INTEGRATION OF UTILITY-SCALE SOLAR PV (USSP) INTO THE PENINSULAR MALAYSIA GRID

SINGLE BUYER VIEWS & EXPERIENCES

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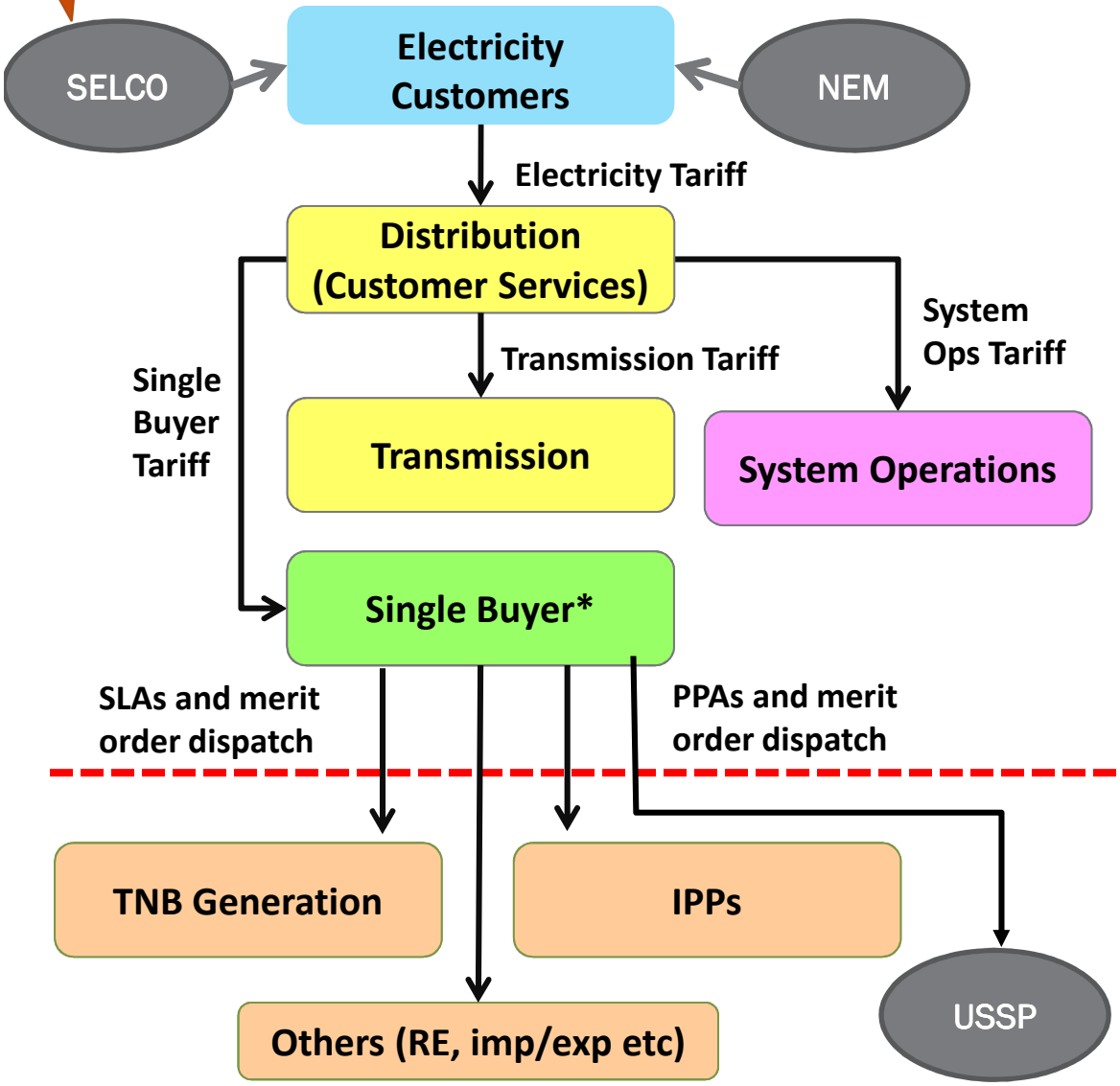
Single Buyer, TNB

