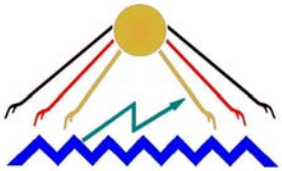


Solar Thermal Power Plants and Desalination Symposium- Cairo University

Nov 11th, 2007

Potential For Local Manufacturing of Solar Thermal Systems in Egypt

Prof. Adel Khalil

Vice Dean for Graduate Studies and Research

Faculty of Eng.- Cairo University

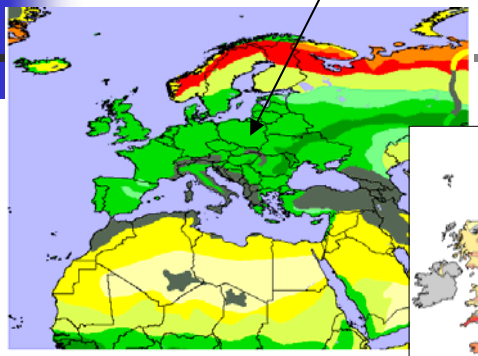
Scope

- Global, MENA and National Review of RE Technologies, Markets and Policies.
- Industrial survey of current and future potential for Manufacturing components and systems.
- Positioning of RE technologies
- Future scenario analysis
- Development strategy and action plan.
- Role of Research and Development

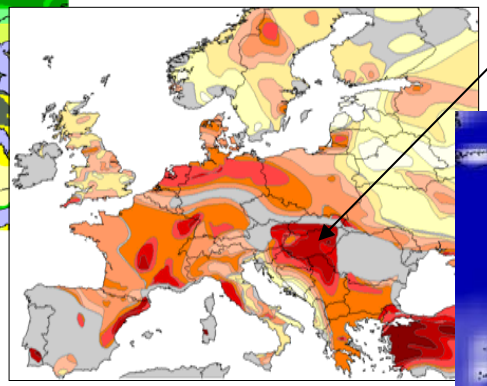
Renewable Energy Resources in EUMENA (DLR)

(Typical Yield in $GWh_{el}/km^2/y$)

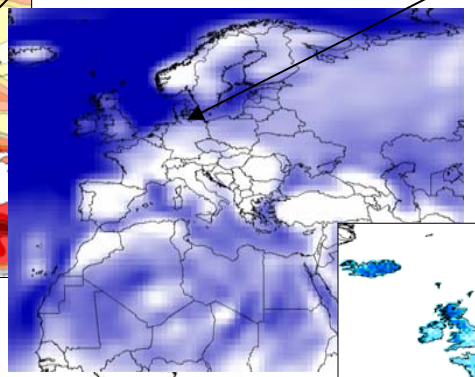
Biomass (1)



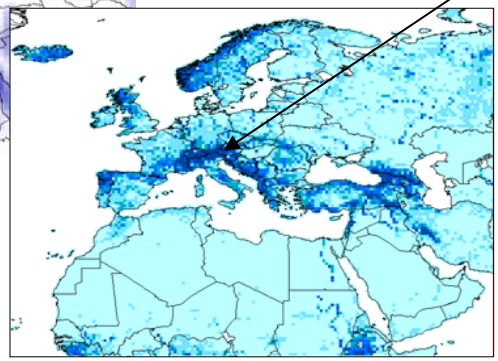
Geothermal Energy (1)

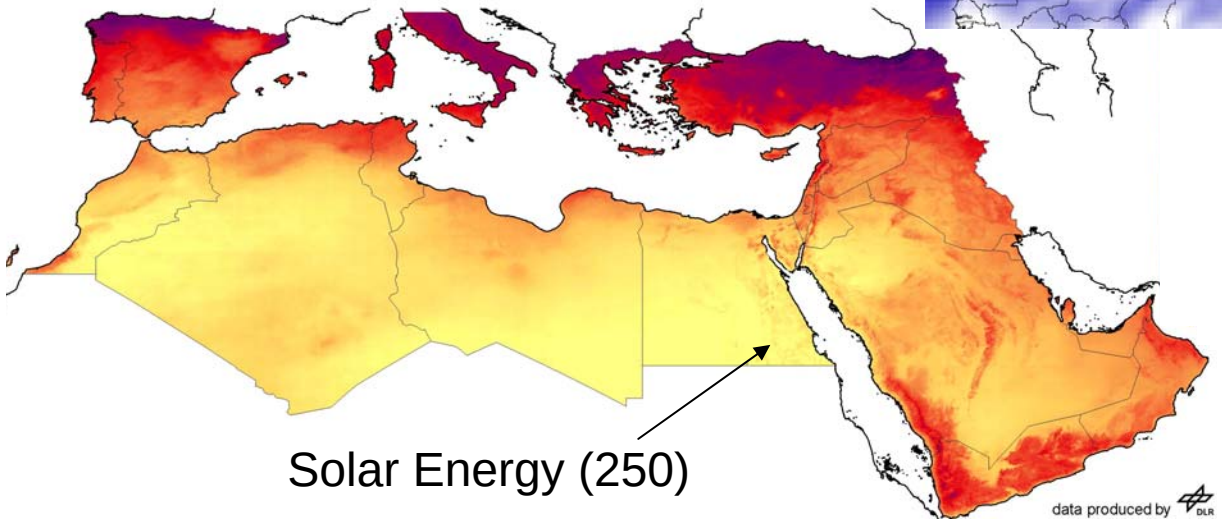


Wind Energy (30)



Hydropower (30)





Solar Energy (250)

Solar Energy Resource Assessment

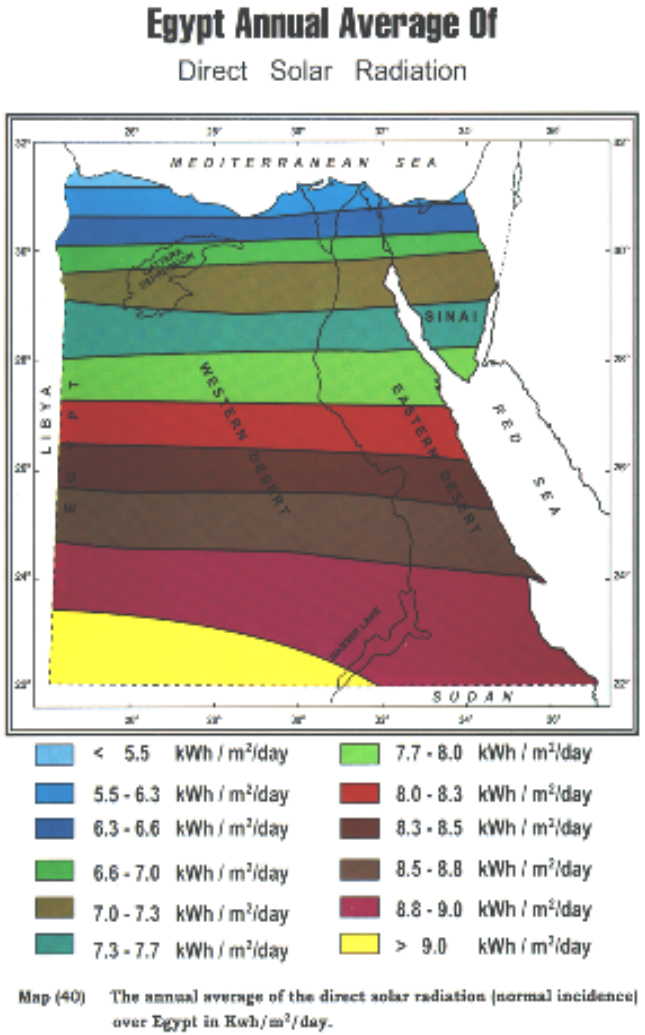
Egypt lies the sun belt area.

