1st Asia-Arab Sustainable Energy Forum

ENERGY FROM THE DESERT

Extended to SSB Scenario

Prof. Kosuke KUROKAWA
Tokyo Institute of Technology
Task 8 OA (up to 2008)
Chairman, Japan Council for Renewable Energy

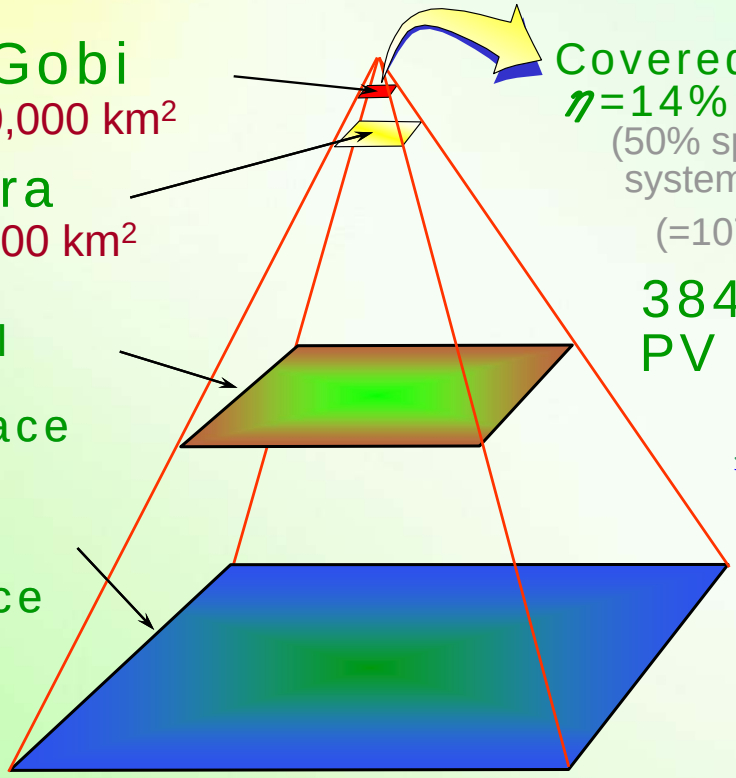
Solar Pyramid: PV Systems for 21st Century

Gobi
1,300,000 km²

Sahara
8,600,000 km²

Total Land Surface

Total Earth Surface



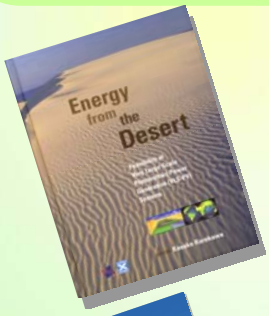
Covered by
η=14% PV modules
(50% space factor assuming 10 % system energy efficiency)
(=107 PWh/y =107 × 10^{12}kWh/y)

384EJ/year
PV Electricity

(1 EJ = 10^{18}J)

World Primary Energy Supply In 2002 = 379EJ/year

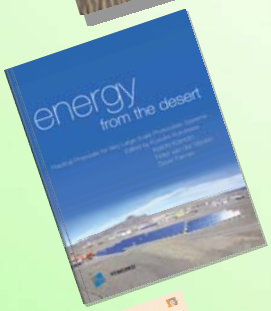
Task 8: Study on Very Large Scale Photovoltaic Power Generation Systems - VLS-PV



1998 (Task 6 - Subtask 5)

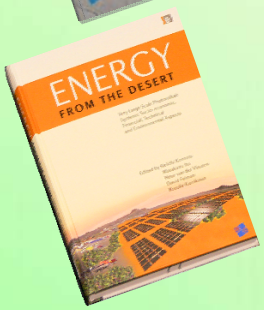
1999 - 2002 Phase I

Energy from the Desert:
Feasibility Study of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems



2003 - 2005 Phase II

Energy from the Desert:
Practical Proposal for Very Large Scale Photovoltaic Systems



2006 - 2008 Phase III

Energy from the Desert:
Very Large Scale Photovoltaic Systems for Socio-Economic Developments

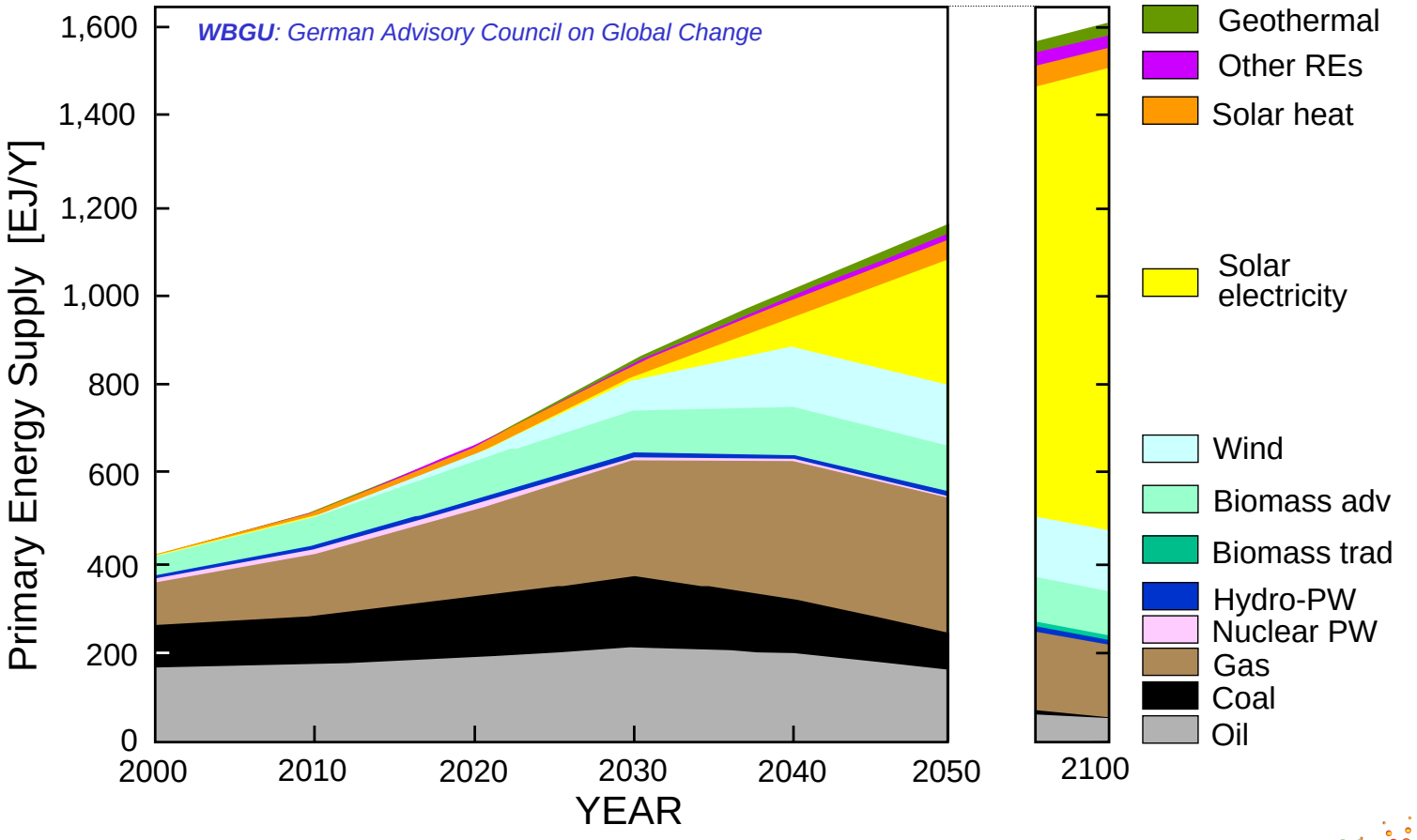
2009 - 2011 Phase IV (going on)

Energy from the Desert:
Practical Project Proposals to Realise Very Large Scale Photovoltaic Systems (tentative)

http://www.iea-pvps.org/products/download/Energy%20from%20the%20Desert%20Summary09.pdf