Single Buyer is an enabler for a fair and non-discriminatory generation sector in Peninsular Malaysia



Natural monopoly

Efficiencies achieved by Incentive based regulation (IBR)

- **Building block model used to develop revenue requirement**
- **Appropriate price control mechanisms developed by the Energy Commission**

Competition

Efficiencies achieved by Single Buyer Rules & competition

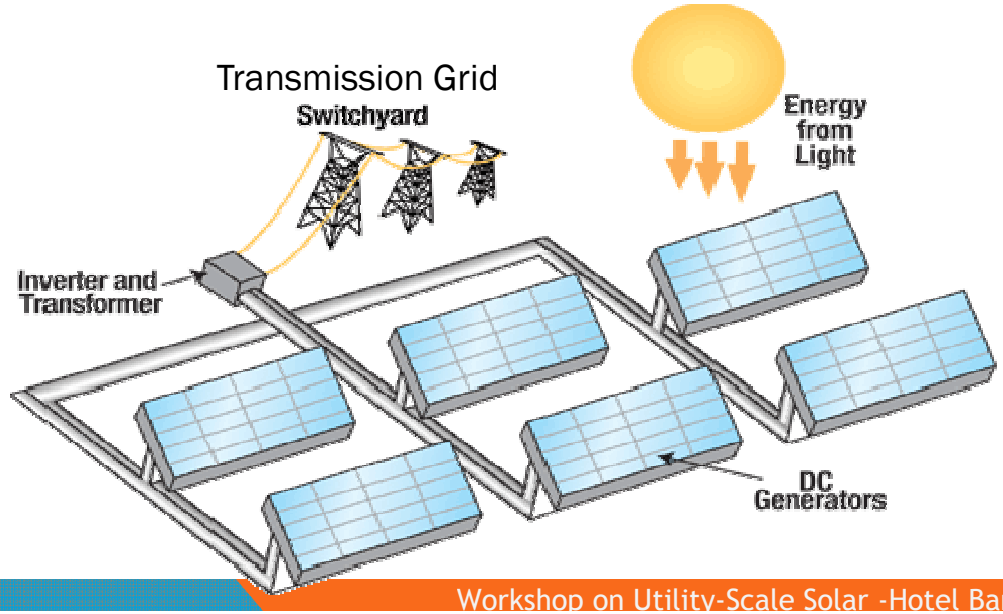
- **Least cost dispatch**
- **Transparent operations**
- **Governance arrangements**

DEFINITIONS & SCOPE

WHAT IS USSP?

What is a Utility-Scale Solar PV power plant (USSP) ?

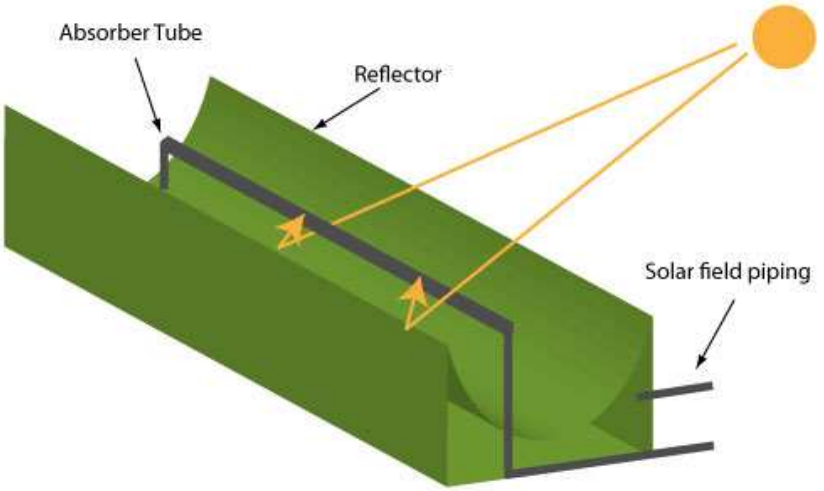
- According to the recent solar workshop on Malaysian Grid Code (MGC) by Suruhanjaya Tenaga (ST) & edited for simplicity:
  - *"A Power Station is also a Major Power Station if it is owned by a Generator and utilise one or more Non-Synchronous Generating Units that are powered by an Intermittent Power Source e.g. solar with a single electrical point of connection directly to the Transmission Grid System with total on-site generation capacity of 50 MW and above"*