In 1991, Solar Atlas for Egypt was issued, concluding that:

1. **Direct Normal Irradiation ranges between 2000 KWh/m²/y at the North and 3200 KWh/m²/y at the South.**

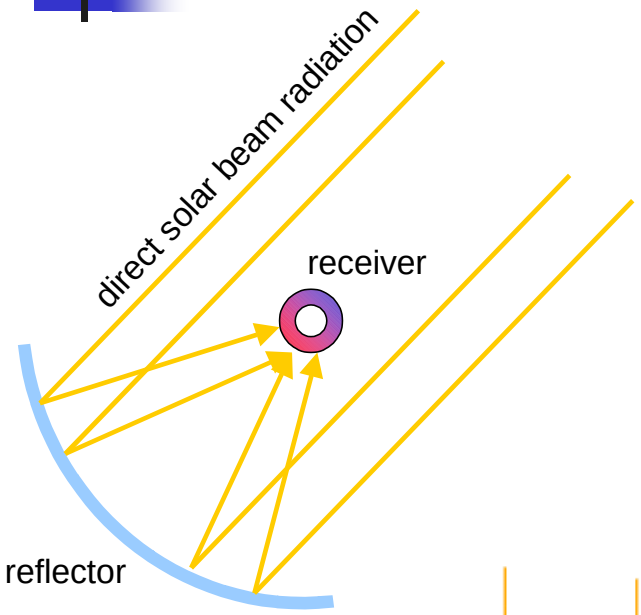
2. **The sun shine duration ranges between 9-11 h/day from North to South, with very few cloudy days.**

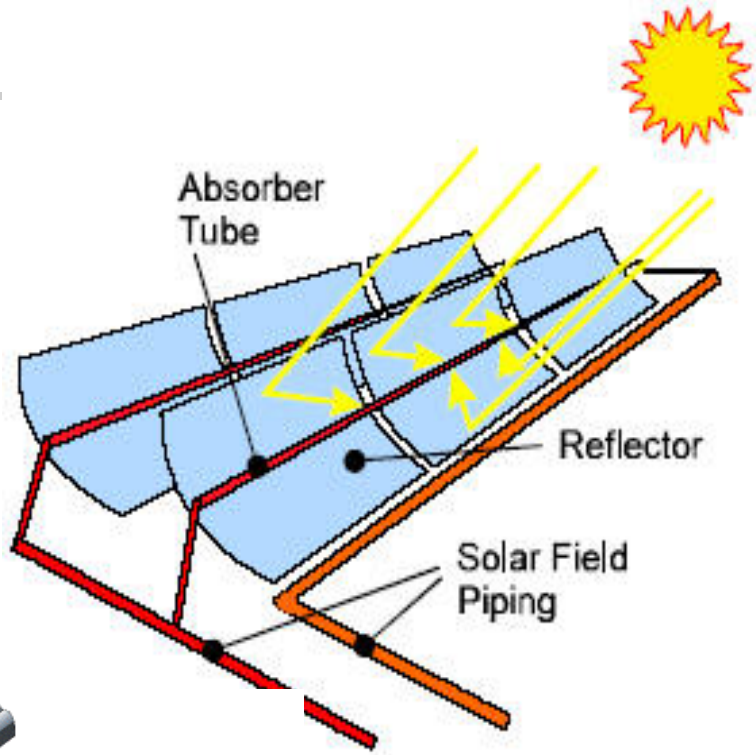
3. **Economic Potential 73656 TWh/Y**

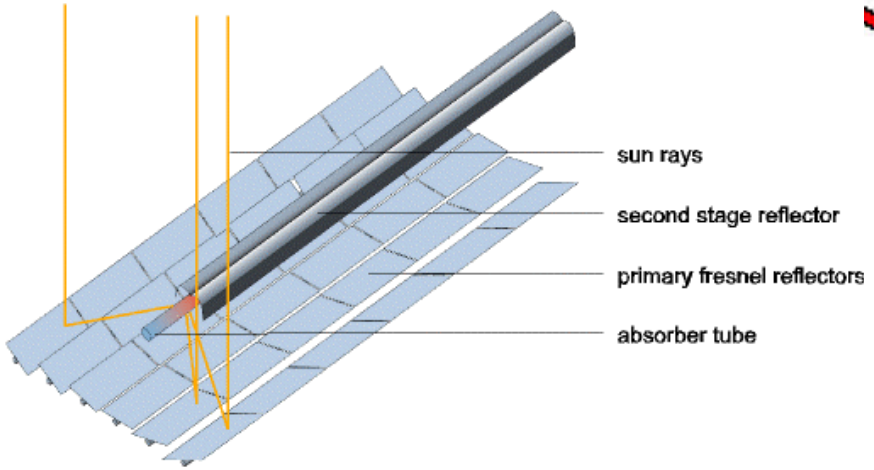


Map (40) The annual average of the direct solar radiation (normal incidence) over Egypt in Kwh/m²/day.

Solar Thermal Electricity Generation (CSP)



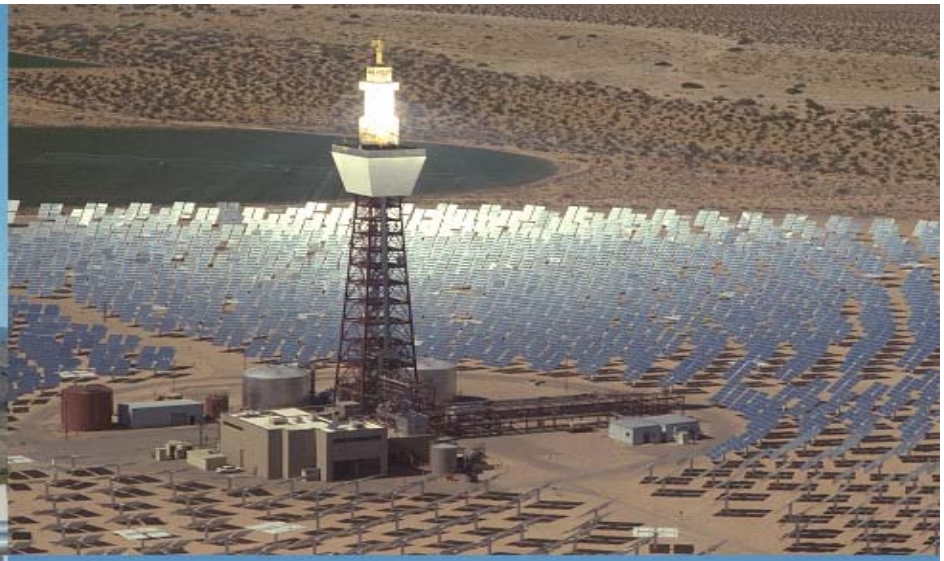




Concentrated Solar Power (CSP) Plants

parabolic trough (PSA)

solar tower (SNL)

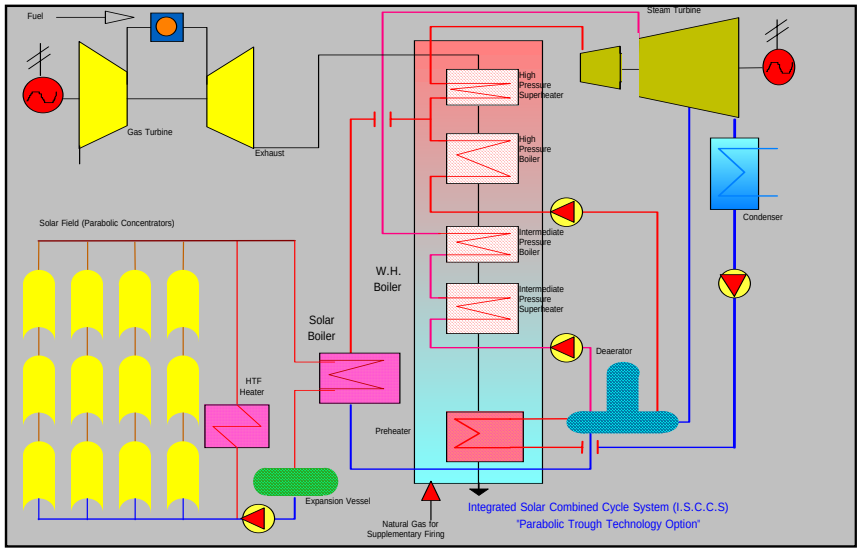


linear Fresnel (Solarmundo)

