Accelerating Global Adoption of Photovoltaic Technologies

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Outline

- Introduction to ISET
- Abundance of Solar Energy
- PV Business in the Industrialized World Today
- World Demographics
- Base of the Pyramid
- Potential for PV business in the Rest of the World
- ISET's Technology for Low Cost PV Manufacturing
- A 50 MW/Yr Turnkey System
- Accelerating Global Adoption of PV
- Summary

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About ISET

- **Founded in 1985 as California (C) Corporation.**
- **Received over US $18 Million in R&D Awards for Technology Development:**
  - Dept. of Defense, Dept. of Energy, NASA, Dept. of Commerce, California Energy Commission (CEC)
- **Patents Issued for Process Technology:**
  - USA, China , India, Europe &Japan
- **Raised funding through 2 rounds of private placement:**
  - June 2006: Series A (US $7.4M)
  - April 2008: Series B (US $10.2M)
  - TOTAL: **US $17.6 Million**
- **Operating in a fully permitted 24000 ft2 building.**

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Company History

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Availability of Solar Energy

- 1 Terawatt (TW) = 1 Trillion Watts
- 2005 US Daily power consumption: 3.35 TW
- 2005 World's Daily Power Consumption: 15.8 TW
- Daily Incident Power on Planet Earth: 174,000 TW

Planet Earth receives energy from the Sun equal to it's annual Energy Usage every 40 minutes.

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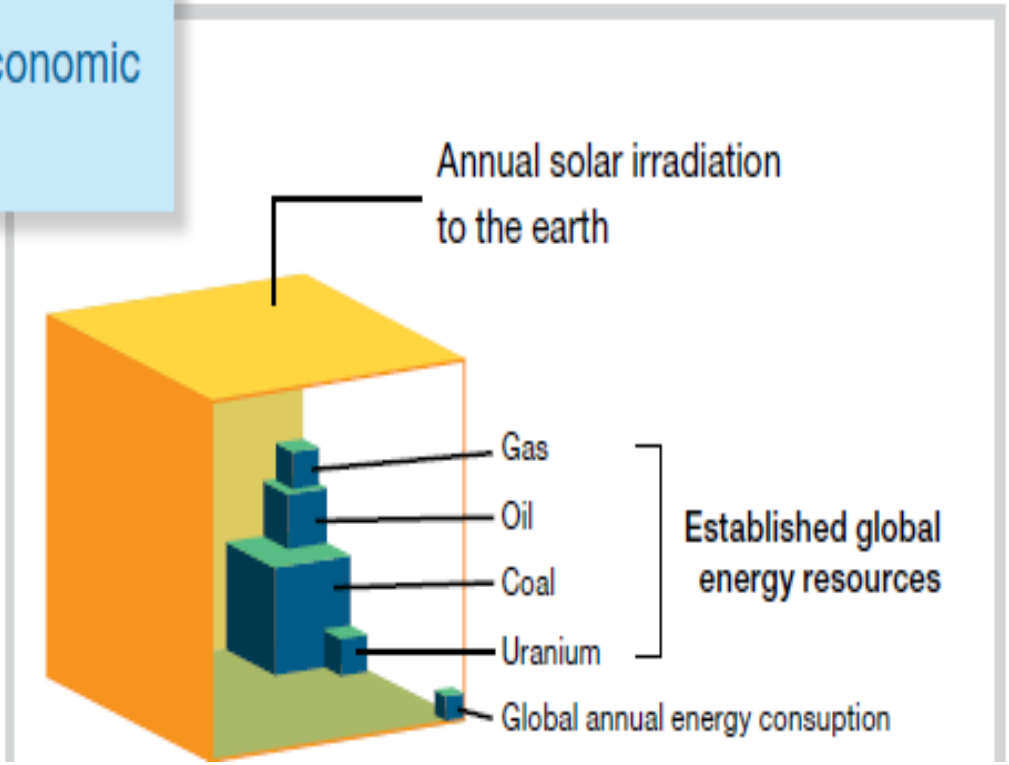
Comparative Abundance of Solar Energy

Photovoltaic is emerging

as a major power source due to its numerous environmental and economic benefits and proven reliability.



