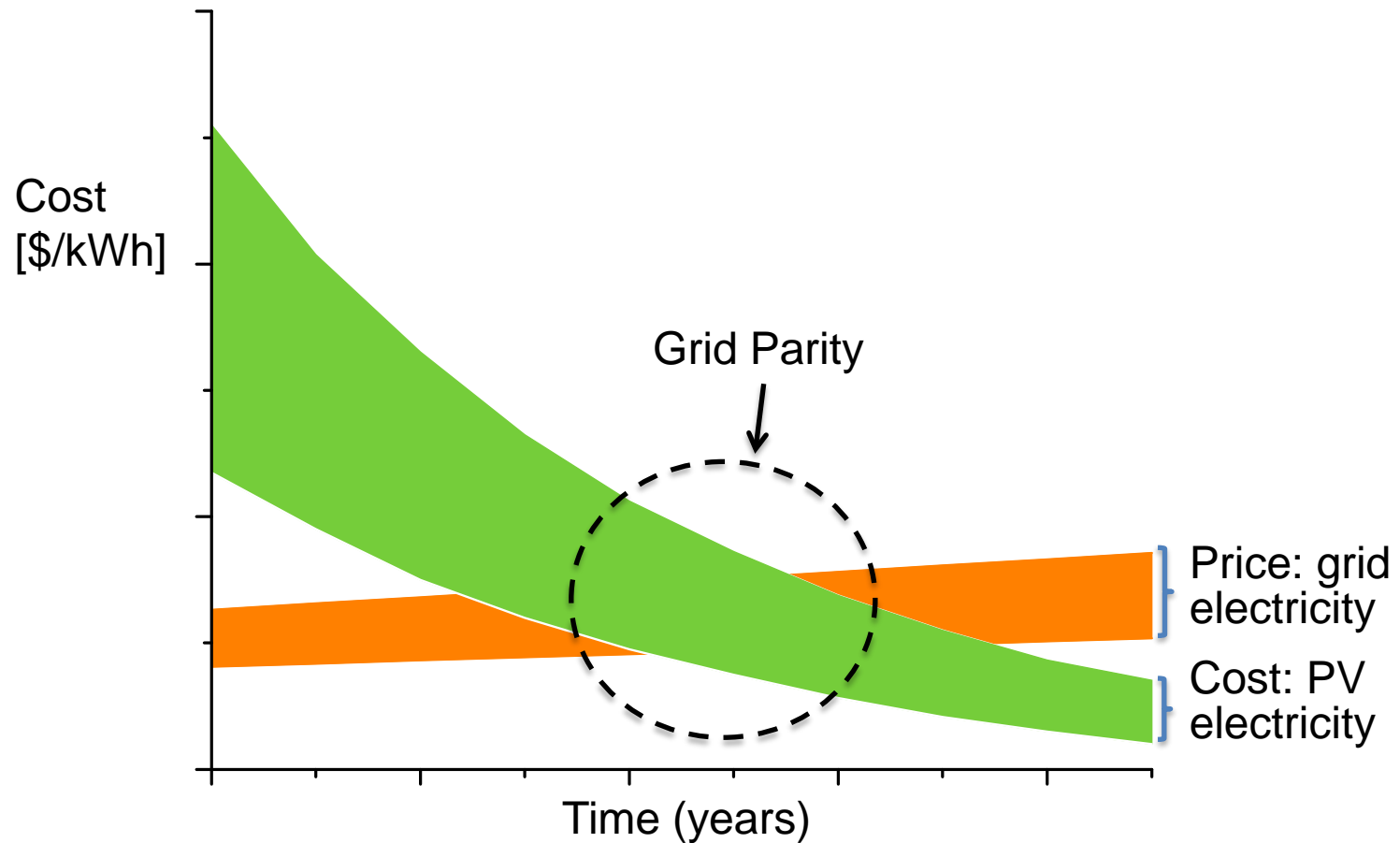
Price experience (learning) curve, silicon-wafer based modules



Source: Solar Generation, IEA-PVPS 2006; SERIS market research 2010

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Grid parity in photovoltaics



Grid parity – a milestone, not the final goal

Grid parity

No further subsidies needed for private installations if net-metering and easy grid access are in place.