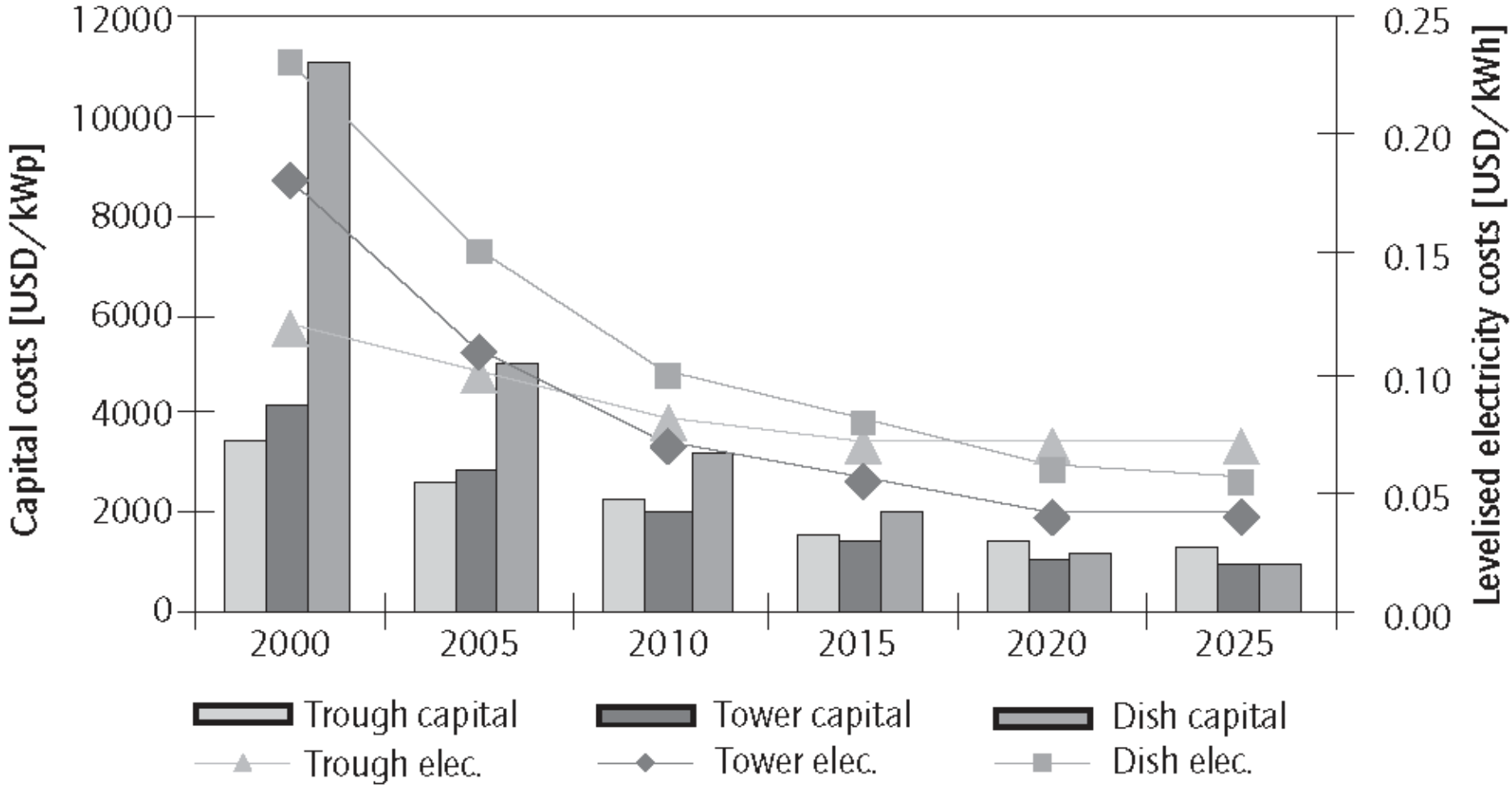
parabolic dish (SBP)

Concentrated Solar Power in Egypt

- A **CSP** experimental plant was built in Maadi-**Cairo** in **1913** by the American Inventor **Frank Shuman**. Five parabolic troughs (each 204 ft long and 13 ft wide), Steam was then produced and used to pump 6000 GPM of water. Oil was later discovered then, He wrote: “One thing I am sure of ; the human race should eventually either utilize solar energy directly or go back to pre-civilization”.
- Two pilot plants for industrial process heating (pharma-Textile..)
- Kuraymat plant will produce 150 MW using solar assisted combined cycle power plant (incremental cost paid by GEF). In contracting stage.



Forecast CSP Investment and Electricity Cost



Investment Learning Curve for Different RETs

Technology Summary Cost (kW/$)	2006	2010	2015	2020	2022
Wind Technology (WT)	1400	1200	1100	1000	900
CSP Technology	4500	4200	4000	3800	3200
Hydropower (HYP)	950	850	800	750	750
PV	6000	5500	5000	4300	4000

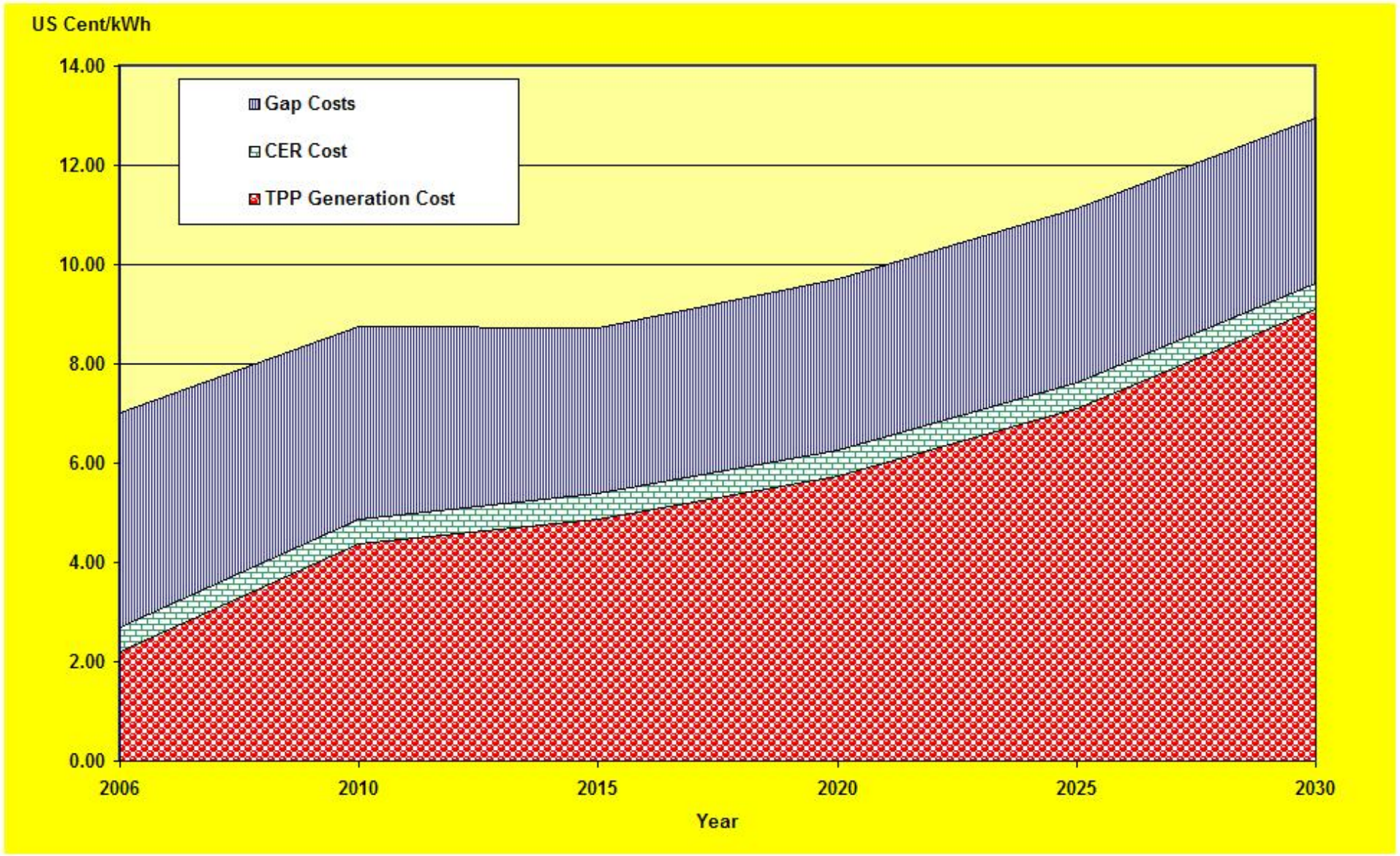
Costs and Characteristics of Renewable Energy Technologies (Source: IEA)

Technology (for Power Generation)	Typical Energy Costs Cents/kWh
Large hydro	3-4
Small hydro	4-7
On-Shore Wind	4-6
Off- shore Wind	6-10
Biomass Power	5-12
Geothermal Power	4-7
Solar PV	20-40
Solar Thermal (CSP)	12-18

Projected Gap in Fuel Prices – Reference Case, US$/million Btu

Fuel	Year					
	2006	2010	2015	2020	2025	2030
NG - Egypt	1.28	2.88	2.91	3.12	3.57	4.30
NG - World	6.06	7.19	6.60	6.93	7.47	7.98
NG - Gap	4.78	4.31	3.69	3.81	3.90	3.68
HFO - Egypt	2.13	2.98	3.01	3.22	3.69	4.44
HFO - World	3.25	3.37	3.45	3.56	3.62	3.90
HFO - Gap	1.12	0.39	0.44	0.34	(0.07)	(0.54)
LFO - Egypt	3.56	5.17	5.23	5.60	6.41	7.72
LFO - World	13.20	13.69	14.01	14.46	14.70	15.84
LFO - Gap	9.64	8.51	8.78	8.85	8.29	8.12