kurochans-net

Our Future Directions toward 2100



http://www.ipcc.ch/news_and_events/docs/ipcc33/SRREN_FD_SPM_final.pdf

ipcc
INTERGOVERNMENTAL PANEL ON climate change

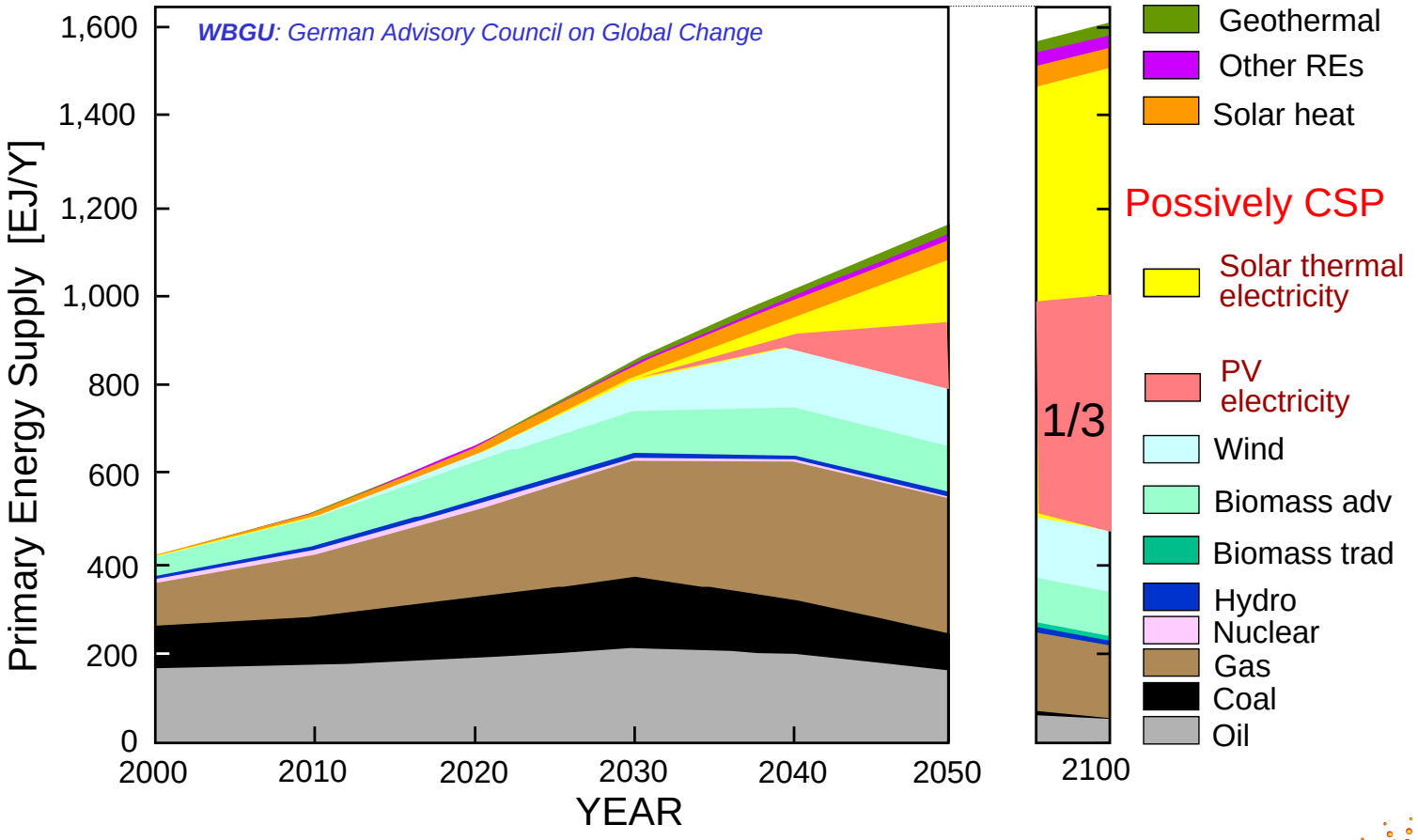
Special Report Renewable Energy Sources (SRREN)

says that

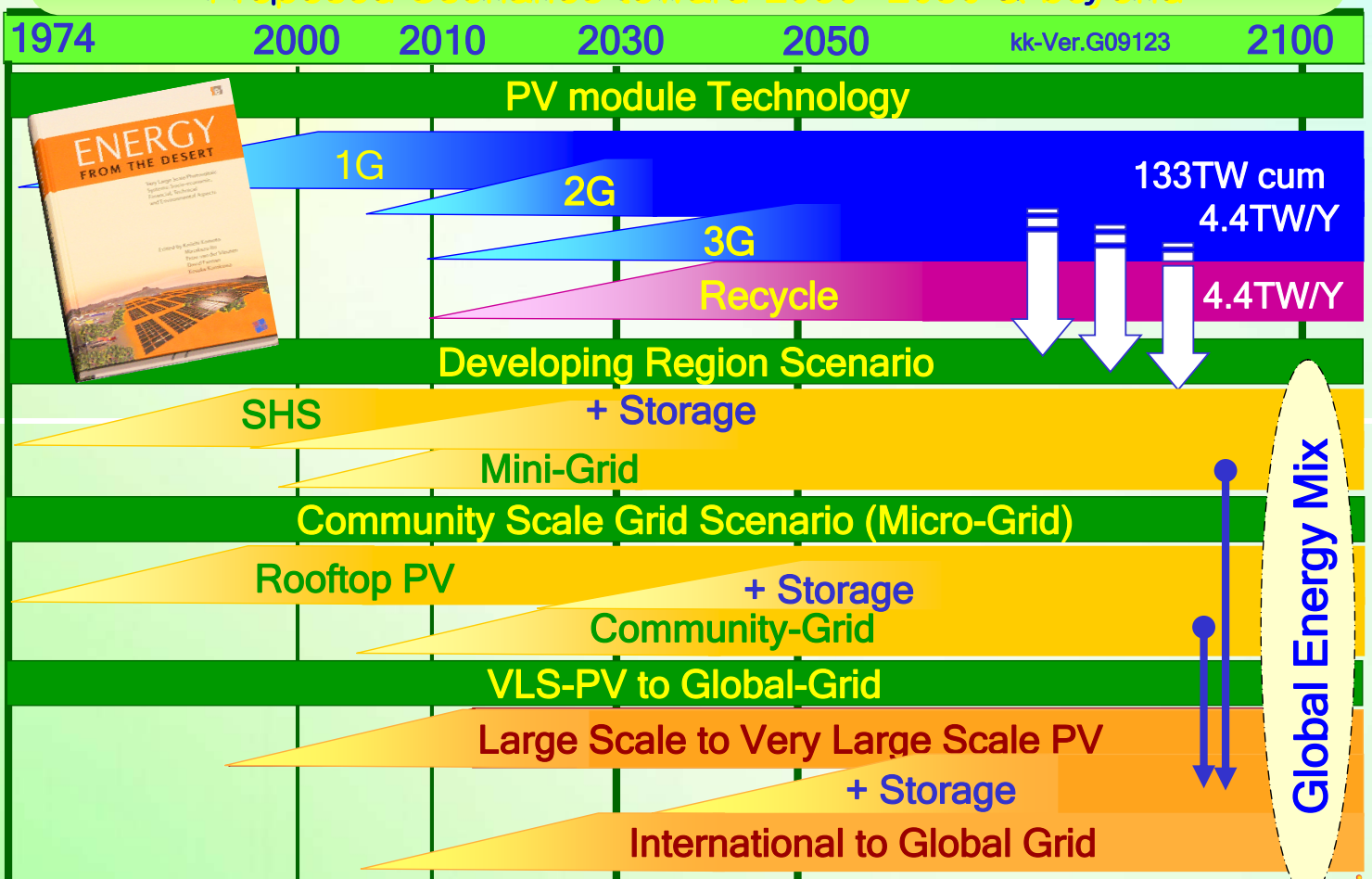
77% of the world energy demand will be supplied by RENEWABLE ENERGY SOURCES in 2050.

This Summary for Policymakers was formally approved at the 11th Session of Working Group III of the IPCC, Abu Dhabi, United Arab Emirates. 5-8 May 2011.