Photovoltaic (PV) is the only proven technology in Malaysia for now

- Concentrated Solar Plant (CSP) technology requires Direct Normal Irradiance (DNI) of at least 1900-2000 kWh/m^2/year in order to be economically feasible
  - Very high sun exposure and low cloud coverage
  - Southern states of the United States, Mexico, Mediterranean sea region, Middle East, South Africa, parts of China, Pakistan, India, Australia and parts of South America
- However, many countries with low DNIs have developed CSPs in their countries
  - Germany, Thailand, etc.

CST technology: Parabolic Trough



This presentation will focus on PV technology

WORLDWIDE TRENDS

HOW OTHER COUNTRIES ARE EMBRACING USSP

What is the deal with USSPs?

Benefits

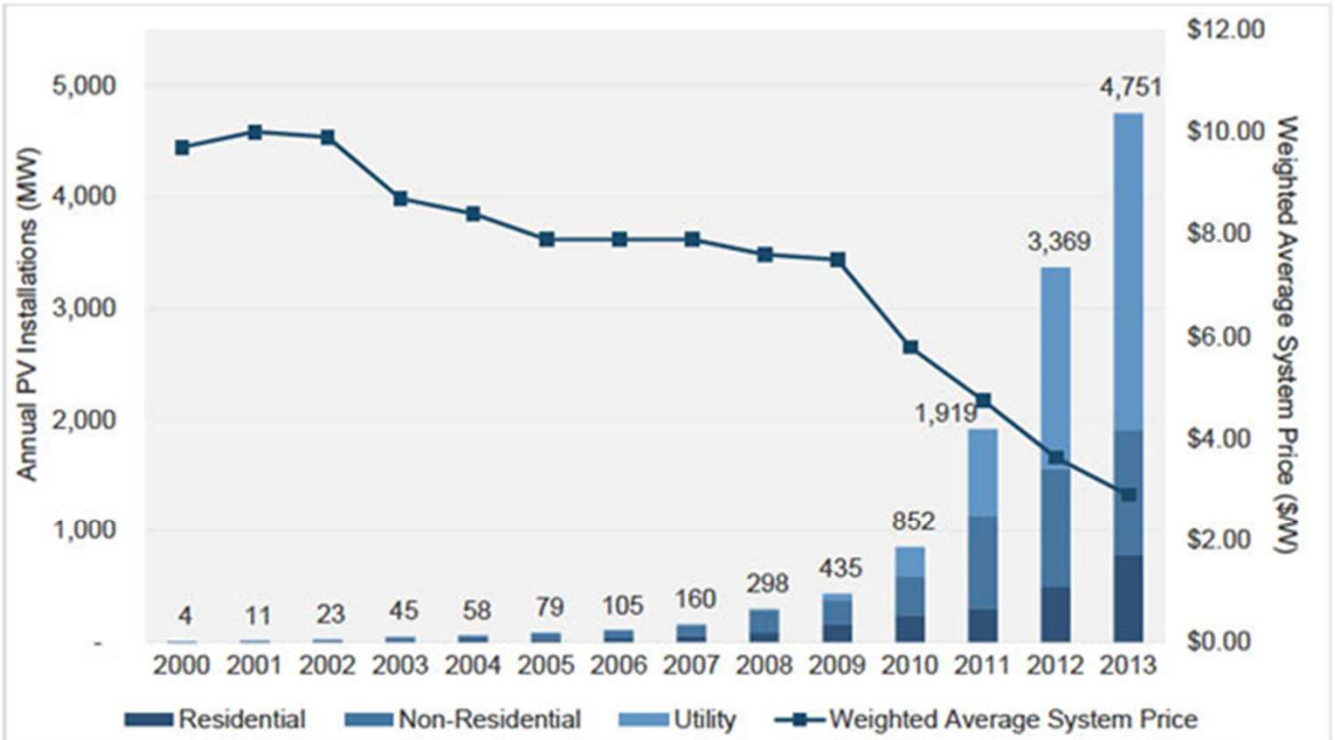
- Meet national renewable standard
- Fuel diversification
- Modularity
- Partial correlation with peak demand
- Free energy source!