Projected Power Generation Costs and Loss in Revenues from CER and Gap Costs



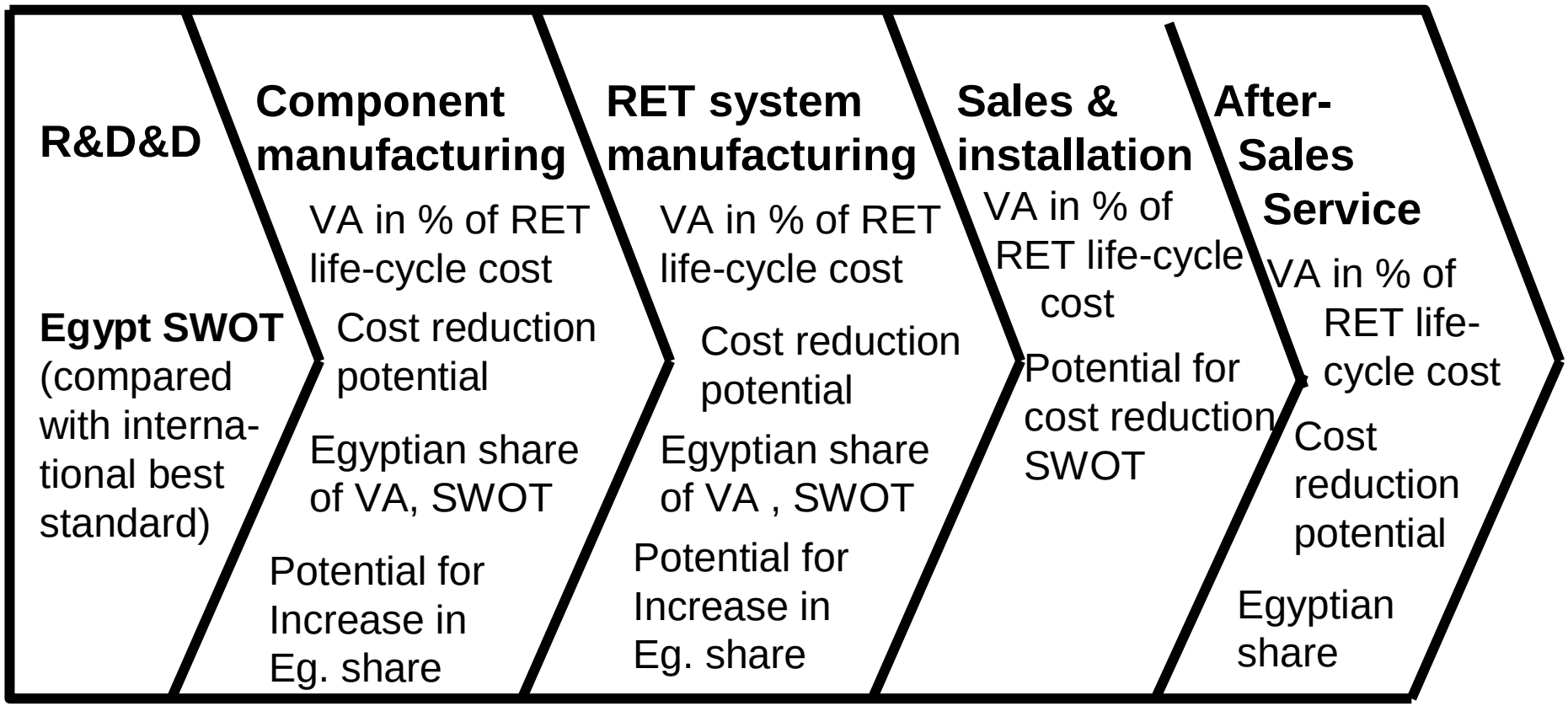
Potential of Egyptian Industry for RE Local Manufacturing

A) Local manufacturing

B) Research and Development needed

C) Technology Transfer/Joint Ventures/Import

Value Chain Analysis



Concentrated Solar Power (CSP)
a) Parabolic Trough

Component	A	B	C
Reflector material and glass		X	X
Vacuum and absorber tube		X	X
Rotary Joints		X	X
Step Motor	X	X	
Steel structure	X		
Sun tracking system		X	X
Control system		X	X
Piping	X	X	
Auxiliaries	X	X	
Trough cleaning system		X	X
Operation and maintenance	X	X	

Concentrated Solar Power (CSP)

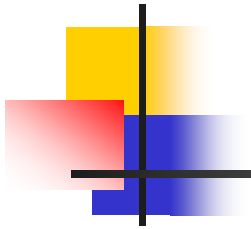
b) Fresnel Collector (Flat mirrors)

Component	A	B	C
Flat mirrors and surface quality	X	X	
Step Motor	X	X	
Steel structure	X		
Sun tracking system		X	X
Control system		X	X
Piping	X	X	
Auxiliaries	X	X	
Cleaning system	X	X	
Operation and maintenance	X	X	

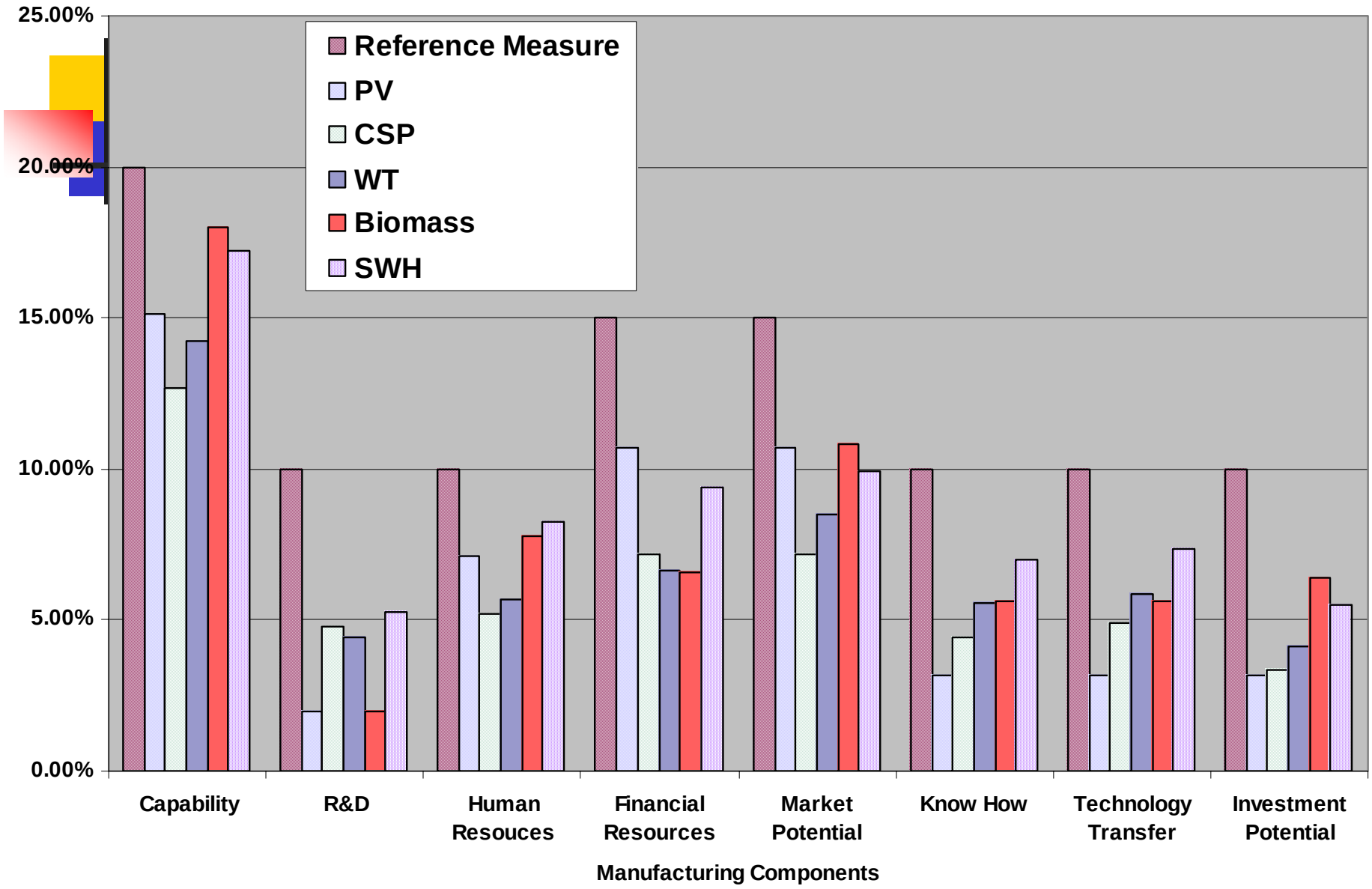
Potential Share of Local Manufacturing

Technology	Reactive Policy	Pro-active Policy
Wind energy	40%	60%
Solar water heaters	70%	95%
Photovoltaic systems	20%	30%
Biomass	50%	95%
Concentrated solar power	30%	50%