Our Future Directions toward 2100



Proposed Scenarios toward 2030–2050 & beyond

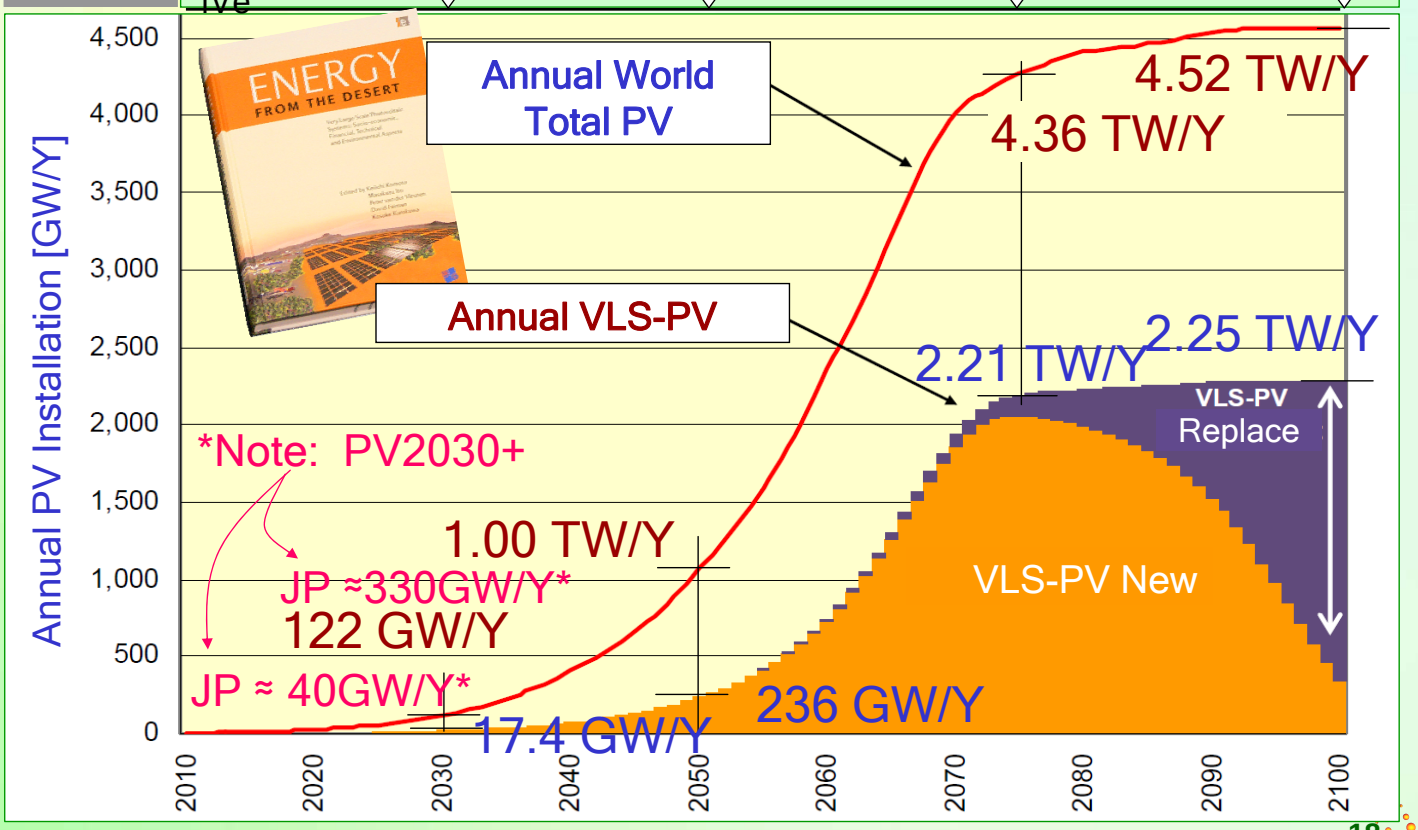


World PV Market Long-Term View

Version 0902205

1/3 of World Total Primary Energy Supply ↓

Cumulative 800 GW 10 TW 75TW 133 TW



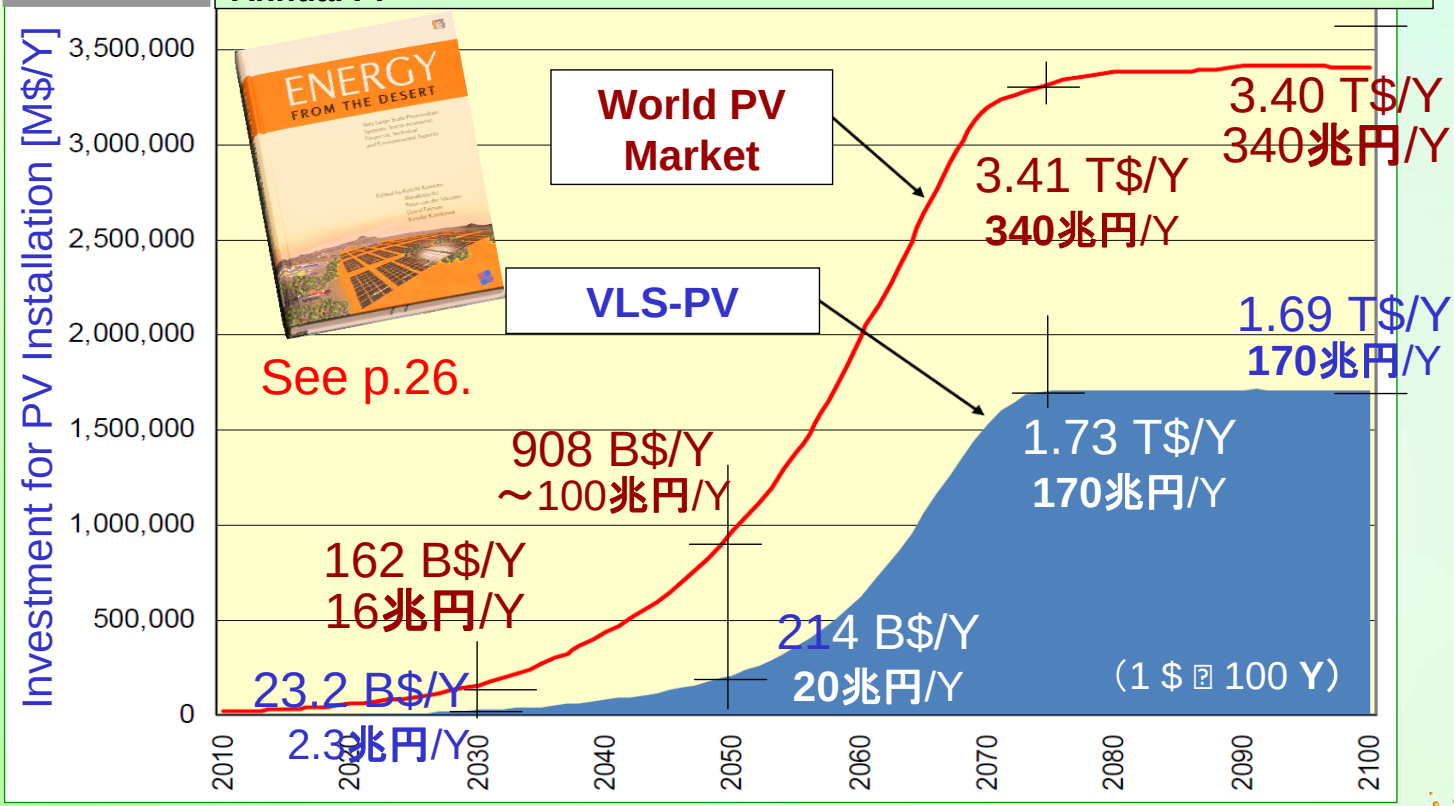
Source: IEA PVPS Task 8 3rd Report "Energy from the Desert"

World PV Market Long-Term View

Version 0902205

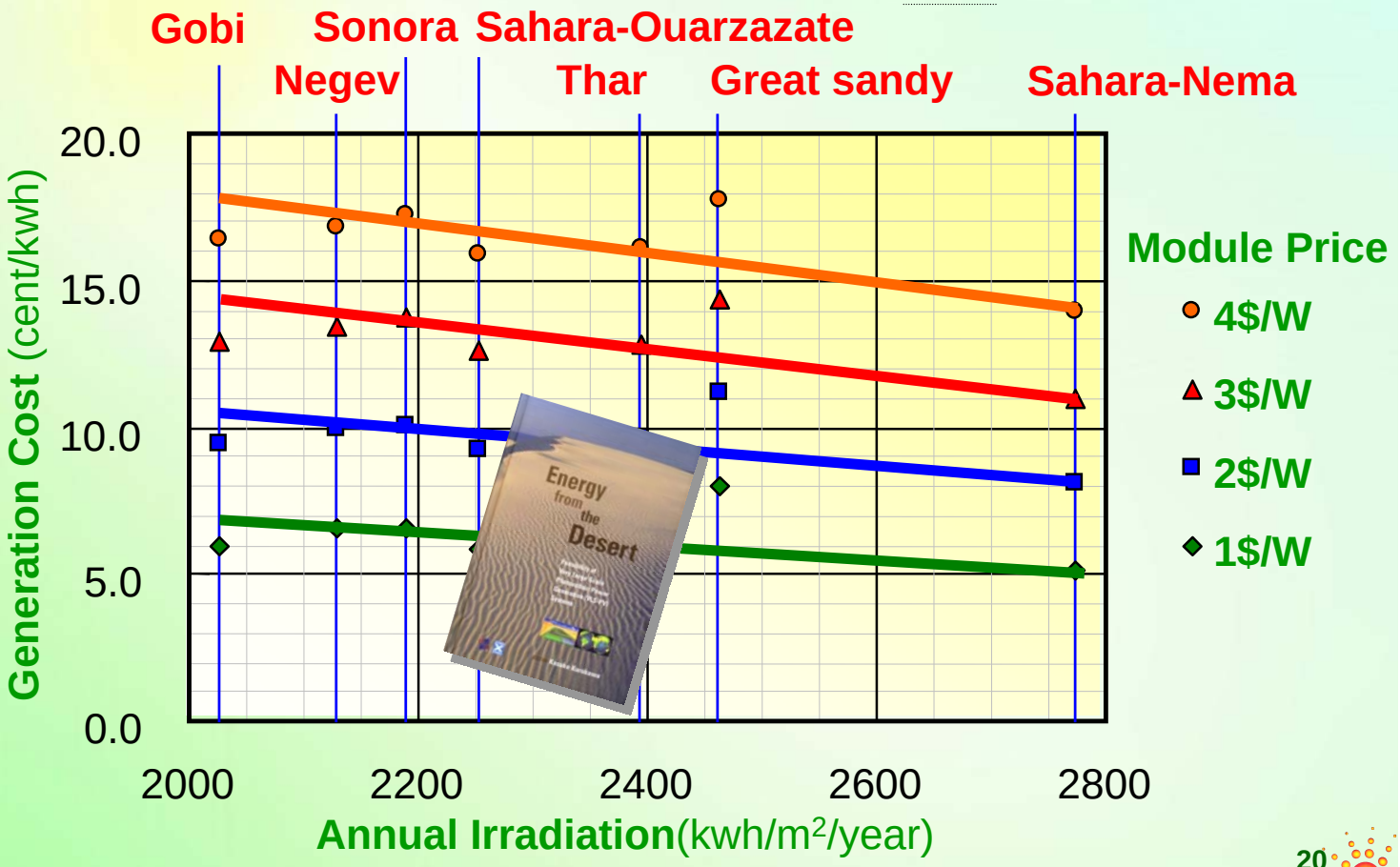
Net Stock 800 GW 10 TW 75TW 133 TW

Annual P. 120 GW/Y 1070 GW/Y 4.26 TW/Y 4.56 TW



Source: IEA PVPS Task 8 3rd Report "Energy from the Desert"

Indicative Generation Cost (USD/kWh)



Results. Generation cost for PV vs. electricity price level and feed-in tariffs

Country	Site	Annual global irradiation (kWh/m²*a)	Annual energy yield (kWh/kWp*a)	Generation cost for PV (ct/kWh)	Grid electricity price level (ct/kWh)	Feed-in tariff rate @ system size (ct/kWh)
Morocco	Casablanca	1772	1337	35.9	~8-12	None
	Quarzazate	2144	1589	30.2		
Tunisia	Tunis	1646	1219	39.4	~2-5	None
	Gafsa	1793	1339	35.8		
Portugal	Porto	1644	1312	36.6	~12	~55 <5 kWp ~31-37 >5 kWp
	Faro	1807	1360	35.3		
Spain	Oviedo	1214	1008	47.6	~9	41.44 <100 kWp 21.62 >100 kWp
	Almeria	1787	1372	35.0		