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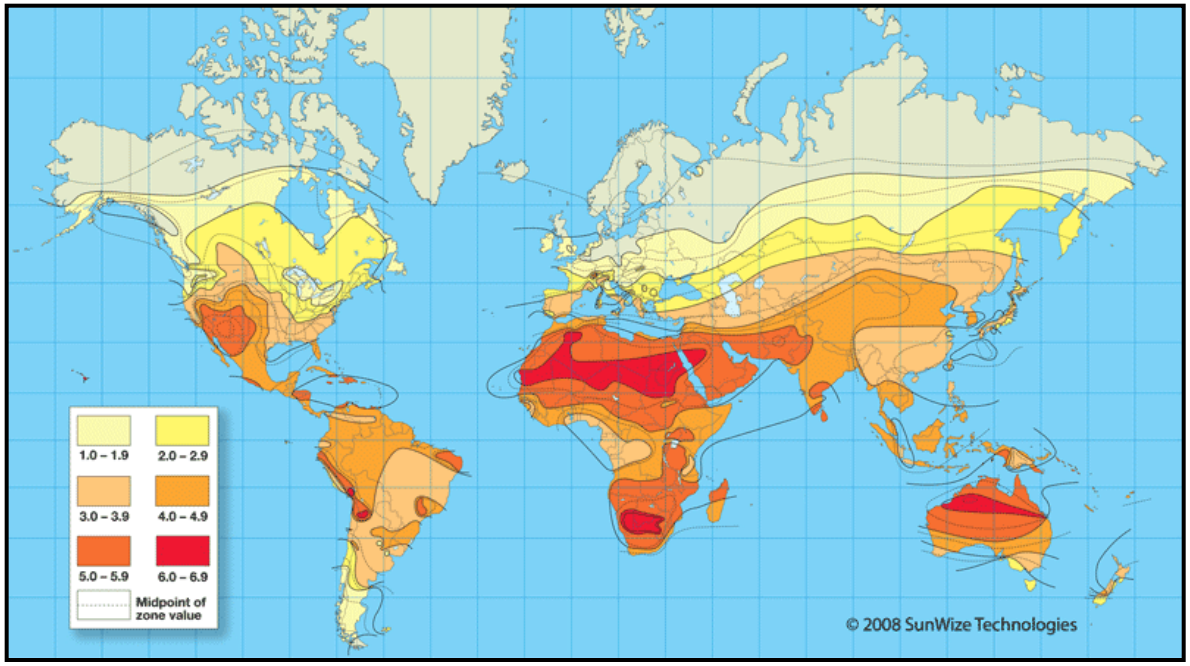
Availability of Solar Energy



- Annual Average Incident Solar Radiation (Hours of Peak Sunshine per Day)
- Abundant Sunshine in Developing Nations:
  - *Africa, Asia, Middle East, South America, Central America, Oceania*
- *Very Large Untapped Market Potential for Low-Cost Photovoltaics.*

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PV Business Status

In the Industrialized World

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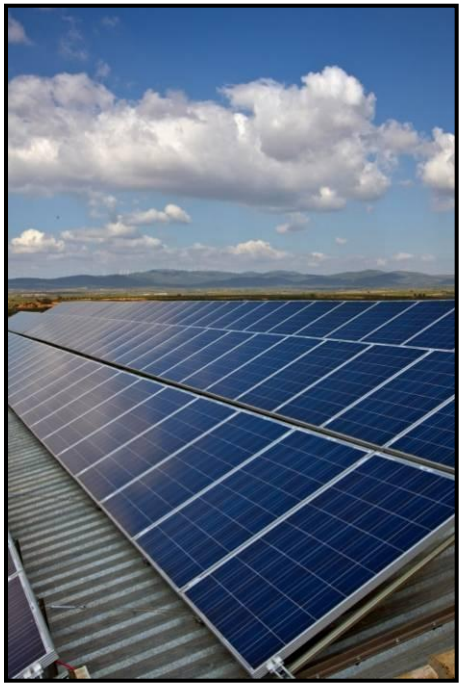
Photovoltaic Business Outlook in the Industrialized World



- *2009 worldwide sales:* **US $38 billion**
- **40+% annual growth** *since 1997.*
- *2020 projected sales volume: >***US $100 billion**

- *Global deployment in 2009: >* 7.5Gigawatts.
- Growing worldwide demand for renewable energy.
- Government support for solar energy in:
  - Germany, France, Italy, UK, Spain, Portugal, Greece, USA, Canada, China, India and others.

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Cost Driver in Industrialized countries - Grid Parity

Price (With No Subsidy) of Residential Grid connected PV Systems					
Annual Output: 1700 KWh/kW	**$5000/kW**	**$4000/kW**	**3000/kW**	**$2500/kW**	**$2000/kW**
Net Monthly Loan Payment					
Term: 25 years *Interest:* 7% *Tax Rate:* 30%	29.74	23.79	17.84	14.87	11.90
Monthly Savings From PV Generated Electricity					
Utility Rate - $**0.12**/kWh	20.40	20.40	**20.40**	**20.40**	**20.40**
Utility Rate - $**0.15**/kWh	21.25	21.25	**21.25**	**21.25**	**21.25**
Utility Rate - $**0.20**/kWh	28.33	**28.33**	**28.33**	**28.33**	**28.33**
		Target Installed Price for	**Grid -Parity**	**$2.00 - $3.00**	**Per Watt**

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Grid-Connected Systems

- **Critical Factors:**
  - Grid-Connected systems **currently** rely on government subsidies.
  - Market pressure to ***reduce total installed system price***.