Markets will grow strongly if they are not constrained by bureaucratic hurdles



further cost reduction in solar electricity
+
inclusion of external costs into electricity prices

Cost parity

between conventional and solar electric energy supply (including systems hardware and operation)

Outline

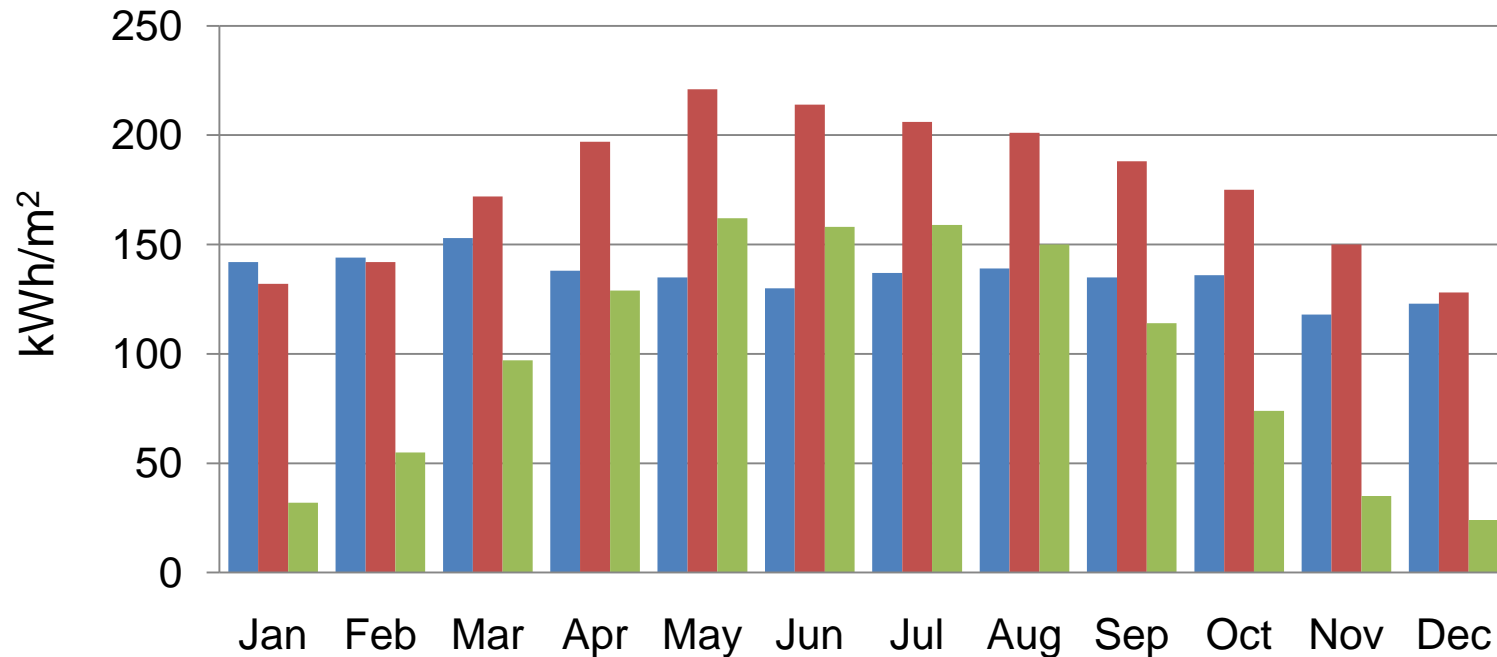
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Monthly solar radiation

at selected sites



■ Singapore:	1634	kWh/(m ² year)
■ Abu Dhabi:	2126	kWh/(m ² year)
■ Berlin :	1189	kWh/(m ² year)

Source: SERIS' research based on Meteonorm data

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Potential of PV in Singapore

a (very) rough assessment

2009 Energy demand: 38 TWh → future energy demand: 50 TWh

Annual solar radiation density 1.6 MWh/(m² year)

Photovoltaic system efficiency, 2020 15%

Specific electricity yield 0.24 MWh/(m² year)