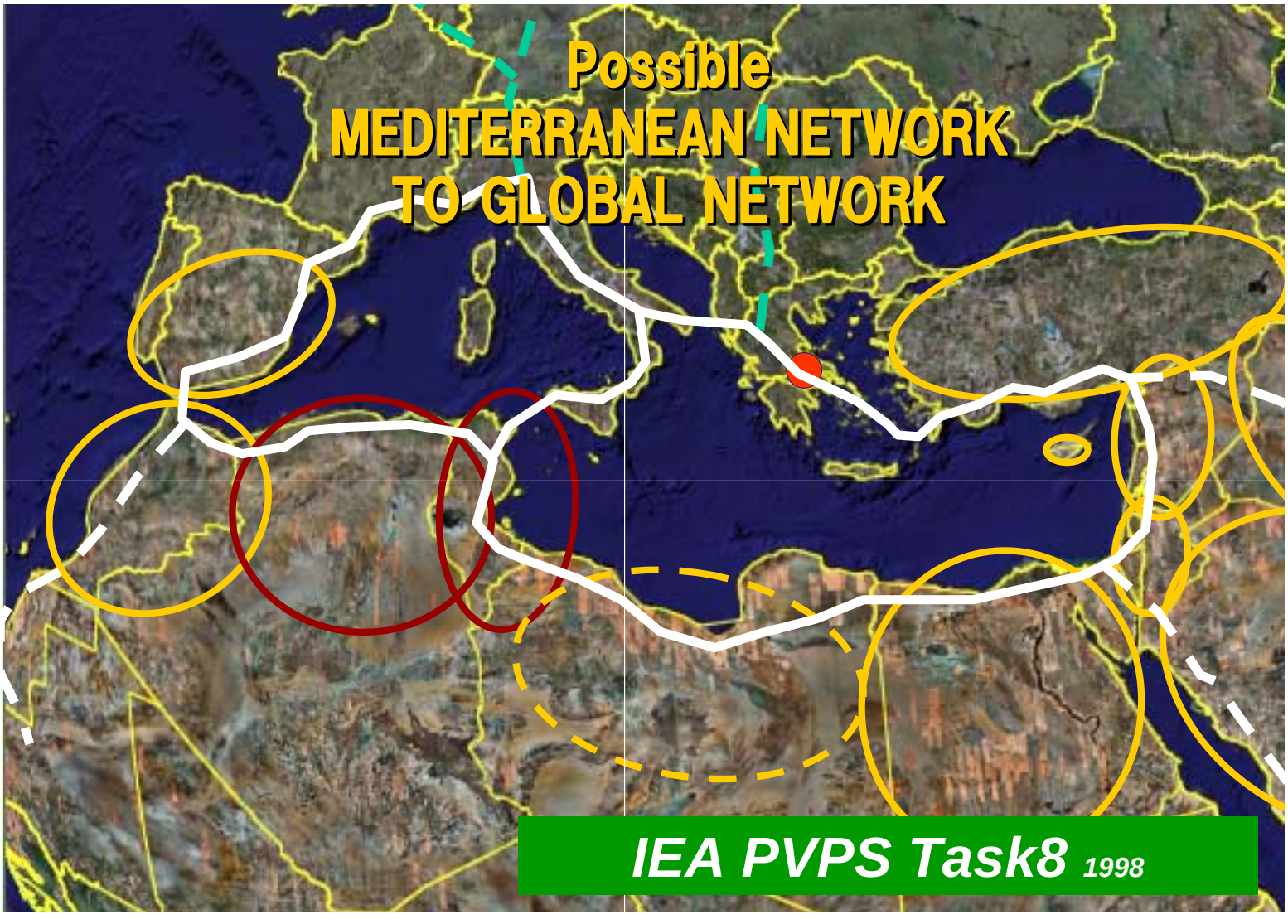
ErSol®

VLS-PV IEA PVPS Task VIII

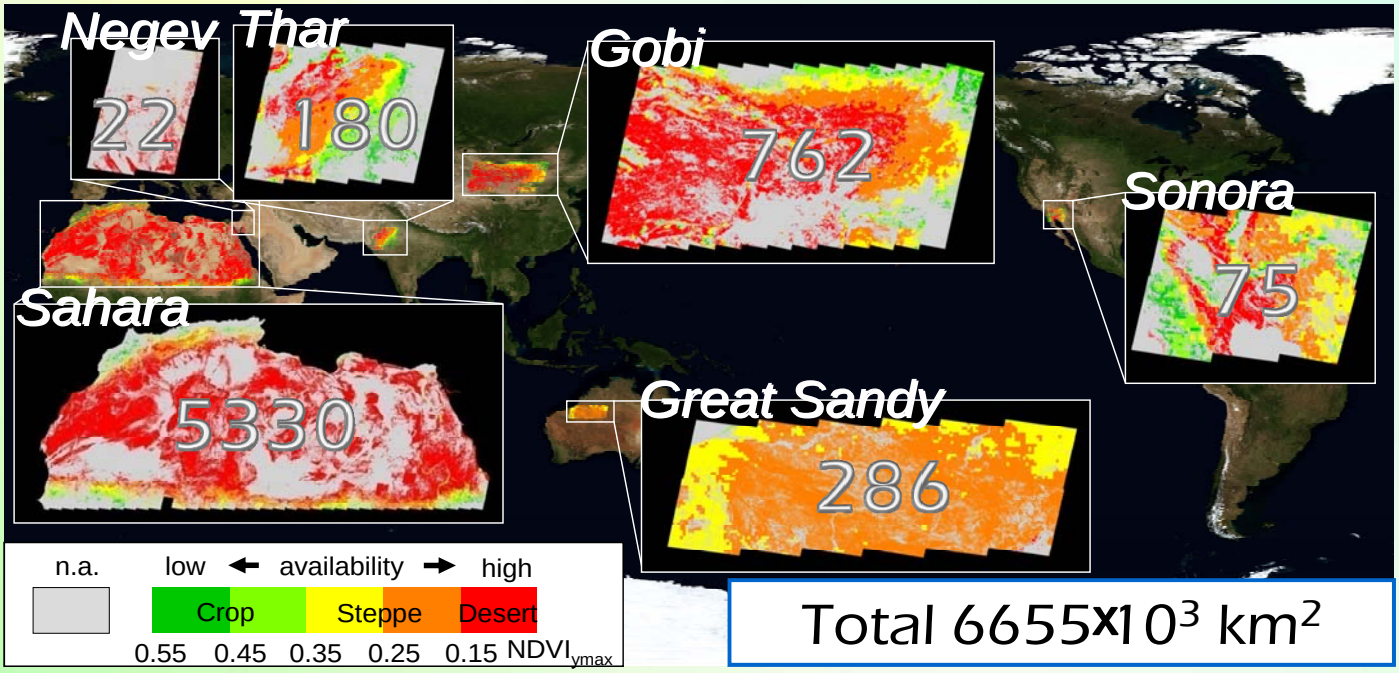
Mediterranean Case Studies

Middle East Case Studies

Country	Technology				Electricity Production in 2002 (TWh) [2]
	Static, 30^0 tilt (TWh y^{-1})	1-axis tracking (TWh y^{-1})	2-axis tracking (TWh y^{-1})	CPV (TWh y^{-1})	
Bahrain	43.5	46.3	22.1	32.4	6.9
Cyprus	604.3	643.1	306.8	450.0	3.6
Egypt	65,102.4	69,283.3	33,048.9	48,478.4	81.3
Iran	106,994.4	113,865.6	54,315.2	79,673.2	129.0
Iraq	28,263.4	30,078.5	14,347.8	21,046.3	34.0
Israel	1,329.6	1,415.0	675.0	990.1	42.7
Jordan	6,014.9	6,401.2	3,053.4	4,479.0	7.3
Kuwait	1,165.4	1,240.3	591.6	867.8	32.4
Lebanon	669.0	712.0	339.6	498.2	8.1
Oman	13,894.9	14,787.2	7,053.7	10,346.8	9.8
Qatar	748.0	796.0	379.7	557.0	9.7
Saudi Arabia	128,222.1	136,456.5	65,091.3	95,480.3	138.2
Syria	12,036.9	12,809.9	6,110.5	8,963.2	26.1
Turkey	50,407.7	53,644.9	25,589.2	37,536.0	123.3
UAE	5,420.4	5,768.4	2,751.6	4,036.3	39.3
Yemen	34,529.2	36,746.7	17,528.6	25,712.1	3.0



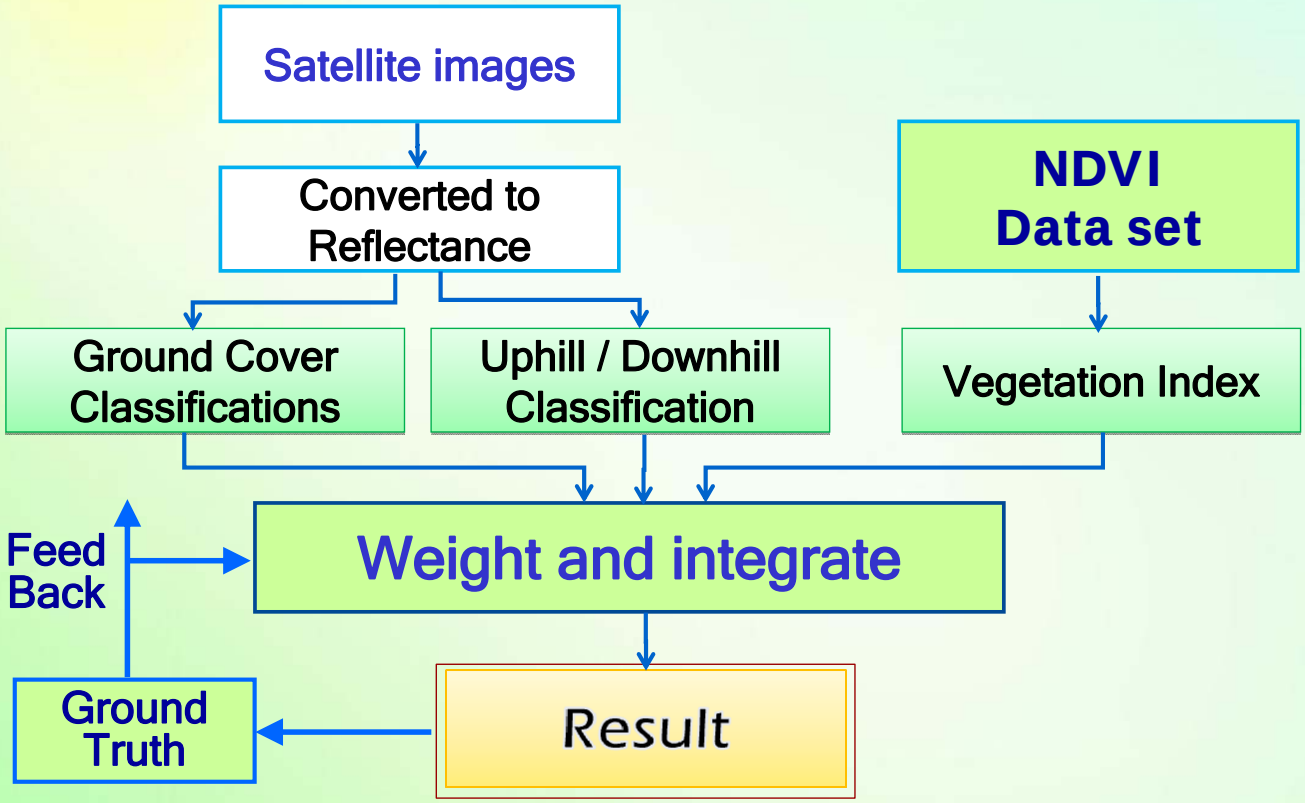
Suitable, Stable Area on the world 6 deserts