Challenges

- Non-dispatchable
- Power swings
- Low capacity factor
- Back-up requirements
- Grid reinforcements
- Land requirements

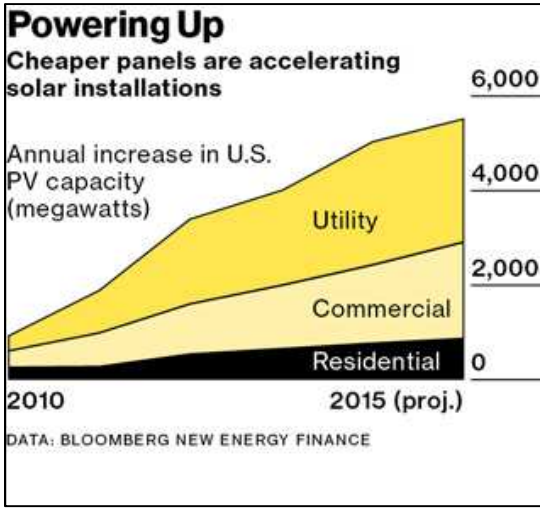
Everybody loves sunshine...

Figure 2.1 U.S. PV Installations and Average System Price, 2000-2013



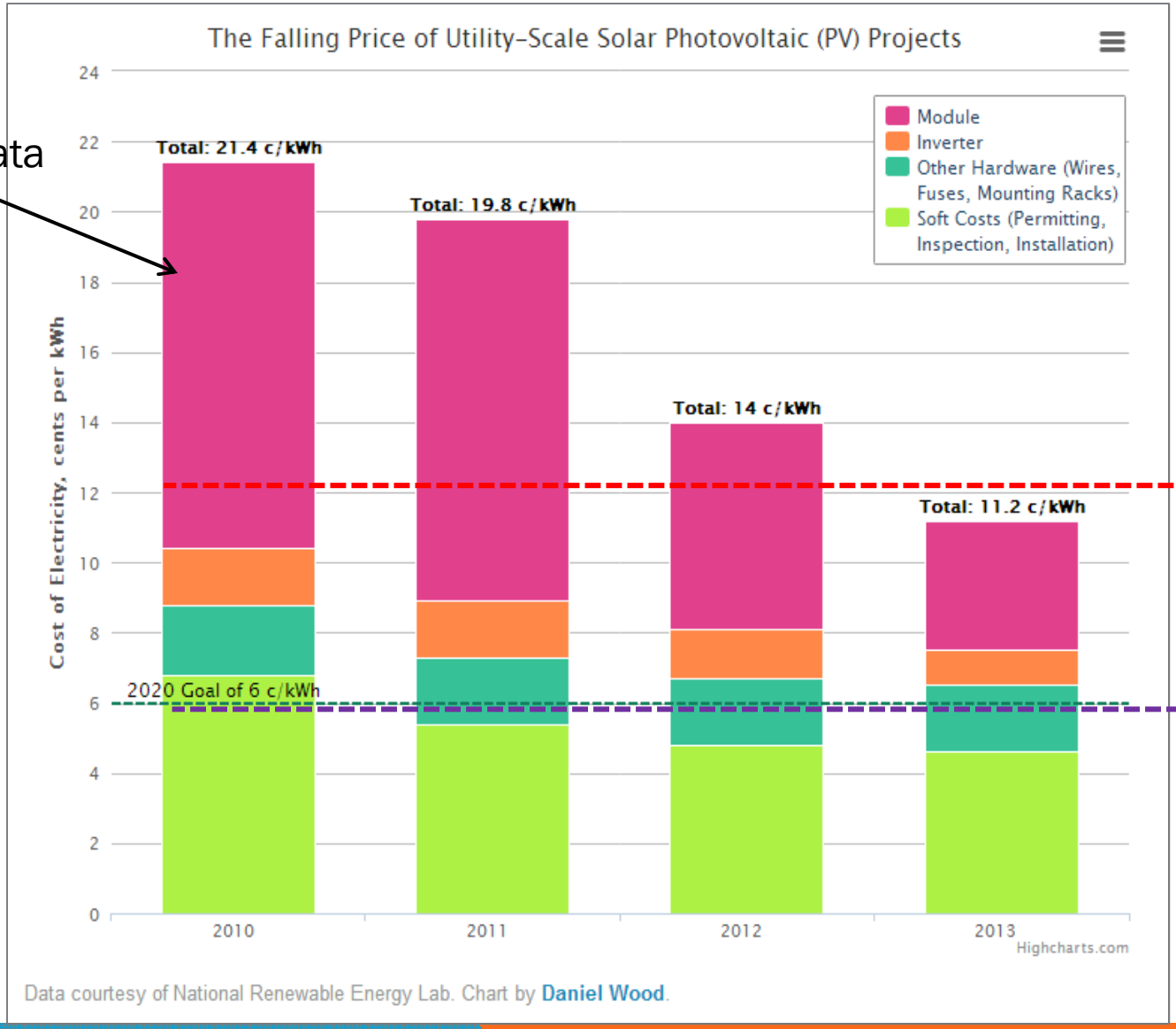
Installations (MW)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Residential	1	5	11	15	24	27	38	58	82	164	246	304	494	792
Non-Residential	2	3	9	27	32	51	67	93	200	213	339	831	1,072	1,112
Utility	0	3	2	3	2	1	0	9	16	58	267	784	1,803	2,847
Total Installations	4	11	23	45	58	79	105	160	298	435	852	1,919	3,369	4,751