Components	Current Price/Watt	Target Price/Watt
PV Module:	$1.50 - $2.25	$1.00 - $1.25
Inverter:	$0.35 - $0.65	$0.25 - $0.30
Installation & Materials:	$2.00 - $3.00	$1.00 - $1.50
TOTAL:	$3.85 – $5.95	**$2.25 - $3.05**

Grid Parity is expected to achieved between 3-5 Yrs.

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Market Projections for the Industrialized World

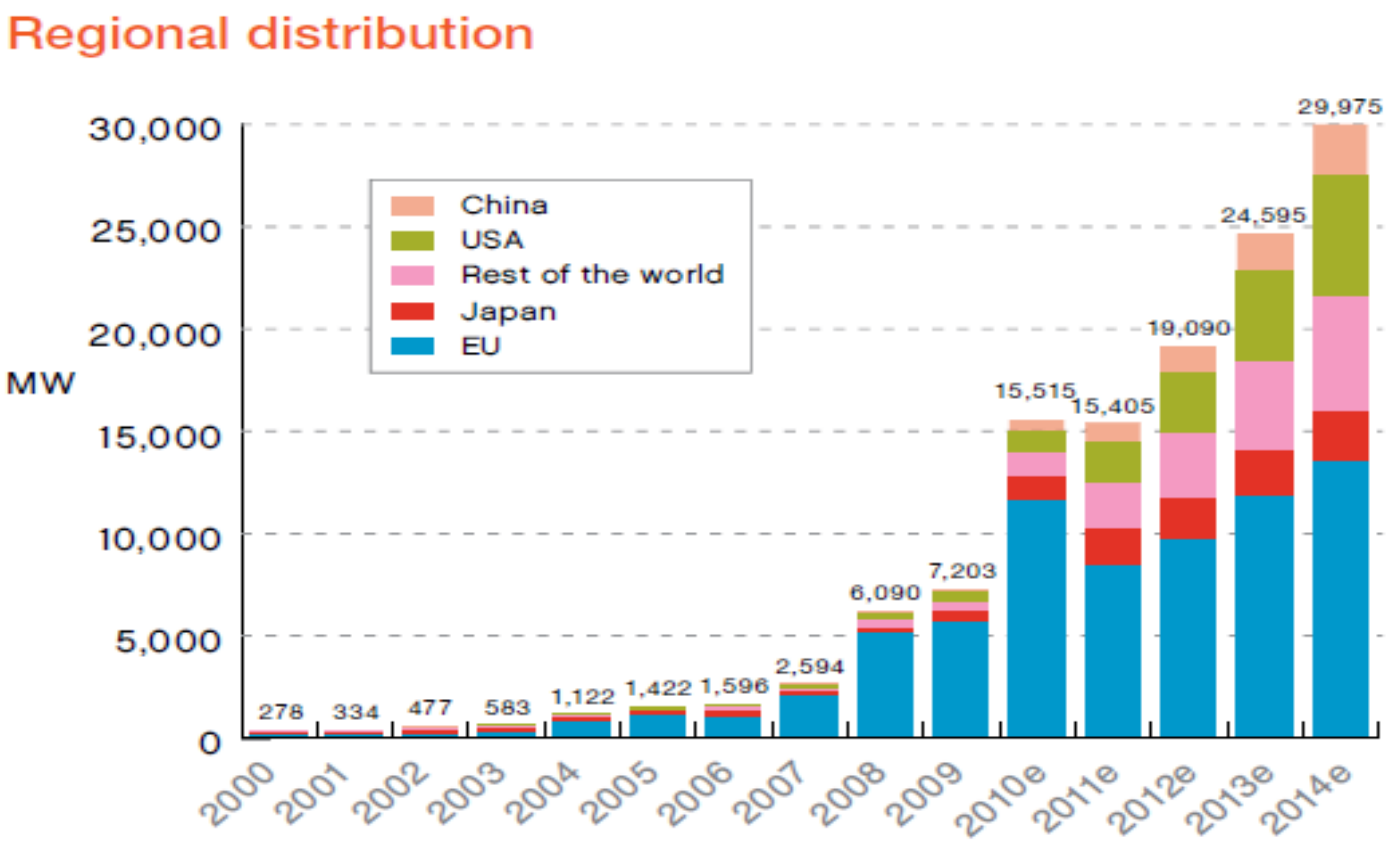

Figure 5 - Regional PV distribution in the World (Policy-Driven scenario)