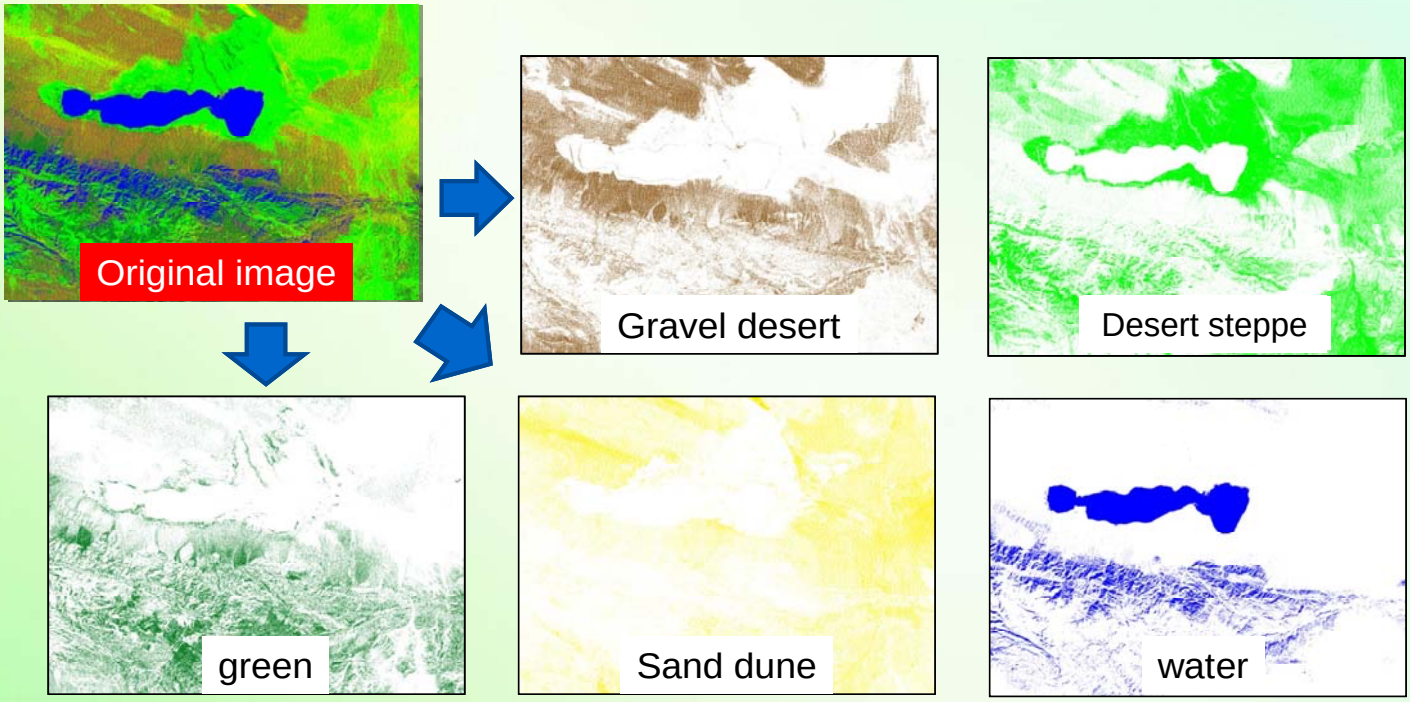
Total 6655x10^3 km^2

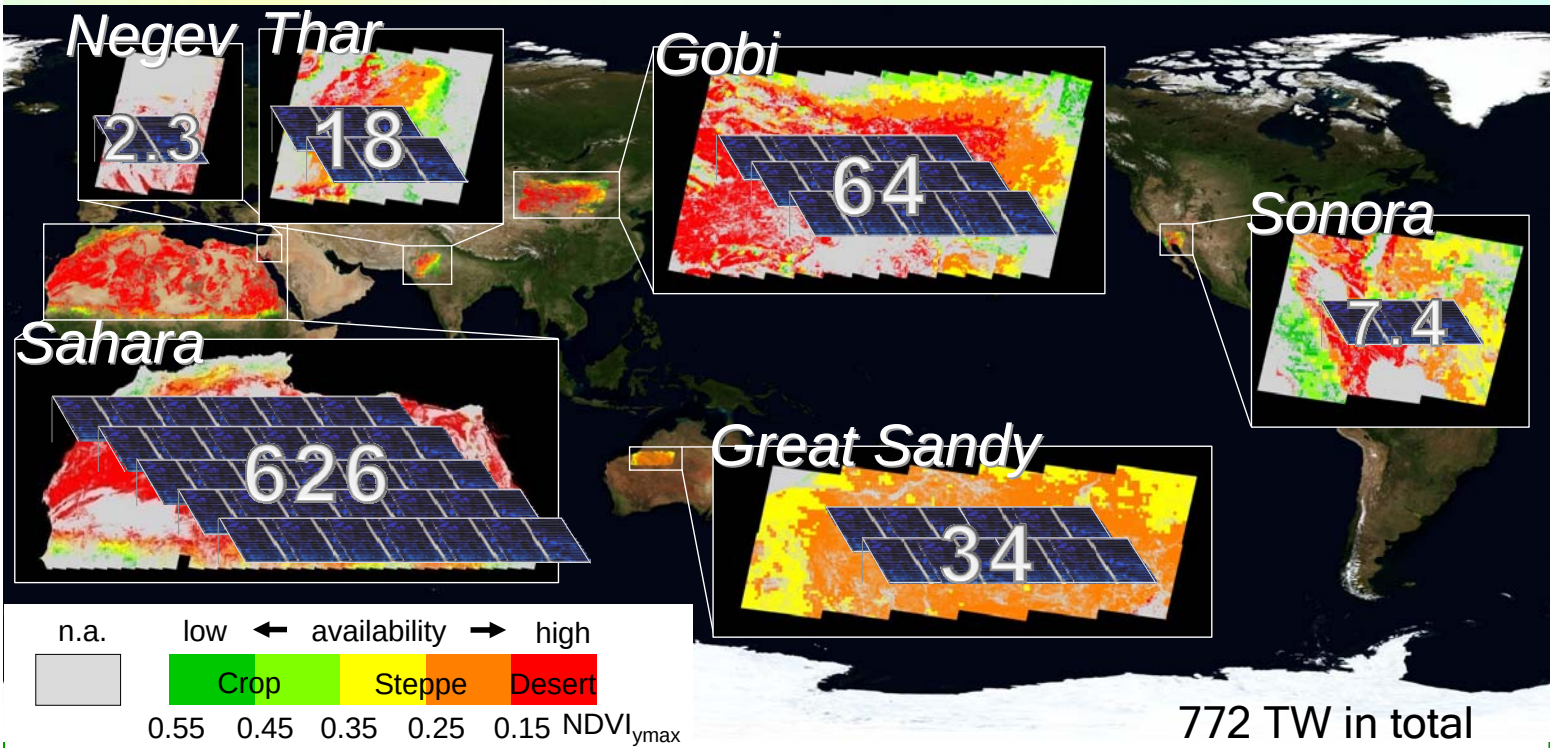
Steppe + Desert

Global Potential Analysis



Classification of the Desert into Ground Surface Conditions

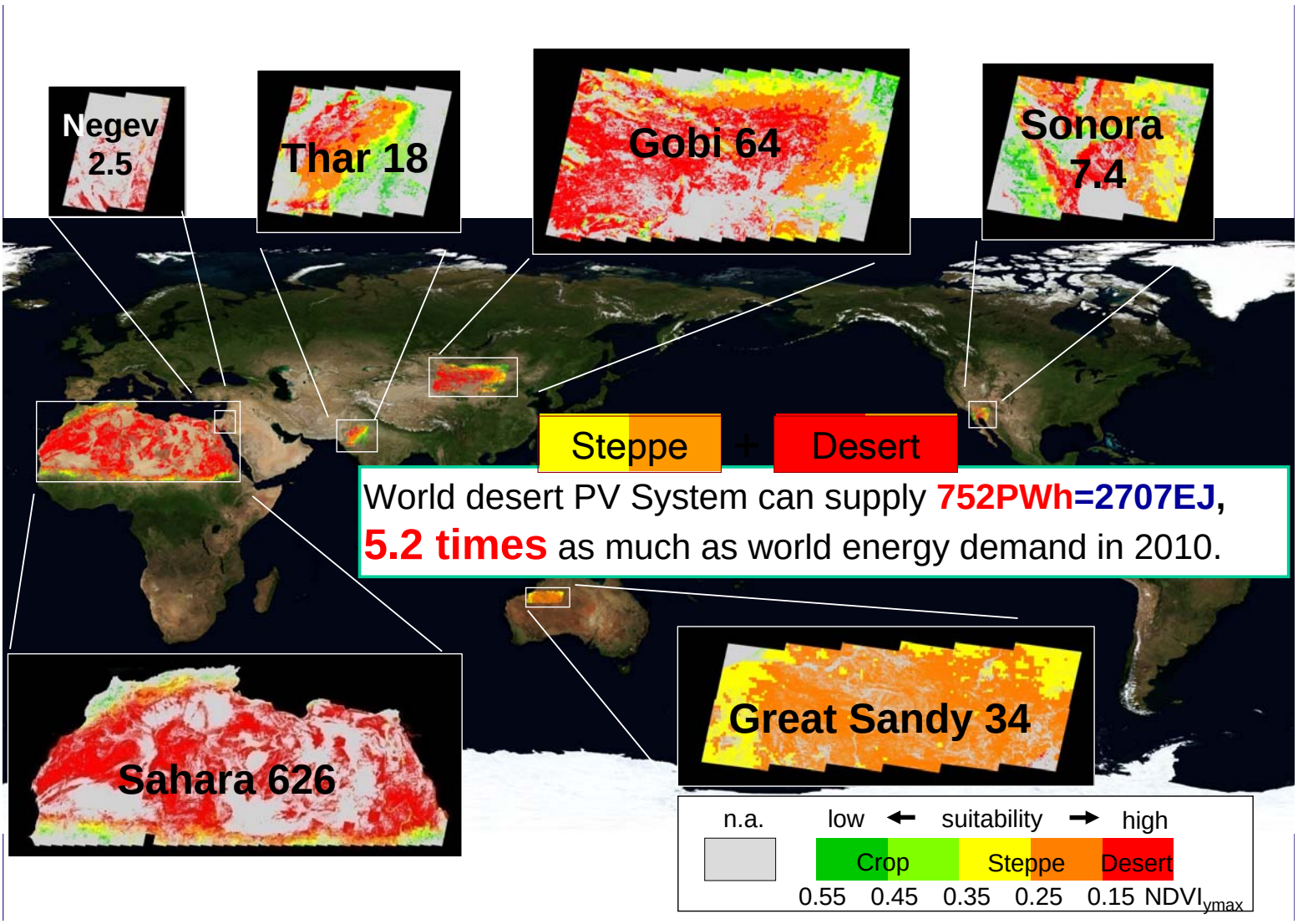




Steppe + Desert

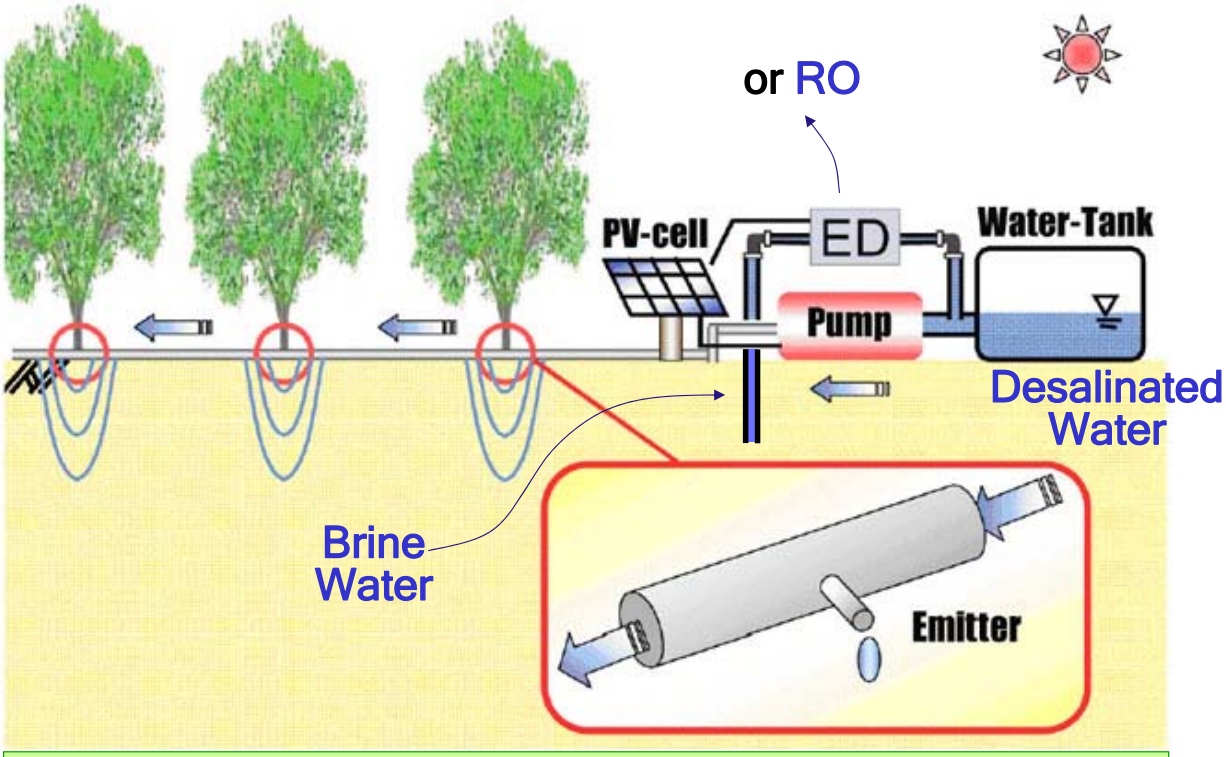
772 PWh

5.2 x as much as world energy demand in 2010 or 1.9 x in 2100


Negev 2.5
Thar 18
Gobi 64
Sonora 7.4