GTM RESEARCH SEIA



In order to be competitive… USSPs need high capacity factor and cheap land cost…

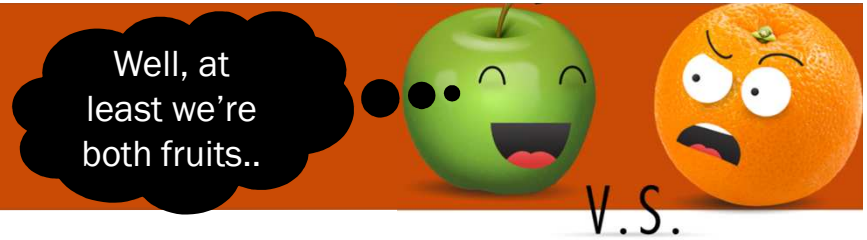
U.S. data



1MDB PPA price is ~USD$0.12 / RM0.40-0.46 per kWh

Cheapest solar PPA currently: DEWA 200 MW USSP in Dubai @ USD $0.059 perkWh

Grid parity is a fallacy? The LCOE matrix overvalues RE

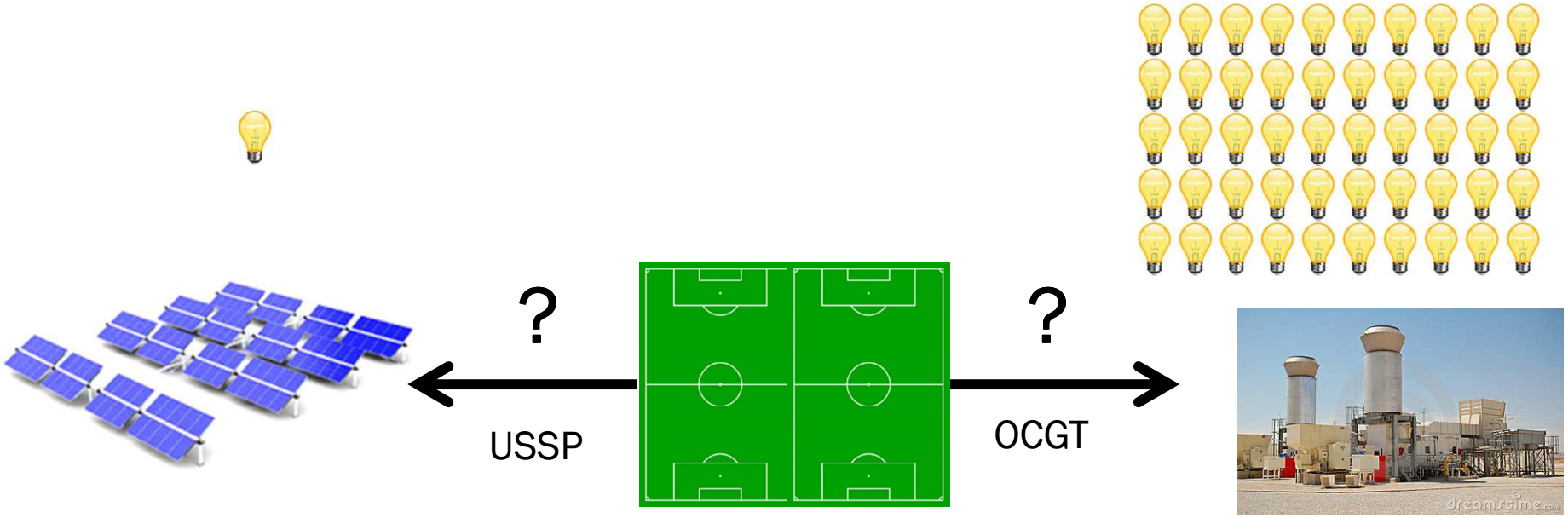


- A paper entitled: Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies[1]
- By Professor Paul L. Joskow from Masschusetts Institute of Technology said:
- The life-cycle levelised (LCOE) cost metric typically used to compare the economics of conventional and renewable generating technologies is flawed
  - Wind, solar, cannot be economically dispatched
  - Does not take into account hourly energy price fluctuations
  - Overvalue intermittent generating technologies
- A new framework was recommended:
- the economics of all generating technologies, both intermittent and dispatchable, can be evaluated based on the expected market value of the electricity that they will supply, their total life-cycle costs, and their associated expected profitability.

American Economic Review, Vol. 101, No. 3, pp. 238-241, 2011.

Solar PV technologies requires massive land area... an OCGT can produce ~50x more energy for the same footprint![1]

- A land-use requirement study conducted in the United States (US) reported an average 2.8 acres of land to Generate 1GWh of Solar Energy Per Year
  - 2.8 acres = 1.13 hectares = ~2x football pitch
  - For the same footprint, an OCGT can produce ~50 GW.h per year



1 Sean Ong, Clinton Campbell, Paul Denholm, Robert Margolis, and Garvin Heath, "Land-Use Requirements for Solar Power Plants in the United States", National Renewable Energy Laboratory, Technical Report NREL/TP-6A20-56290, June 2013http://www.thestar.com.my/Business/Business-News/2013/10/28/Seda-gets-wind-of-it-Sustainable-energy-agency-mulls-over-wind-as-renewable-resource/?style=biz

Topaz Solar Farm in California is currently the world's largest USSP

Top 10 World's Largest Solar PV Projects under Construction

The table below shows the Top 10 of the World's largest solar PV projects under construction. All data was taken from the companies' respective websites, official statements and news releases.
If we've missed a project, please send us your feedback and suggestions to topten (at) solarplaza (dot) com