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World Demographics

Projected Changes and Trends

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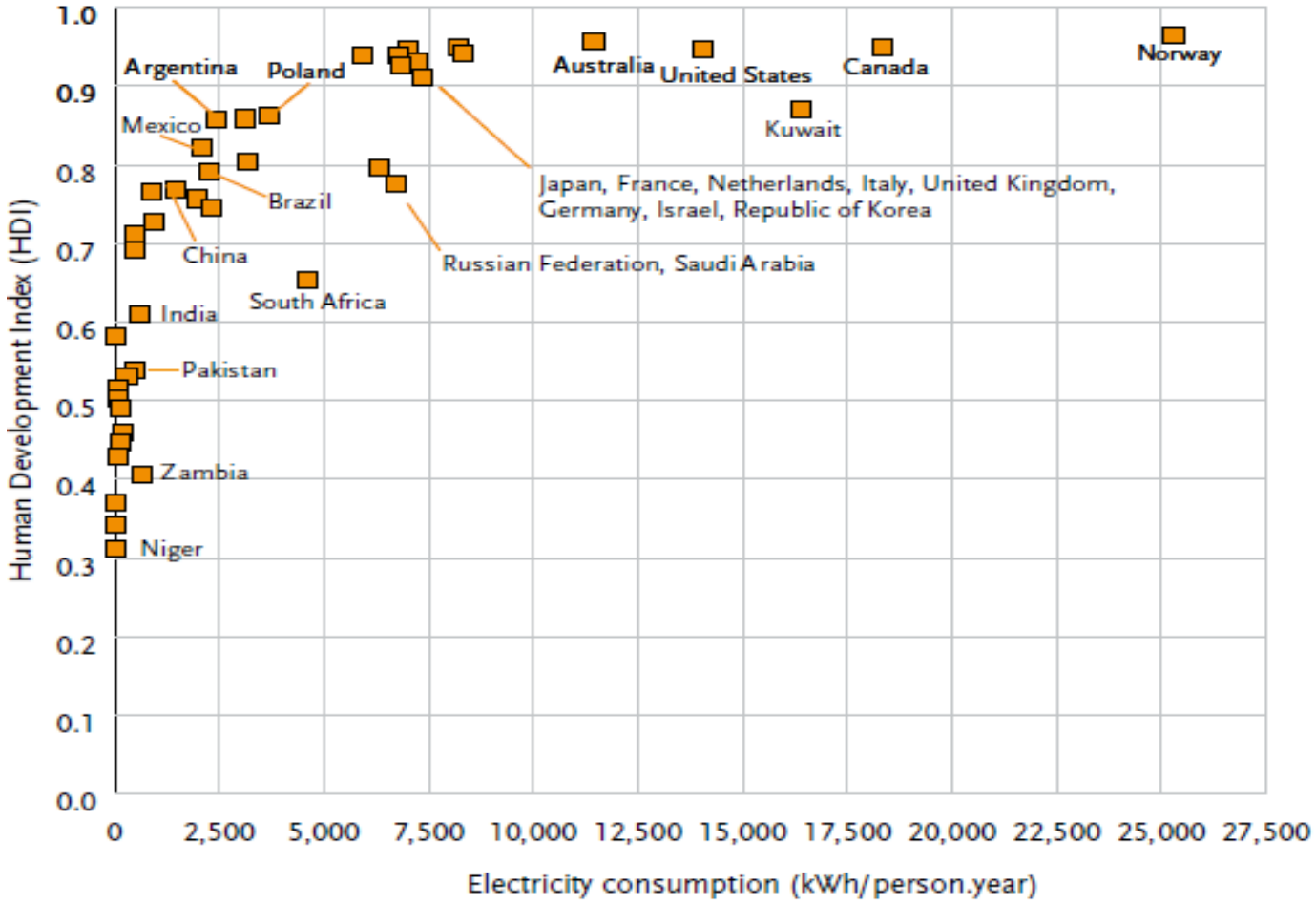
Electricity Consumption Vs. HDI



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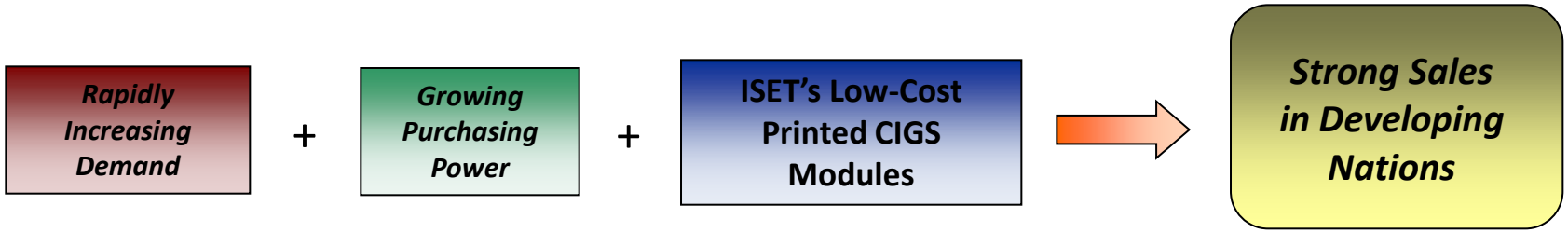
World Demographics

- ***Near-term planning must include strong strategy for sales to Developing Countries.***

World Population (Billions)