Steppe + Desert
World desert PV System can supply 752PWh=2707EJ,
5.2 times as much as world energy demand in 2010.
Great Sandy 34
Sahara 626
n.a.
low ← suitability → high
Crop
Steppe
Desert
0.55 0.45 0.35 0.25 0.15 NDVI$_{ymax}$

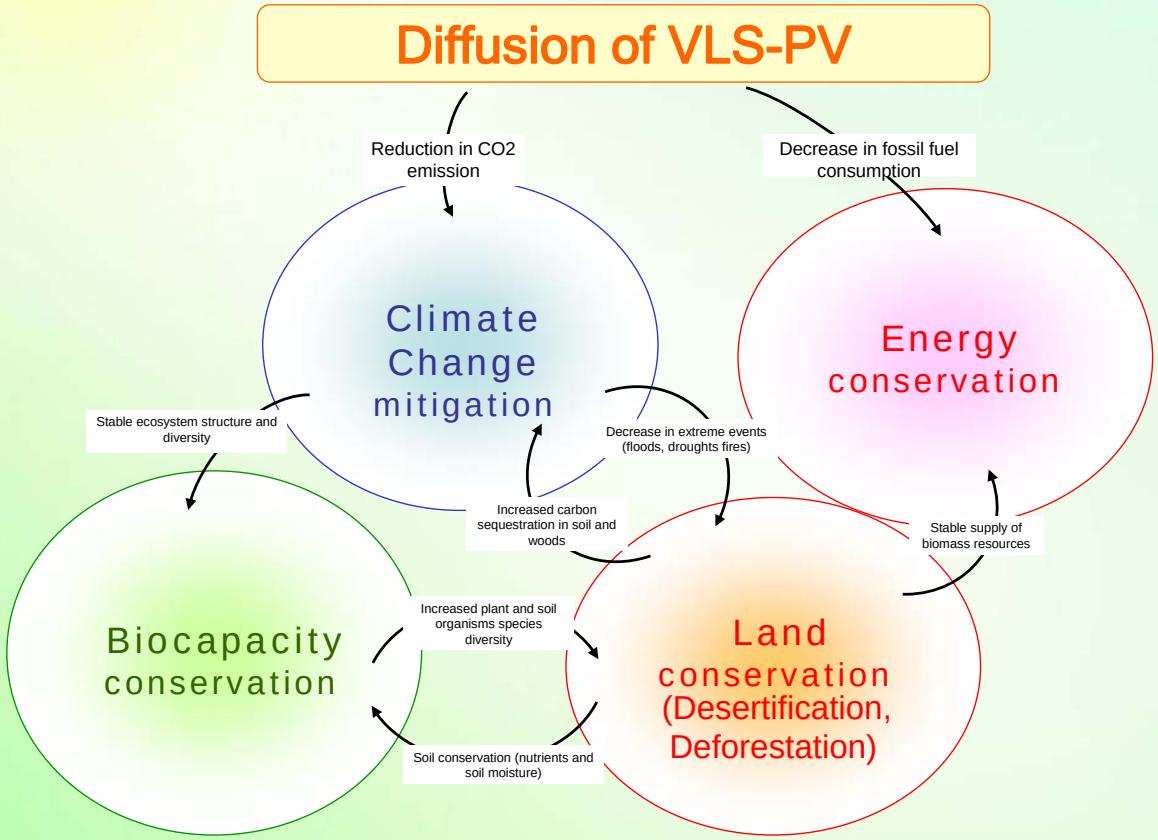

Careless Irrigation may cause soil degradation.
To assure sustainable agricultural development,
A New Approach comes .....
Agriculture in Sahara
- IRA, Tunisia -