	Name	Developer	Capacity (MW)	Country	Module Type
1.	Topaz Solar Farm	First Solar	550	USA	CdTe
2.	Desert Sunlight Solar Farm	First Solar	550	USA	CdTe
3.	Agua Caliente Solar Project	First Solar	290	USA	CdTe
4.	California Valley Solar Ranch	SunPower	250	USA	c-Si
5.	AV Solar Ranch One	First Solar	230	USA	CdTe
6.	Mesquite Solar Ranch one	Sempra U.S. Gas & Power	150	USA	PV
7.	Copper Mountain Solar two	Sempra U.S. Gas & Power	150	USA	CdTe
8.	Imperial Solar Energy Center South	Tenaska Solar Ventures	130	USA	CdTe
9.	Vega Solar Power Plant	Solarhybrid AG	123	Italy	PV
10.	Sorrento Solar Farm	BlueChip Energy	100	USA	PV

Note: This table was first published on April 25 , 2012.

Type:
GROUND MOUNT

Developer:
FIRST SOLAR, INC.

Number Of Modules:
9,000,000

Owner:
MID AMERICAN SOLAR

PPA:
PACIFIC GAS & ELECTRIC

http://www.solarplaza.com/Top10-worlds-largest-solar-projects-under-construction/

Cheapest USSP is currently the 200 MW DEWA phase #2 in Dubai

- **Location:**
  - Mohammed bin Rashid Al Maktoum solar park, Dubai
- **Capacity :**
  - 200 MW
- **Developer:**
  - Riyadh-based ACWA Power International & TSK
- **Buyer:**
  - Dubai Electricity & Water Authority (DEWA)
- **Price:**
  - USD $0.059 cents/kWh
- **PPA Concession period:**
  - 25 years
- **Construction cost:**
  - $330 million
- **C.O.D**
  - April 2017
- **Area:**
  - 4.5km^2

USSP IN MALAYSIA

THE 1MDB PILOT PROJECT

Background of utility-scale solar plant (USSP) in Malaysia

1MDB Solar Plant Project Factsheet

Company	60:20:20 joint venture between 1MDB, TNB & DuSable Capital Management LLC
Area	200-500 acres
Location	Kedah
Capacity	50 MW_{AC}
Point of interconnection	132kV
Technology	Fixed Thin film CdTe
Concession period	25 years
Tariff	Between RM 0.40-46 sen/kWh[1]
C.O.D	2016 (best case)

1MDB, TNB seal solar deal

BRIGHT PROSPECTS: National utility to buy power generated from 50MW plant for up to 25 years

KUALA LUMPUR

MALAYSIA Development Bhd (1MDB) has sealed a power purchase agreement (PPA) with Tenaga Nasional Bhd (TNB) in relation to a mega solar power project in Kedah.

This officially confirmed that 1MDB has secured the job to build the 50-megawatt (MW) solar plant, the biggest of its kind in Malaysia and the largest non-hydro renewable energy plant domestically.

TNB, in a brief statement yesterday, said it will buy power generated from the plant for up to 25 years.

It did not disclose other details, such as the PPA rate, exact plant location or whether TNB will own a stake in the venture.

Those details are expected to be revealed during the visit of United States President Barack Obama to Malaysia later this month.

It is understood that this is partly because the technology provider for the proposed power plant is a US-based company.

But Business Times learnt that TNB will likely have a minority stake in 1MDB Solar Sdn Bhd, which will undertake the project that is expected to cost around RM1 billion.

Business Times had last week reported that 1MDB and TNB were in talks to jointly develop the country's largest solar power plant, which could be the start of a larger expansion in domestic solar generation.

The scale of the project is "too large" for open bidding, hence, it was based on direct negotiations between 1MDB and the Energy, Green Technology and Water Ministry, with both the Energy Commission and the Sustainable Energy Development Authority (Seda) playing a smaller role.

The Seda Feed-in-Tariff bidding system only allows up to 30MW for renewable energy projects and up to 1MW for solar.