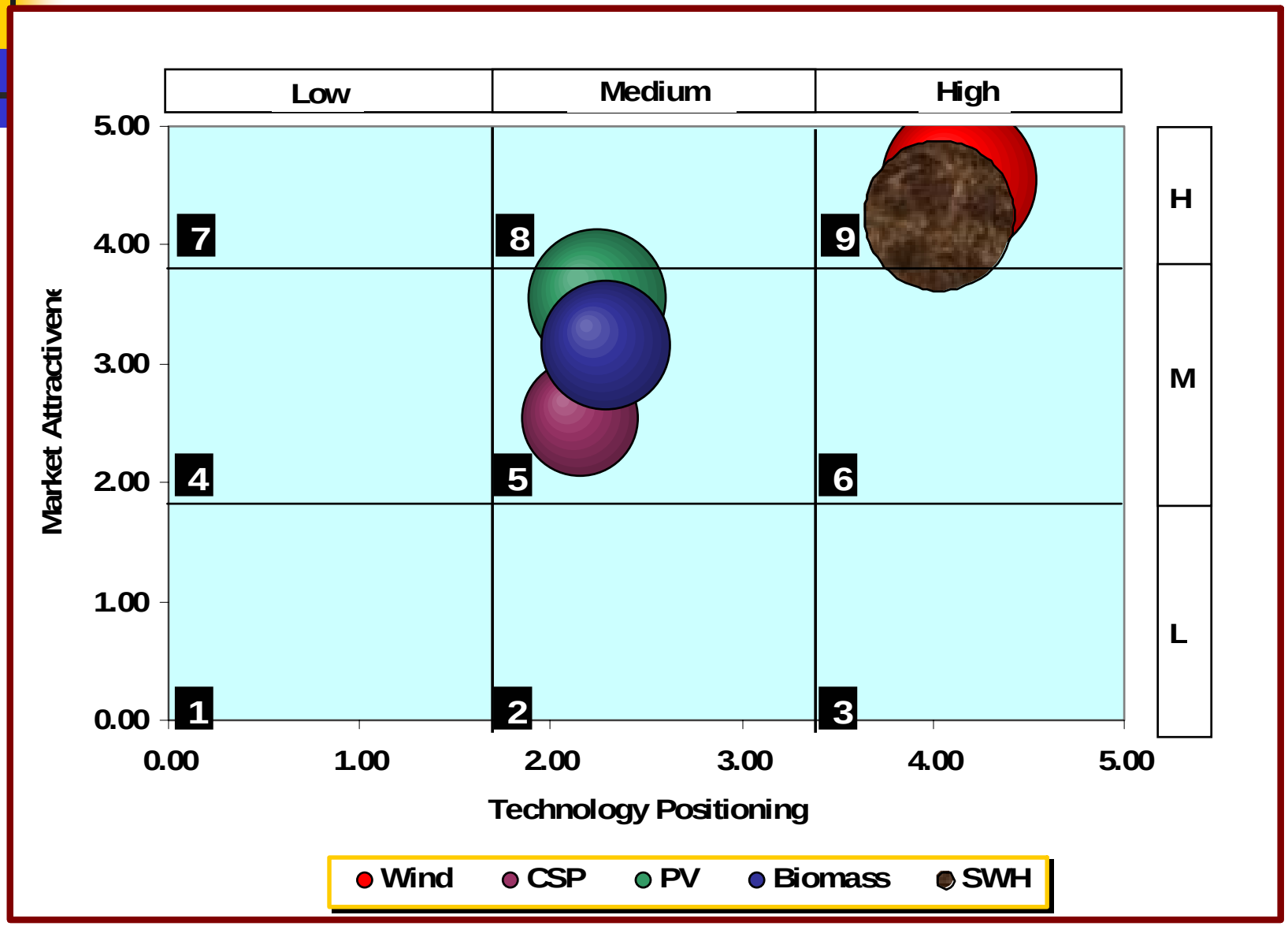
POSITIONING OF RE TECHNOLOGIES (factors affecting positioning)



1. Average annual growth rate & size
2. Value Added for industry
3. Competition Strength
4. Technology requirements
5. Technology perspective future
6. Technology Maturity
7. Environmental impacts
8. Technology Provisions
9. Implementation Satisfaction


25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Reference Measure
PV
CSP
WT
Biomass
SWH
Capability
R&D
Human Resouces
Financial Resources
Market Potential
Know How
Technology Transfer
Investment Potential
Manufacturing Components

Positioning of Renewable Energy Technologies in Egypt



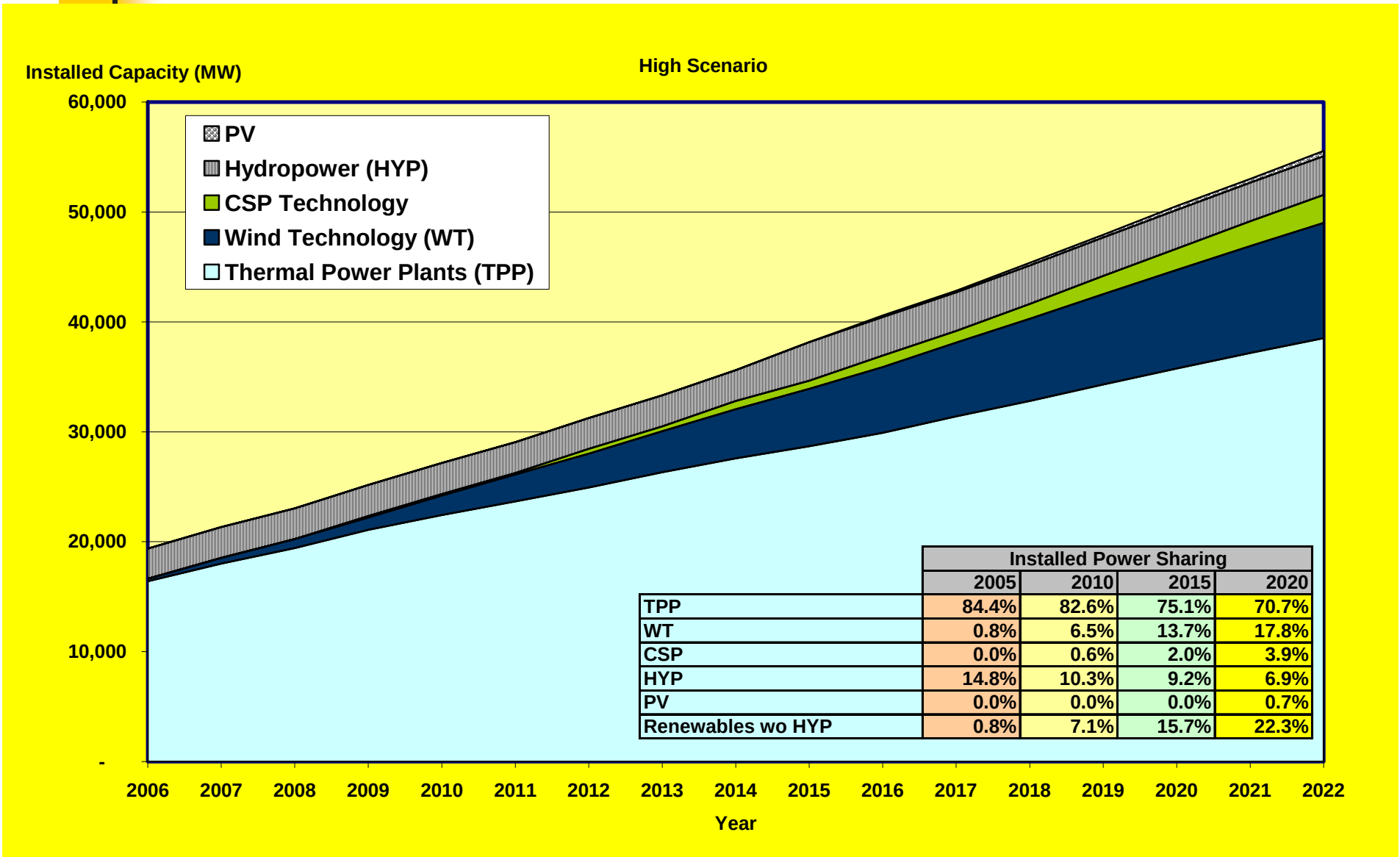
SCENARIO ANALYSIS

- Reference scenario (liberated fuel cost)
- Low scenario (MOEE Plan)
- Med. scenario (RE: 15.5% of inst. Electric power and 10.8% of Elect. Energy Generation by 2022)
- High scenario (RE: 22.3% of inst. Electric power and 16 % of Elect. Energy Generation by 2022)