Year	Developed Nations	Developing Nations	Total
2009	1.2	5.6	6.8
2050	1.3	8.0	9.3



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Demographics –Age Distribution

File:Median age.png

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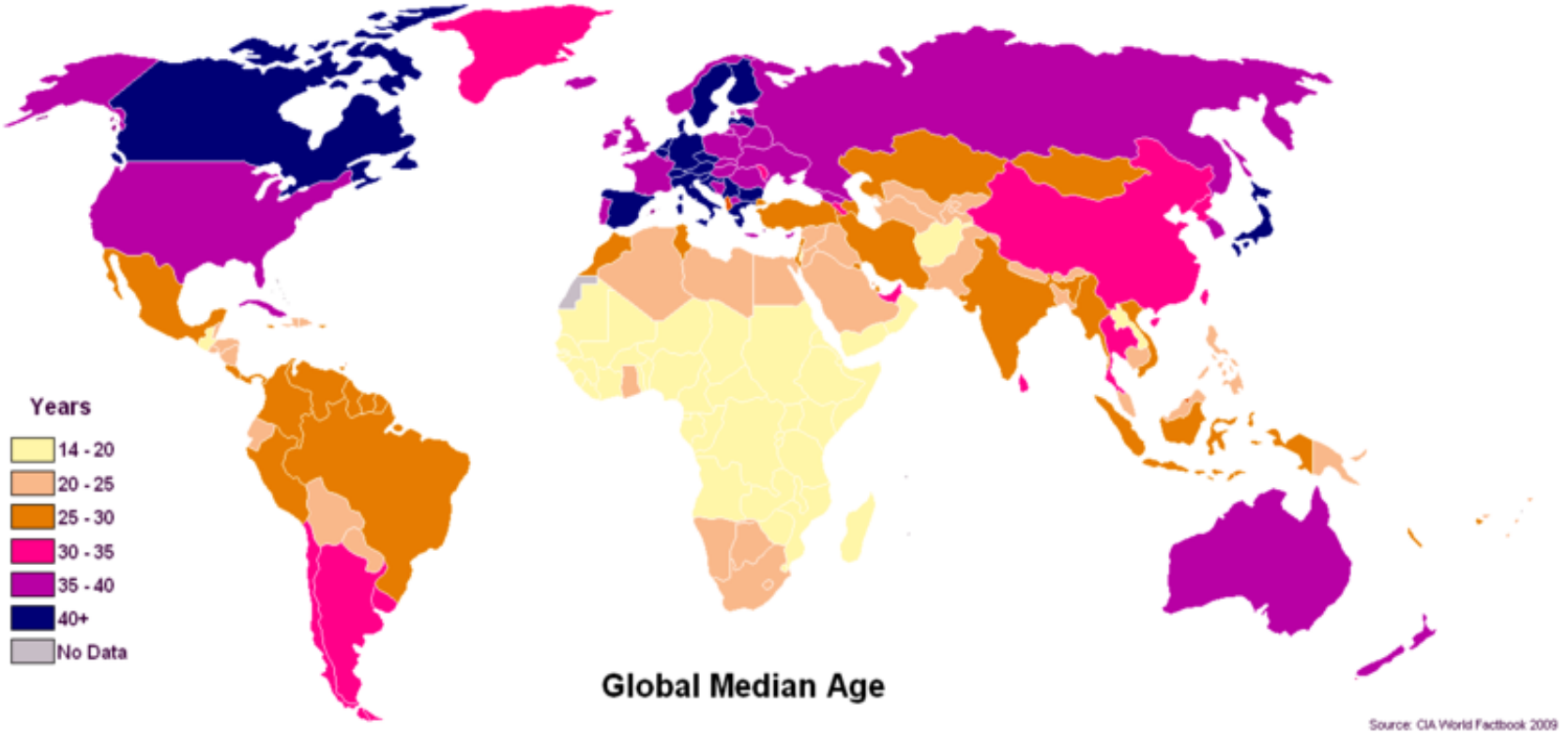

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Limited Buying Power of World's Population