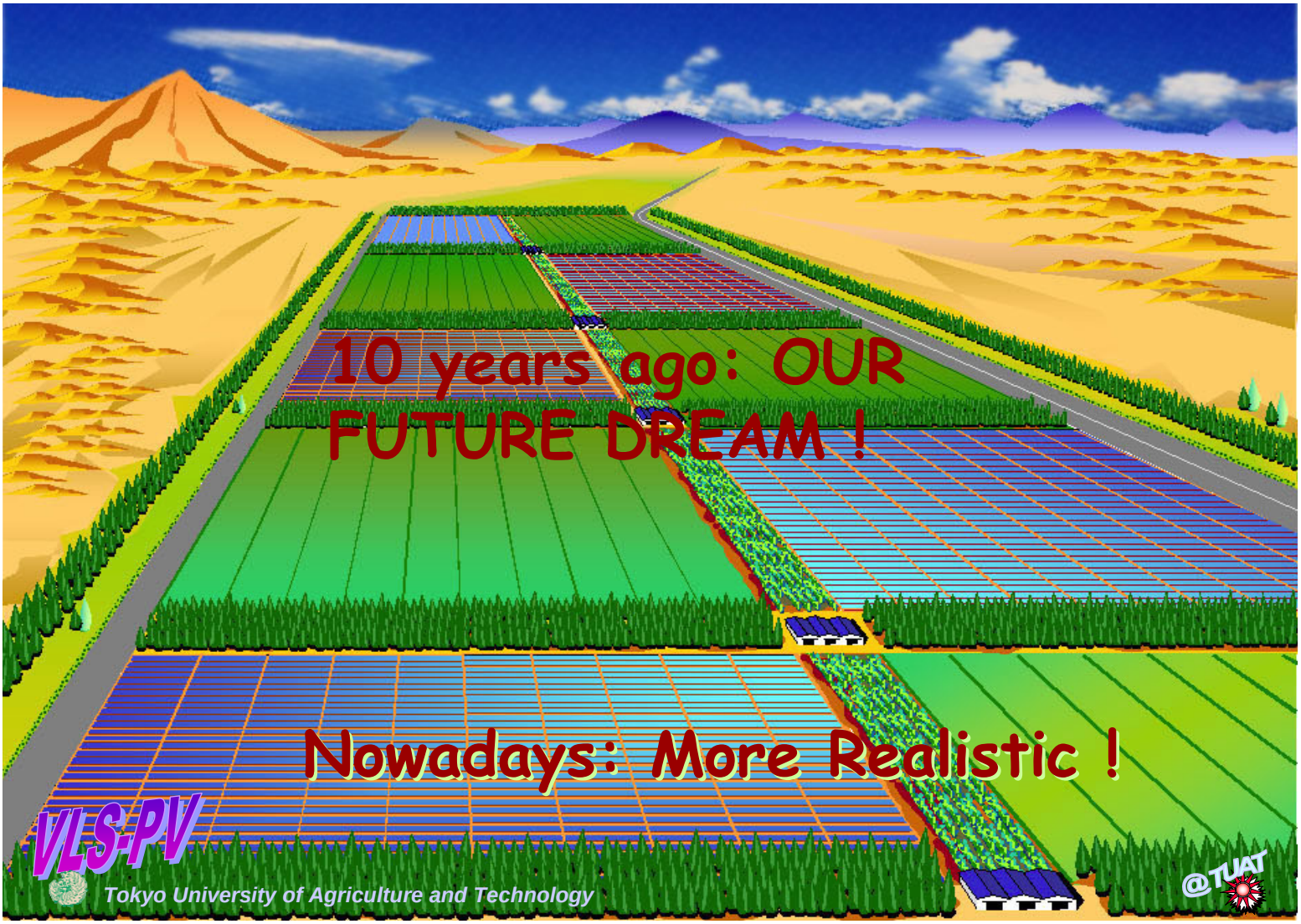
PV Power for Sustainable Agriculture in the Desert



Large Possibility: [PV + Agriculture]

PV Energy to develop Sustainable Community in the Desert Region



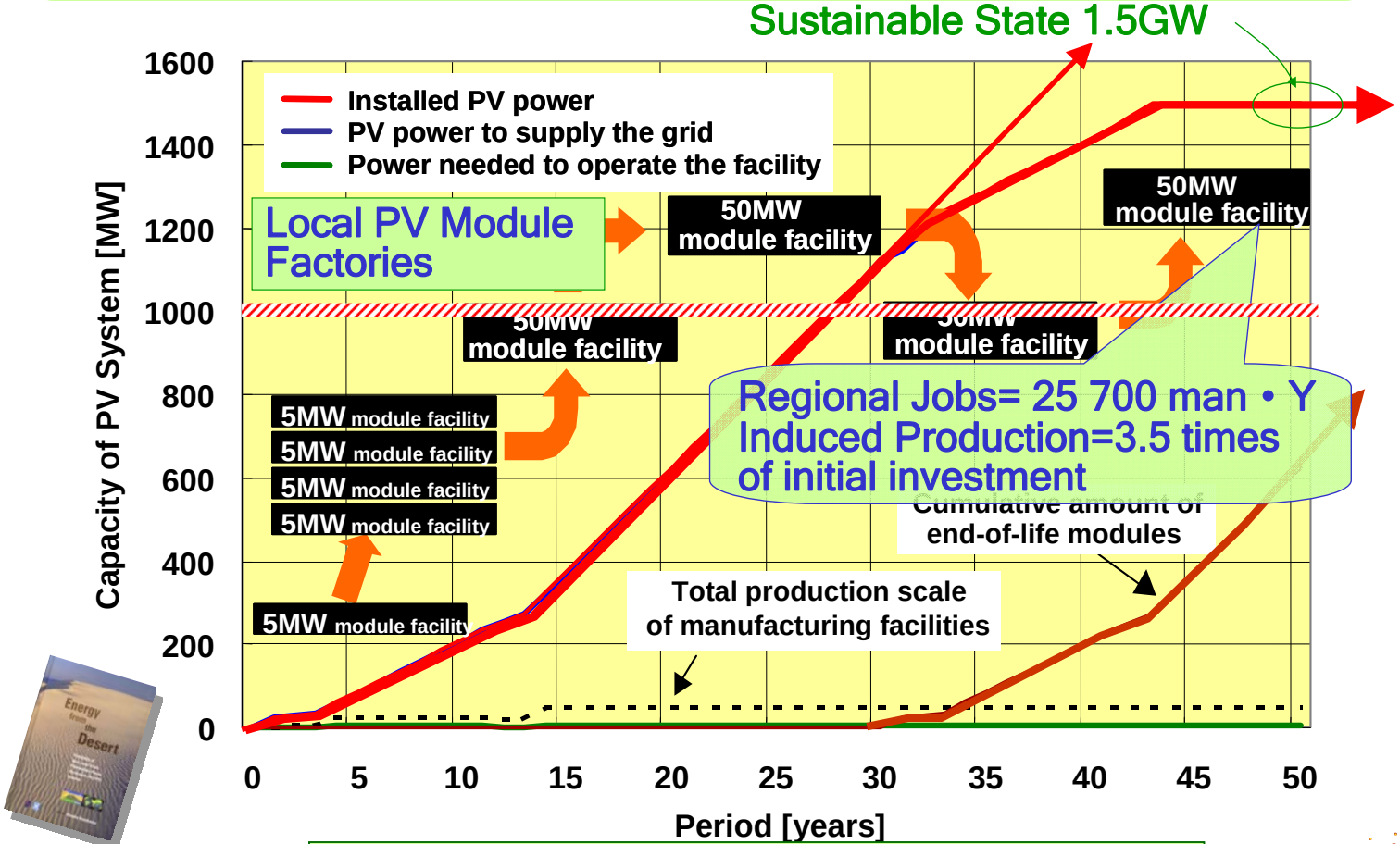

10 years ago: OUR FUTURE DREAM !
Nowadays: More Realistic !
VLS-PV
Tokyo University of Agriculture and Technology
@TUAT


60MW PV Plant: Olmedilla (Cuenca)
Presently World Largest PV Plant
08905

Super-Mega Solar

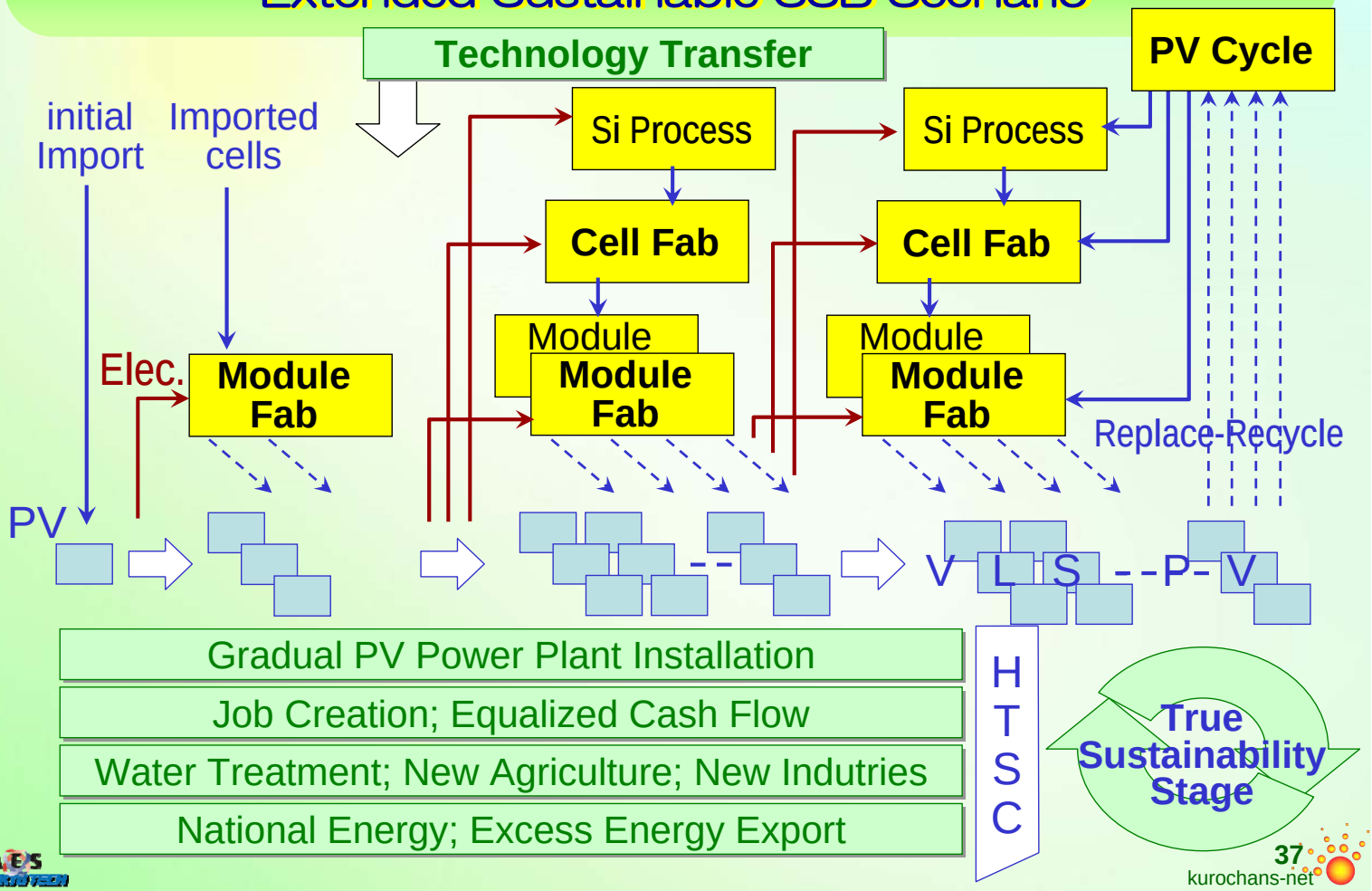
Sarnia 97 MW Plant, Ontario, Canada: World Largest PV（Dec. 2010）