Scenarios can also be classified as

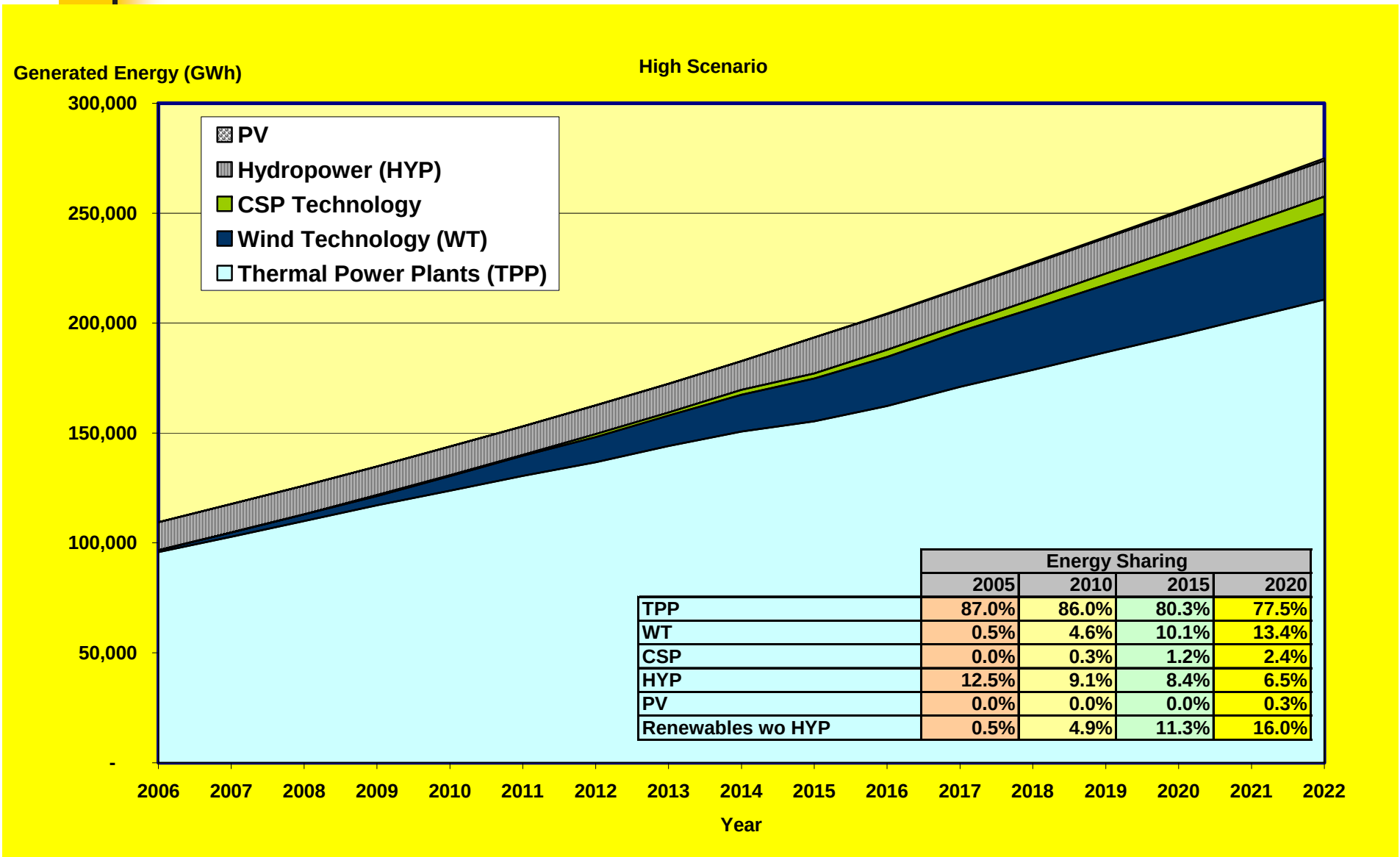
- Reactive scenario (business as usual)
- Proactive Scenario

Power Generation Needs and Recommended Energy Technologies – High Scenario



Installed Power Sharing	2005	2010	2015	2020
TPP	84.4%	82.6%	75.1%	70.7%
WT	0.8%	6.5%	13.7%	17.8%
CSP	0.0%	0.6%	2.0%	3.9%
HYP	14.8%	10.3%	9.2%	6.9%
PV	0.0%	0.0%	0.0%	0.7%
Renewables wo HYP	0.8%	7.1%	15.7%	22.3%

Energy Generation Needs and Recommended Energy Technologies – High Scenario

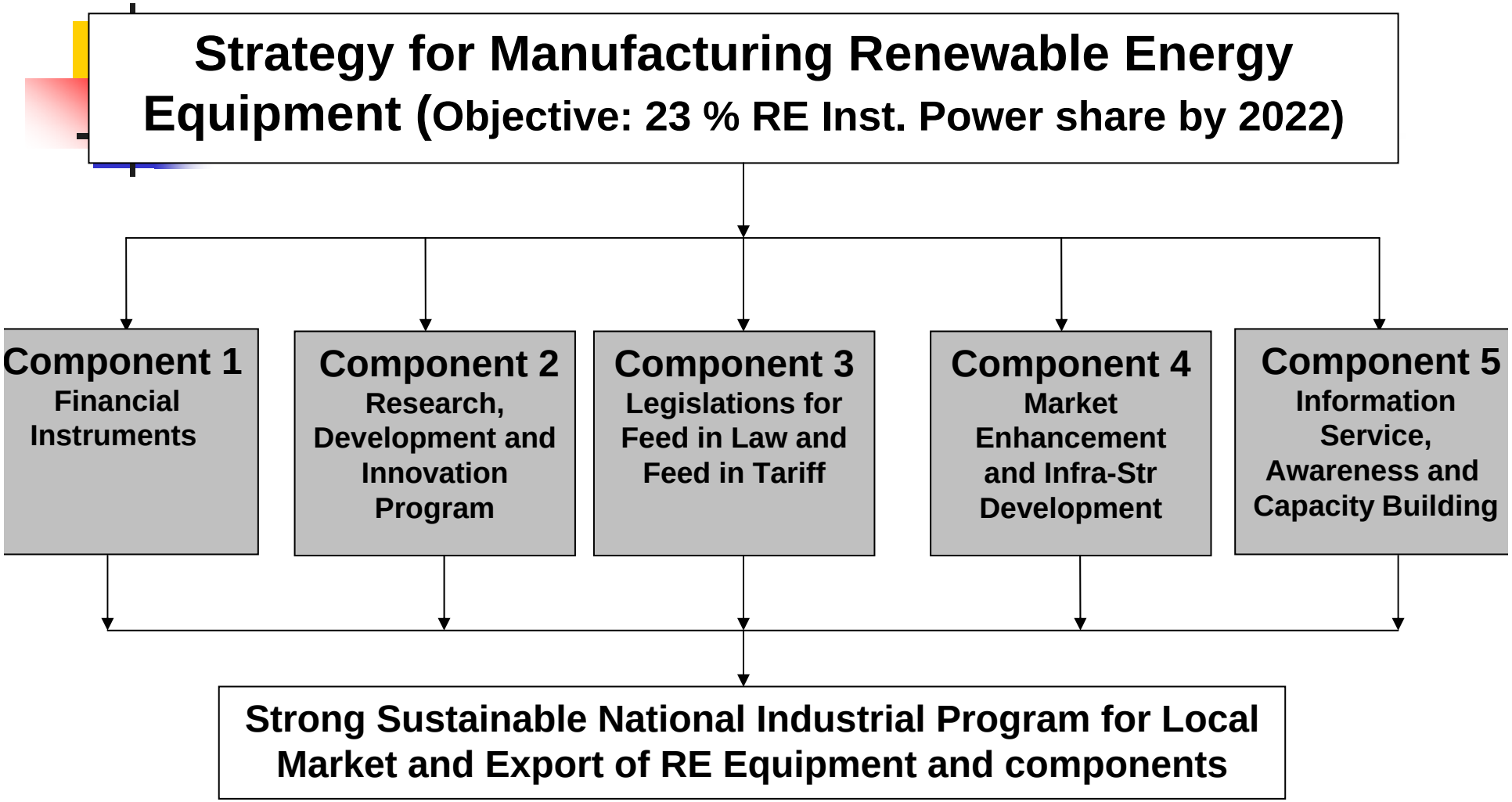


	Energy Sharing			
	2005	2010	2015	2020
TPP	87.0%	86.0%	80.3%	77.5%
WT	0.5%	4.6%	10.1%	13.4%
CSP	0.0%	0.3%	1.2%	2.4%
HYP	12.5%	9.1%	8.4%	6.5%
PV	0.0%	0.0%	0.0%	0.3%
Renewables wo HYP	0.5%	4.9%	11.3%	16.0%

Development strategy targets

To achieve 22 %RE target by 2022, a proactive policy to promote RET should be adopted.