PV system area necessary to cover 20% of future electricity demand 42 km²

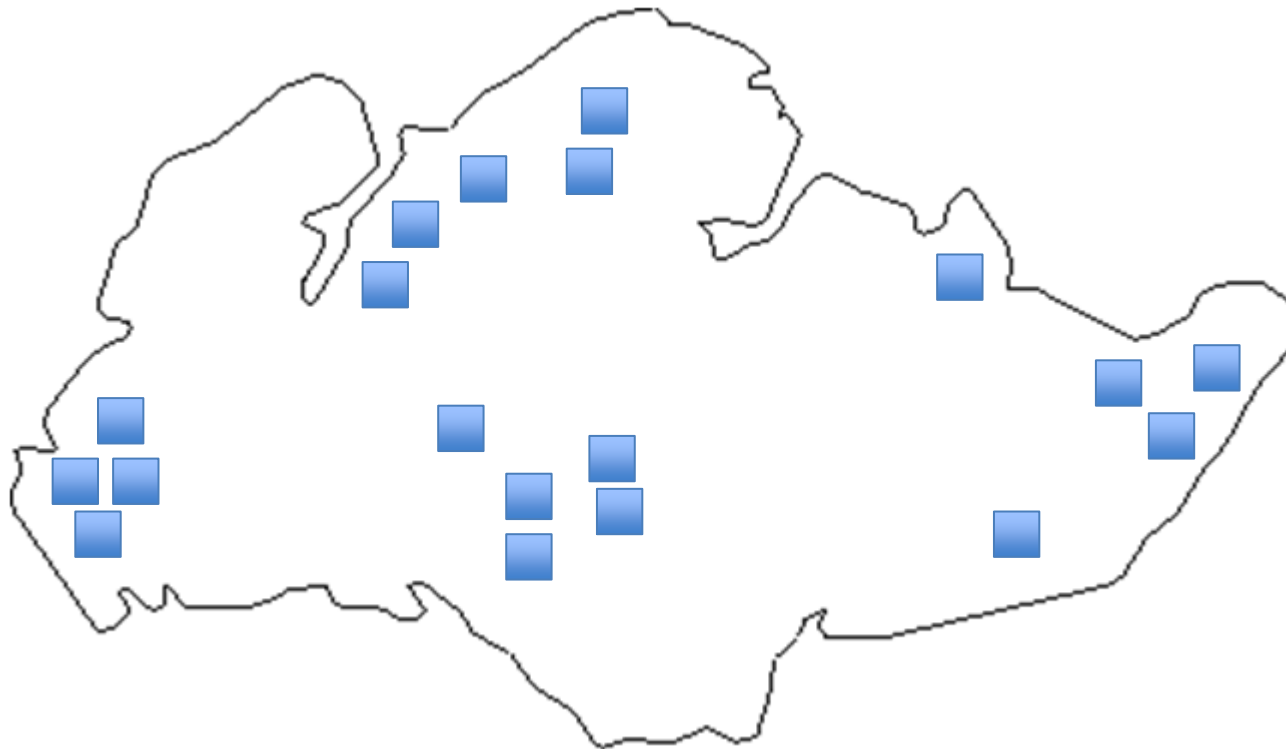
Surface area of Singapore (main island) 617 km²

Source: EMA and SERIS' research based on Meteonorm data

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Necessary PV area

for the generation the of 10 TWh/year solar electricity in Singapore



■ represents an area of
1.5 km x 1.5 km

The actual distribution of
PV areas will be more finely
dispersed

Technology: 2020

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Peak PV power

for an annual generation of 10TWh



- ❑ Specific yield of PV installations in Singapore:

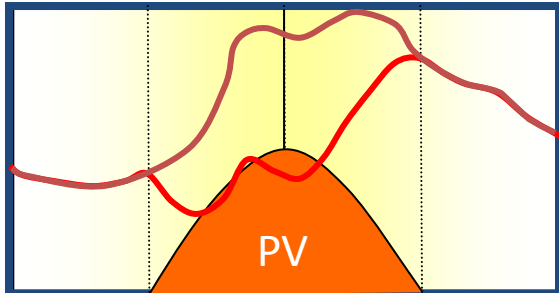
1.3 MWh/(year & kW_p installed)

- ❑ Peak power of an installation that generates 10 TWh/a:

7.7 GW

Smart grids

merging of power and information networks



- ❑ Matching demand and generation
 - prognosis
 - control
 - storage
 - smart metering
 - variable tariffs

- ❑ “Intelligent” and highly efficient power electronics

- ❑ Large-area grids

Thank you for your attention!

More information
www.seris.sg