Sustainable VLS-PV Development Concept

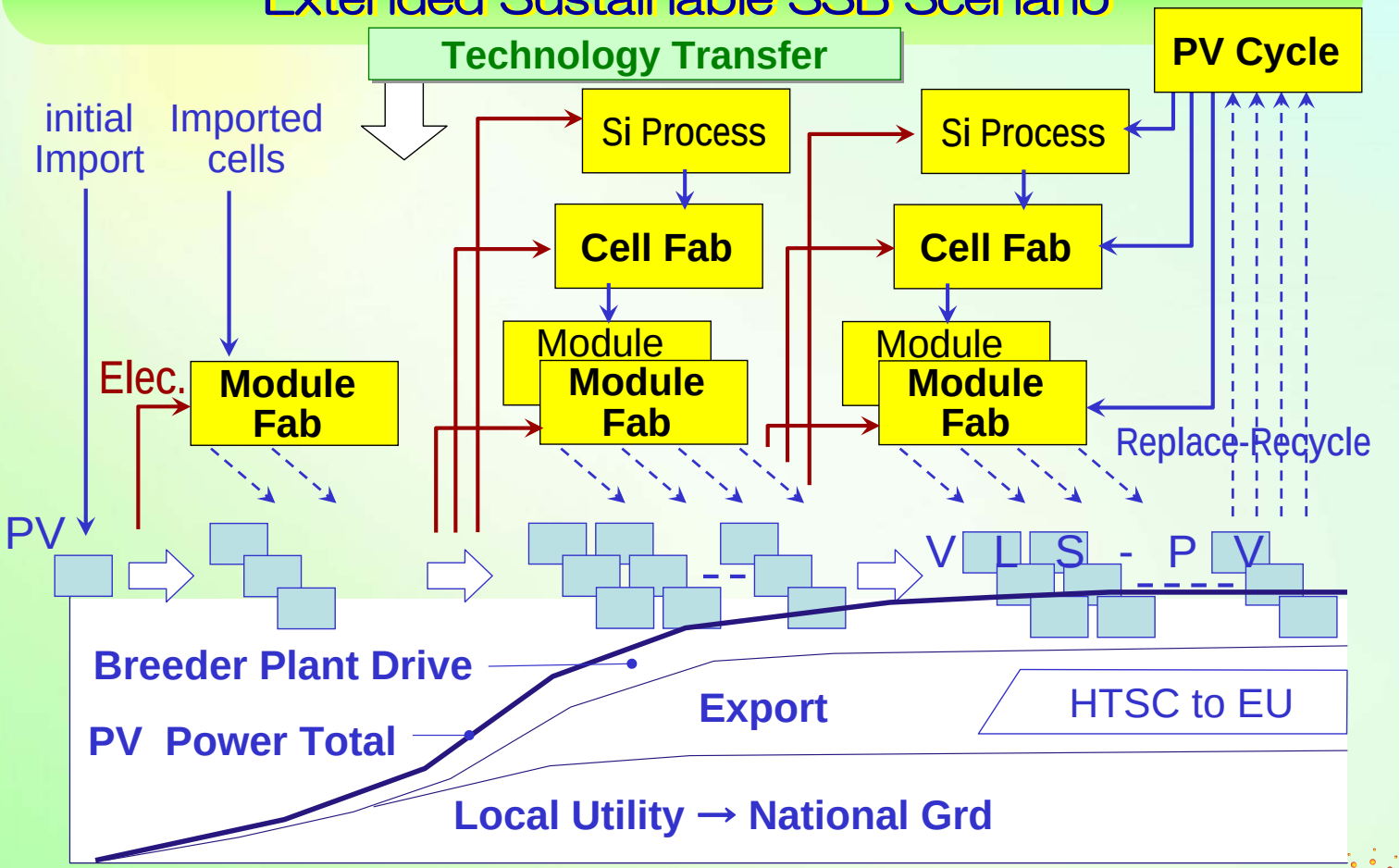


Lifetime: PV system=30yrs., facility=10yrs.

Extended Sustainable SSB Scenario



Extended Sustainable SSB Scenario



Industrial Structure

Si Feedstock

カーボン木材チップ → Metallurgy ← 電力

MG Si

水素精製エネ → Gass Purif.

還元剤 ガス類 水素 表面処理剤 → Purification ← 還元エネルギー

SOG Si

ルツボ 離型剤 不活性ガス → CZ / Cast ← 精製エネルギー 溶融等熱源 表面処理エネ

Wafer Quality

TF Quality

TCO/ITO glass → Wafer

原料ガス ドーパント 反射防止膜 導電材料 → PN / ARC / Contact ← 熱処理熱源 電極焼成等

Cell Quality

Cell

ハンダ インターコネクタ 表面板ガラス 透明接着シート 裏面保護シート 金属フレーム → Tabbing / Laminate ← ハンダ熱源 ラミネート熱源

Module Quality

Reliability

Module

Civil Work Q.

Q. Certification

Power Elerc.

Utility IF

Test Standard

Array Parts → Structure / Wiring ← マンパワー 機動力

BIPV Parts →

Array

On-site Testing

パワーデバイス IC部品 センサ計器 → Inverter

Utility IF →

電極材料 電解質 電池容器等 → Storage

System Integration ← マンパワー 機動力

Optimization

System

Sys.Evaluation

PV → SSB Technology Flow

Supply Chain with A Very Broad Base

Products

Process

Support Tech

Direct/Indirect Materials →

Energy Consumption - - →

..... →

Another Pass for Thin Film

Super-Mega Solar

Hokuto Mega-Solar Site, 19 AUG. 2011

Proposal for Algerian Colleagues

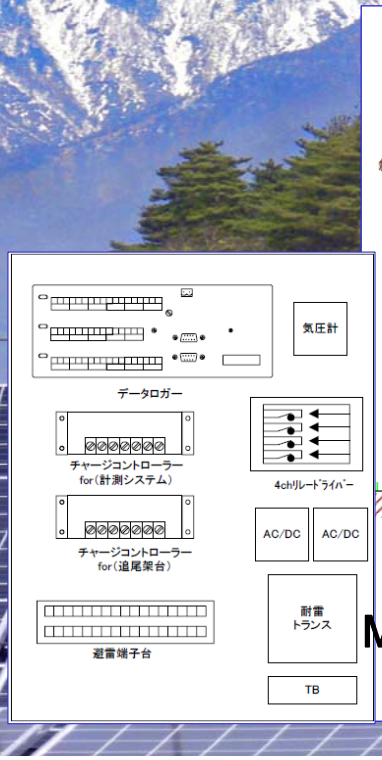
IV Curve Tracer and Scanners →

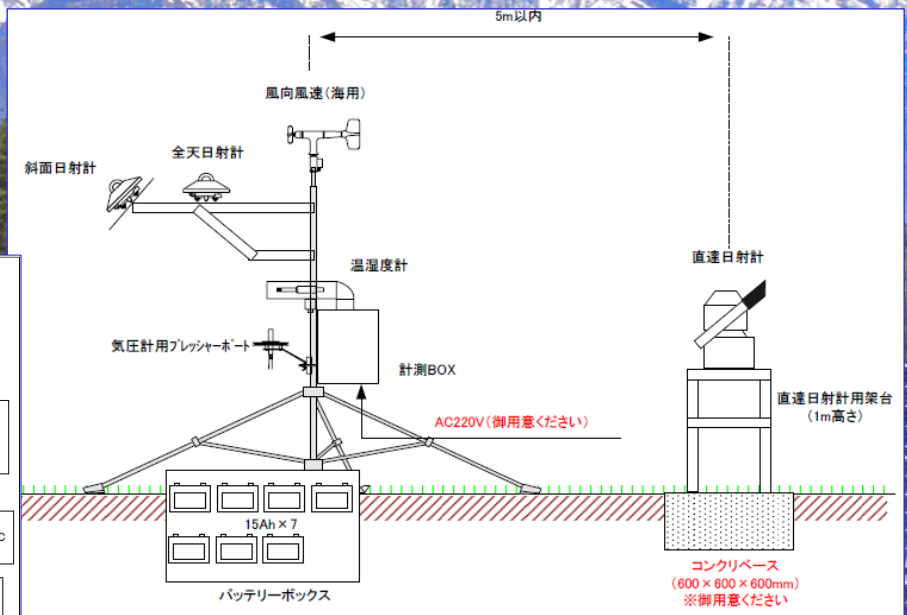
Intended Objective forthe1st Stage:
Better Understanding of PV Performance in Sub-Sahara; Higher Education; Training for regional PV System Integrators.

PV Module Test Bed

Hokuto Mega-Solar Site, 19 AUG. 2011

Proposal for Algerian Colleagues





Meteorological Monitoring (temporary)

○計測システム:3日間の停電に対応
ただし、直達日射は24時間停電に対応

SOLAR ENERGY

FOREVER and EVER!

PDF will be uploaded to

www.kurochans.net