- Installation of 10335 MW of wind Energy (WE).
- Installation of 2550 MW of concentrated solar power (CSP).
- Installation of 500 MW photovoltaic (PV) arrays.
- Installation of 1.2 million sq.m of solar water heaters (SWH).
- Saving of 4 million ton oil equivalent by utilizing biomass.
- Acquiring 0.5 % share of European Union RET market by 2012 which Represents 0.625 billion US $ manufactured components of RE systems.
- These estimates are based on the high RET scenario and the EU RET market of 100 billion Euros.


Strategy for Manufacturing Renewable Energy Equipment (Objective: 23 % RE Inst. Power share by 2022)
Component 1
Financial Instruments
Component 2
Research, Development and Innovation Program
Component 3
Legislations for Feed in Law and Feed in Tariff
Component 4
Market Enhancement and Infra-Str Development
Component 5
Information Service, Awareness and Capacity Building
Strong Sustainable National Industrial Program for Local Market and Export of RE Equipment and components

Local Manufacturing Investment, R&D, and Market Volume for CSP Technology (million US$)

Scenario	CSP	2006-2010	2011-2015	2016-2022	Total
High	Market Volume	636	2,419	6,611	9665.625
	Share of Local Manufacturing	50%	60%	70%	
	Investment in Manufacturing Processes	212	762	2,343	3,316
	R&D Investment	7	27	82	116
Medium	Market Volume	636	1,209	4,324	6,169
	Share of Local Manufacturing	50%	60%	70%	
	Investment in Manufacturing Processes	212	275	1,755	2,242
	R&D Investment	7	10	61	78
Low	Market Volume	636	-	2,314	2,949
	Share of Local Manufacturing	50%	60%	70%	
	Investment in Manufacturing Processes	212	-	875	1,086
	R&D Investment	7	-	31	38

Projected Additional Revenues Due to RETs Implementation in Power Generation – High Scenario (million US$)

Year		2006-2010	2011-2015	2016-2022
CER Costs	WT	60	290	902
	CSP	4	33	155
	HYP	5	20	105
	PV	-	-	19
	Total	69	344	1,180
	Annual Average			**94**
Gap Costs	WT	581	2,461	7,164
	CSP	38	283	1,231
	HYP	48	170	835
	PV	-	-	148
	Total	667	2,914	9,378
	Annual Average			**762**

Removal of Barriers To Rets Implementation In Egypt

- Economic & financial barriers,
- Awareness & information barriers
- Technical barriers
- Market barriers
- Social barriers
- Institutional & policy barriers

Financial Instruments

- Soft Loans
- Commercial loans
- Revenue bonds
- Ownership certificate
- Developing RE Projects as CDM-Projects
- RE fund

Financial Assumptions

- Loan Interest Rate % = 14.00%
- Cost of Capital % = 7.00%
- Loan Repayment Period = 10.00
- Escalation Rate % - Manpower and Spare Parts = 7%
- Technology Average Life Time (years) = 25

Projected Energy Generated Costs based on Soft Loan Alternative (US$/kWh)

Loan Scenario					
	Debt	50.00%	Equity	50.00%	
	2006	2010	2015	2020	2022
WT	0.0405	0.0348	0.0319	0.0284	0.0256
CSP	0.1610	0.1562	0.1492	0.1403	0.1207
PV	0.2757	0.2529	0.2299	0.1949	0.1813
Hydro	0.0245	0.0220	0.0207	0.0189	0.0189

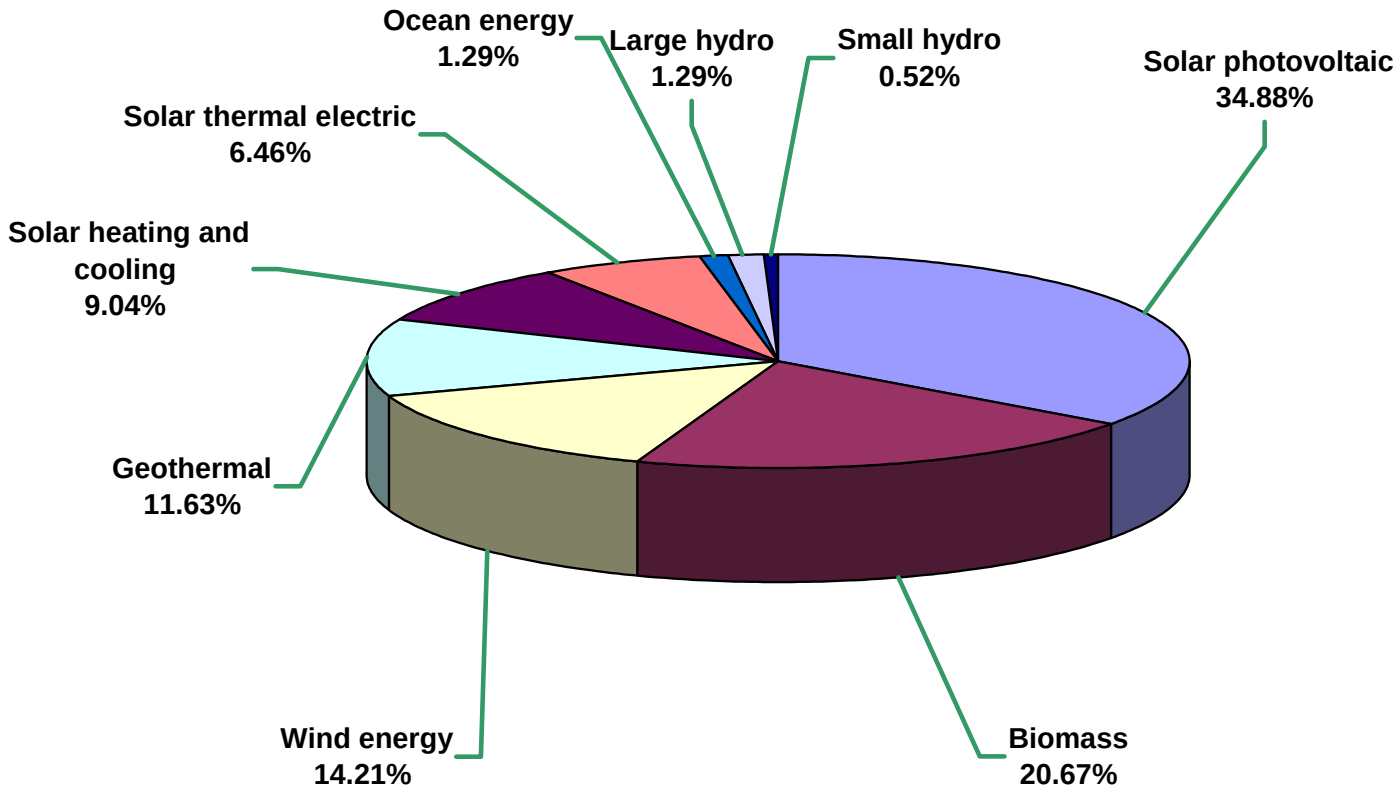
Projected Energy Generated Costs based on Grant Alternative (US$/kWh)

Grant Scenario					
	Grant	35.00%	Equity	65.00%	
	2006	2010	2015	2020	2022
WT	0.0310	0.0266	0.0244	0.0216	0.0195
CSP	0.1236	0.1213	0.1160	0.1087	0.0942
PV	0.2060	0.1889	0.1717	0.1449	0.1348
Hydro	0.0193	0.0173	0.0163	0.0148	0.0148

Innovation R&D program

- Fostering Innovation Culture
- Establishing A Framework Conductive To Innovation
- Gearing Research To Innovation
- Establishing a center of excellence for RET
- National research plan including solutions to problems facing the five selected RETs

Distribution of R&D Budget in Renewables According to Each Technology (Source: IEA)



Tailored Legislation

Objective: The creation of a legal, institutional and incentive framework to stimulate and support large scale annual investments in RE in fulfillment of Government policy objectives for the energy sector:

Scope:

- **Feed-in Law and Feed in Tariff in order to secure the RET market**
- **Liberation of fuel prices**
- **Removal/reduction of taxes and duties**
- **RE Incentives**