File:Percentage population living on less than 1 dollar day 2007-2008.png

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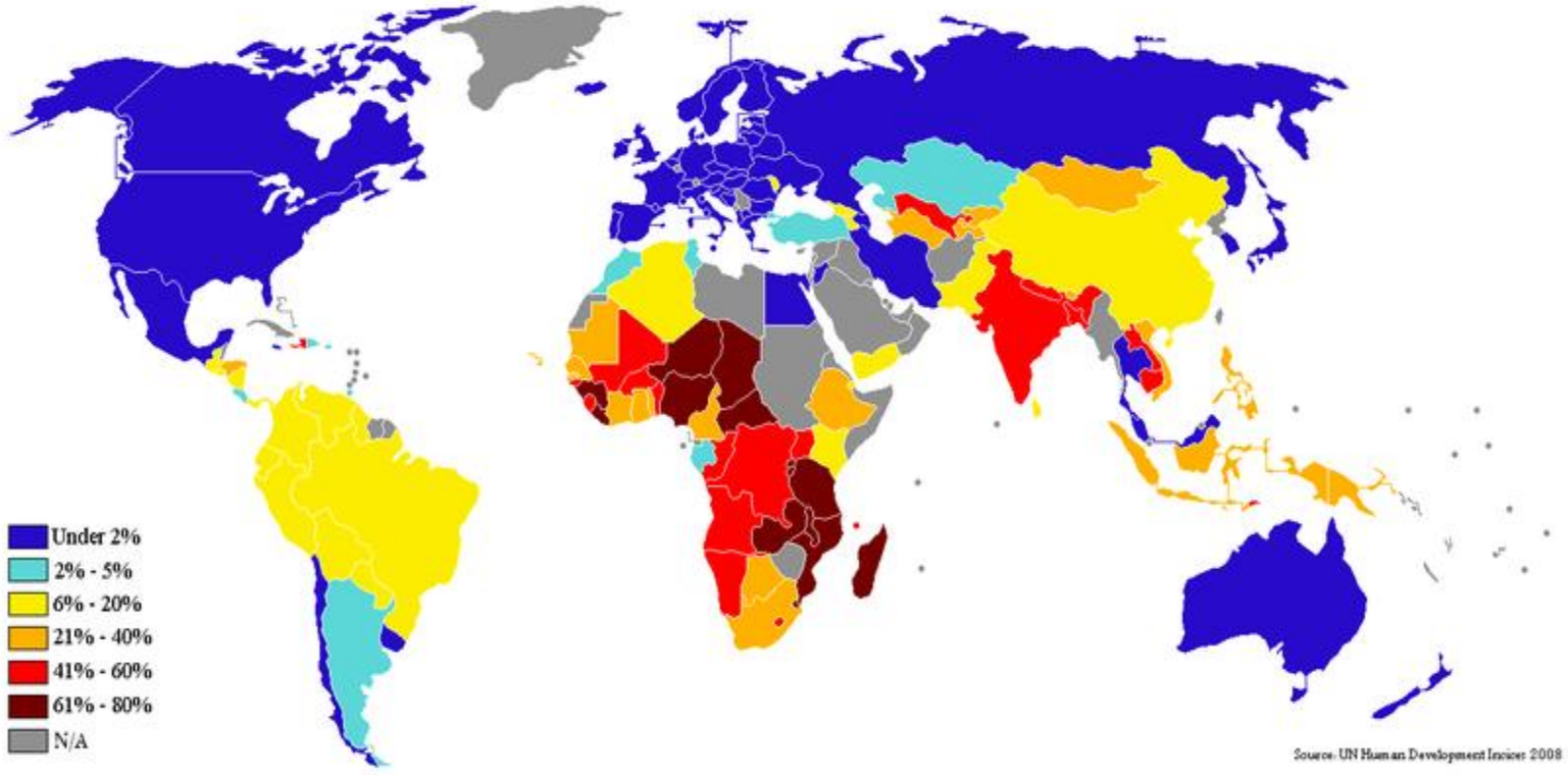