In a separate statement to Bursa Malaysia yesterday, TNB said the PPA provides that 1MDB Solar will design, build, own, operate and maintain a solar photovoltaic energy (solar PV)-generating facility with a 50MW alternate current (MWac) in Kedah.

"The PPA is in relation to the pilot project for the 50MWac solar PV, which forms part of the initiative to support the national agenda for the development of renewable energy in Malaysia," it added.

It was reported that 1MDB has proposed a rate of between 40 sen and 46 sen per kiloWatt hour (kWh), which will make it the lowest price for any solar-generated electricity in Malaysia.

The current Seda rate is 61.2 sen per kWh.

1 http://www.thestar.com.my/Business/Business-News/2014/05/05/1MDB-plans-giant-solar-farm-It-is-believed-to-have-formed-a-joint-venture-with-TNB-and-a-US-firm-fo/?style=biz/

There is a need for a set of technical rules and framework to regulate solar PPAs

- The Malaysian Grid Code (MGC) does not include provisions for USSP
  - Currently, it is being revised by the Regulator
  - In the meantime, no other solar PPAs will be awarded
- The 1MDB solar PPA however, has already specified the technical requirements & operating characteristics for USSP PV in its Appendix B
  - Complies with most existing MGC codes
  - Special provision on variable energy

USSPs will be treated no different than other conventional generation plant.

Typical Content of Solar Power Purchase Agreement (PPA)

- Main body
- Appendix A : Project Description & Design Conditions
- **Appendix B : Facility Technical Requirements & Operating Requirements**
- Appendix C : Energy Accounting & Metering Equipment
- **Appendix D : Design of Interconnection Facilities**
- **Appendix E : Meteorological Measuring Facilities**
- Appendix F : Operation & Maintenance
- Appendix G : Calculation of Test Energy Payment, Energy Payment, Non-acceptance payment & Non-Delivery Payment
- Appendix H : Description of Site
- Appendix I : Energy Rate Review & Adjustments & Initial Financial Model
- Appendix J : Consequences of Termination
- Appendix K : Letter of Award

Our standard template for solar PPA is formulated to fulfill most of the requirements of MGC

ALL BASES COVERED!

APPENDIX B

2.0 TECHNICAL LIMITS OF THE FACILITY

- B2.1 Grid frequency variation
- B2.2 Reactive Power
- B2.3 Grid system voltage variation
- B2.4 Grid system fault level
- B2.5 Fault detection & clearing limits
- B2.6 High speed & delayed auto reclosing
- B2.7 Black start

3.0 PERFORMANCE STANDARD & OPERATING GUIDELINES

- B3.1 Voltage Support
- B3.2 High frequency MW response
- B3.3 Protection System
- B3.7 Fault ride-through capability

Malaysia's first USSP PPA is comparable with Grid Code requirement in other countries

Requirement for grid connected solar PV	1st Solar PPA	Germany	UK
To stay connected during fault (fault ride through capable)	Yes	Yes	Yes
Supply reactive power during fault ride-through period	Yes	Yes	Yes
Supply reactive power during operation	Yes	Yes	Yes
Able to control power factor or reactive power	Yes	Yes	Yes
Automatically reduce active power output with increasing frequency	Yes	Yes	Yes
Able to power output (within rating)	Yes	Yes	Yes
Providing primary control power	*to clarify terms	Exempted until further notice	-
Islanded operation capable	Yes	- ditto -	-

CONCLUSIONS & FUTURE WORK

SO, WHAT'S NEXT?

Conclusions

- USS development is crucial for meeting the National Renewable Energy Target
- There needs to be a USS framework for Malaysia
  - Current MGC still requires revision to accommodate the intermittent generation such as Solar PV
  - How to allocate capacity? E.g. bidding or reverse auction
- Technical requirements of solar PPAs will be equal to conventional thermal plants
- Pricing will determine the competitiveness

THANK YOU

Comments & feedbacks are appreciated!

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"For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled."

-Richard Feynman, Nobel Prize Physicist

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