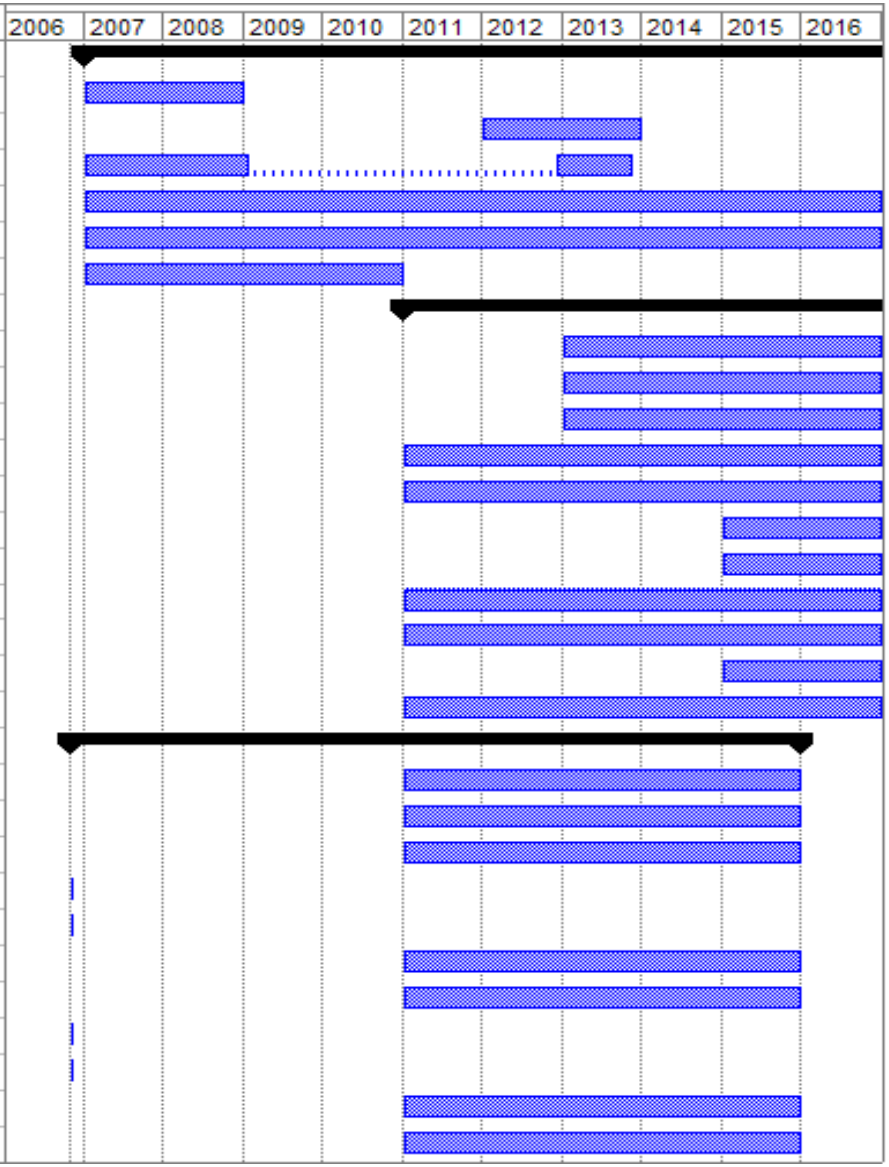
Information Service, Awareness and Capacity Building Program

Awareness and promotion programs such as:

- demonstrations of systems,
- brochures,
- training courses,
- Workshops, seminars and presentations for targeted users.
- School/University educational materials

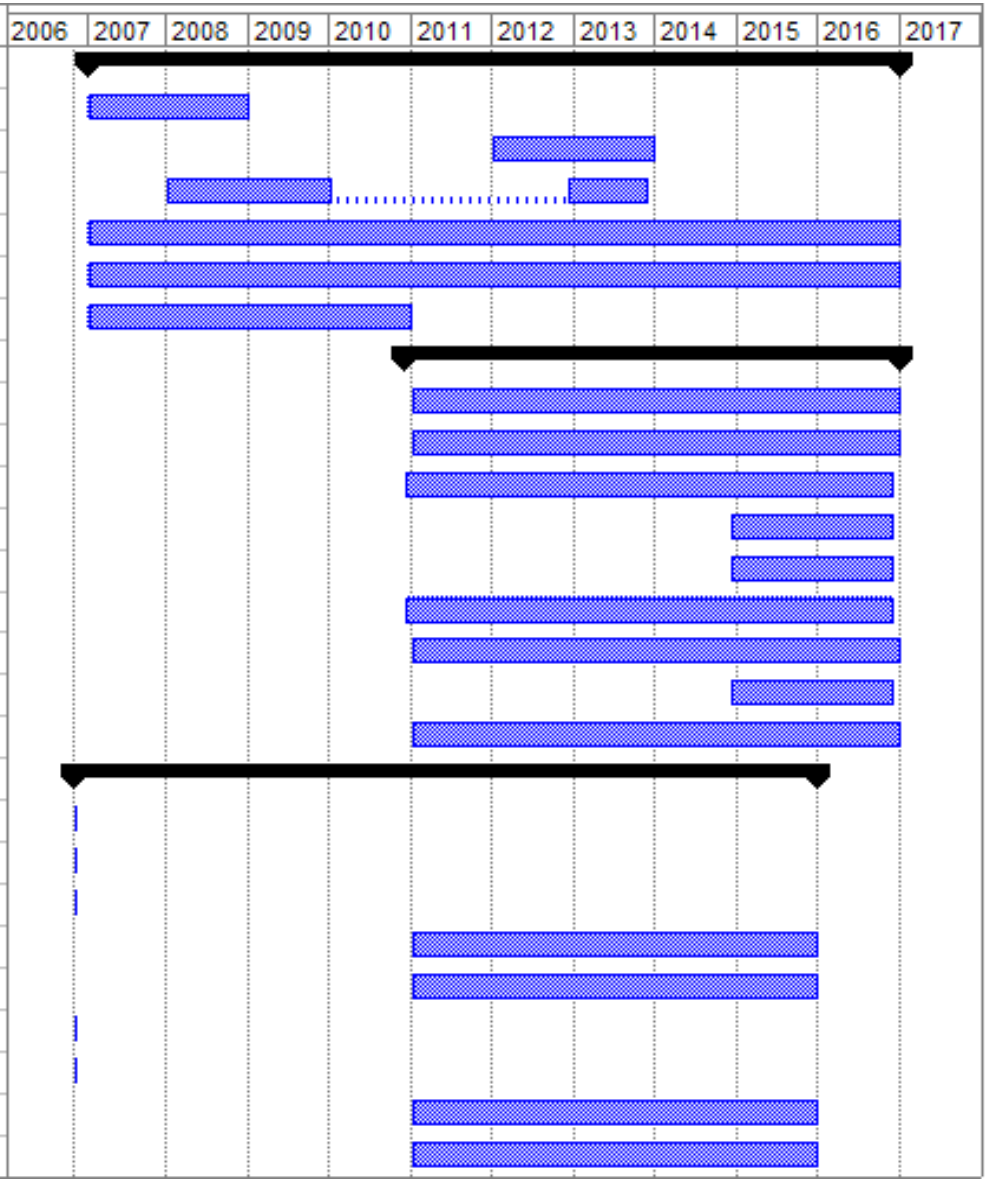
Action Plan for Concentrated Solar Power – Parabolic Trough

ID	Task Name
1	**Activity/Component**
2	Policy Setup
3	Policy Review
4	Laws and Regulations
5	Awareness and Promotion
6	Education and Training
7	Prototype manufacturing & learning
8	**Local Manufacturing (with continuous Inn. and R&D)**
9	Reflector material and glass
10	Vacuum and absorber tube
11	Rotary Joints
12	Step Motor
13	Steel structure
14	Sun tracking system
15	Control system
16	Piping
17	Auxiliaries
18	Trough cleaning system
19	Operation and maintenance
20	**Import/ Joint Venture (with know-how transfer)**
21	Reflector material and glass
22	Vacuum and absorber tube
23	Rotary Joints
24	Step Motor
25	Steel structure
26	Sun tracking system
27	Control system
28	Piping
29	Auxiliaries
30	Trough cleaning system
31	Operation and maintenance



Action Plan for CSP – Fresnel Collector (Flat Mirrors)

ID	Task Name
1	**Activity/Component**
2	Policy Setup
3	Policy Review
4	Laws and Regulations
5	Awareness and Promotion
6	Education and Training
7	prototype manufacturing & learning
8	**Local Manufacturing (with continuous Inn. and R&D)**
9	Flat mirrors and surface quality
10	Step Motor
11	Steel structure
12	Sun tracking system
13	Control system
14	Piping
15	Auxiliaries
16	Cleaning system
17	Operation and maintenance
18	**Import/ Joint Venture (with know-how transfer)**
19	Flat mirrors and surface quality
20	Step Motor
21	Steel structure
22	Sun tracking system
23	Control system
24	Piping
25	Auxiliaries
26	Cleaning system
27	Operation and maintenance



RENEWABLE ENERGY FUND

- This fund can cover the gap between RE feed in tariff and the average price of generated electricity by thermal power plants.
- The RE fund could finance R&D for RETs' systems and their components design for local manufacturing activities.
- Cost savings resulting from electricity generation by hydropower plants as compared to thermal power plants, could also finance the deficit for feed in tariff and R&D for RETs if any.

Decree by the Supreme Council of Energy (10/4/2007)

- Strategy to reach 20 % of generation capacity from renewable energy by 2020.
- The strategy includes a plan for local manufacturing, legislations to encourage investments in RE, plan for tendering and electricity market liberation.

Thank you