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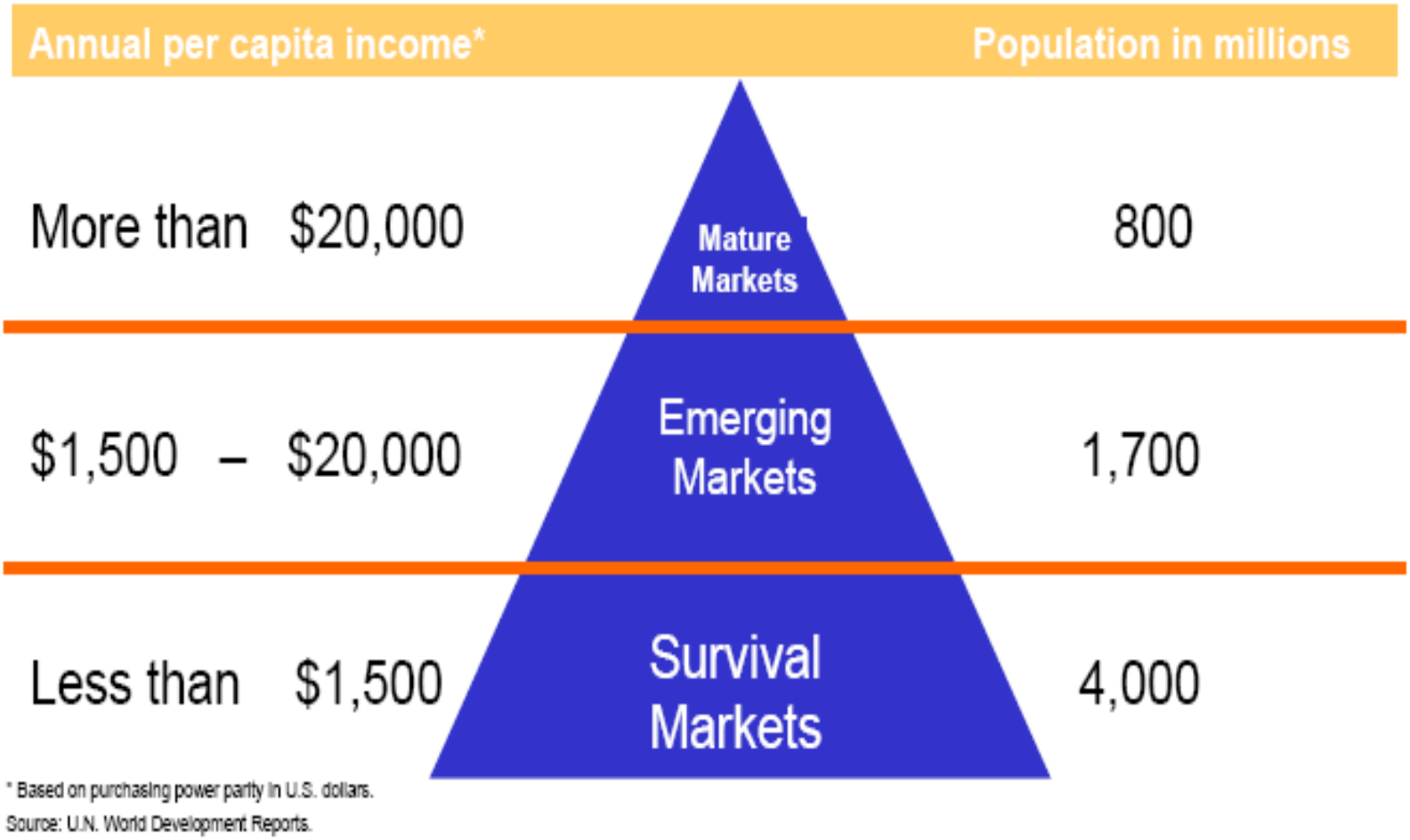
Population Vs. Per Capita Income



* Based on purchasing power parity in U.S. dollars.

Source: U.N. World Development Reports.

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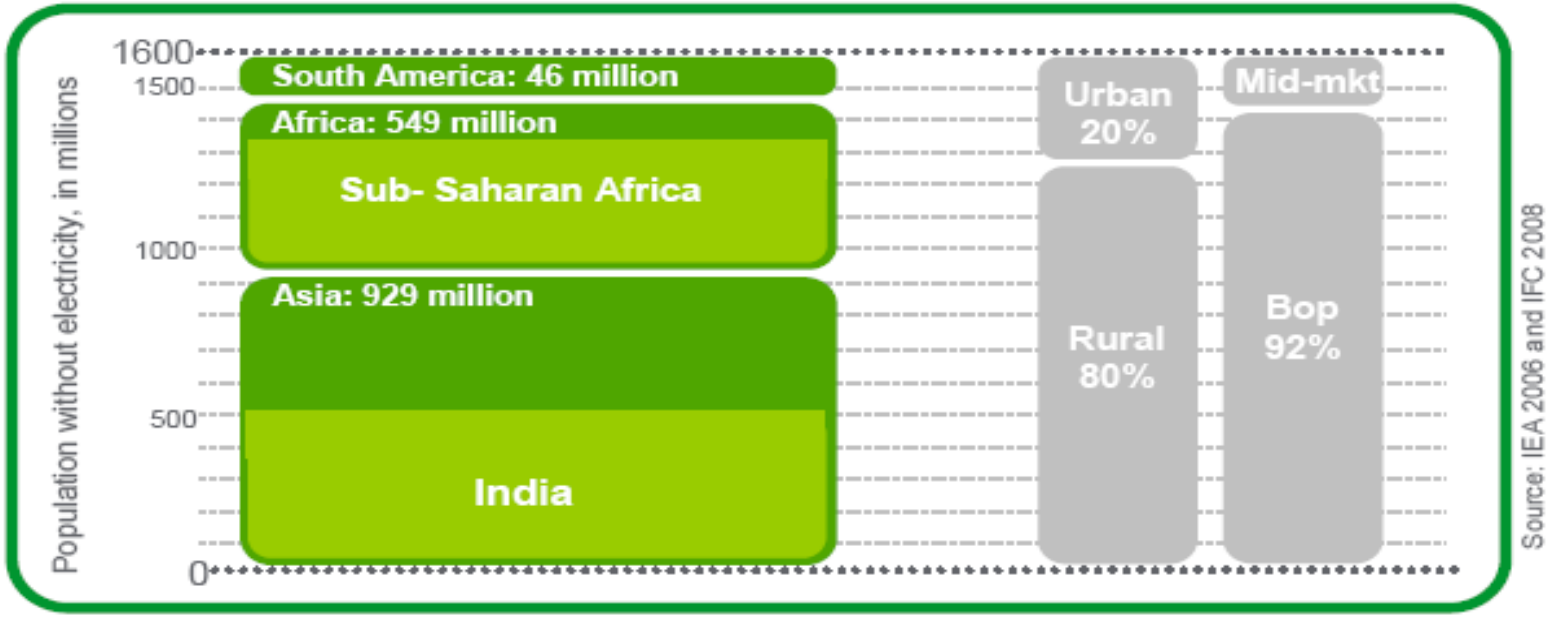
People without Access to Electricity

Today :

1.6 billion people don't have access to electricity



And 2 billion people forced to rely on traditional biomass sources due to the lack of clean and safe cooking fuels

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People with No Access to Electricity

1.6 billion people

are heavily impacted by lack of access to electricity

- The lack of electricity
  - endangers **peoples' health**
  - puts a strong **brake on development**
  - increases environmental **damages**
- Slum inhabitants (1bn people increasing by 500,000 per week) connect to the grid in **poor conditions** because of their situation
- Access to electricity is intrinsically hard, they **pay more** and they get a **poorer service**
- Remote villages must be focused to develop the people, the agriculture and to reduce slump growth.

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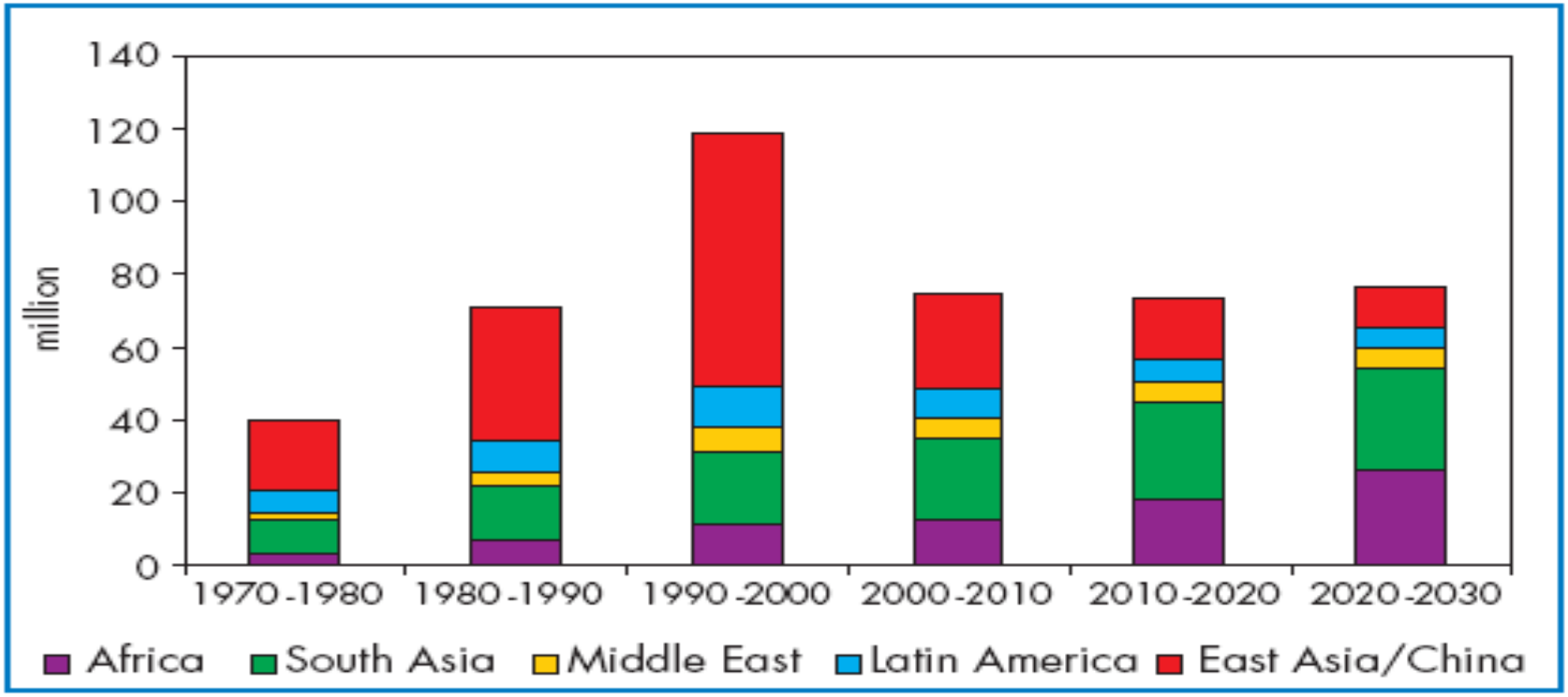
People Gaining Access to Electricity

Figure 13.9: **Annual Average Number of People Gaining Access to Electricity**



Source: IEA analysis.

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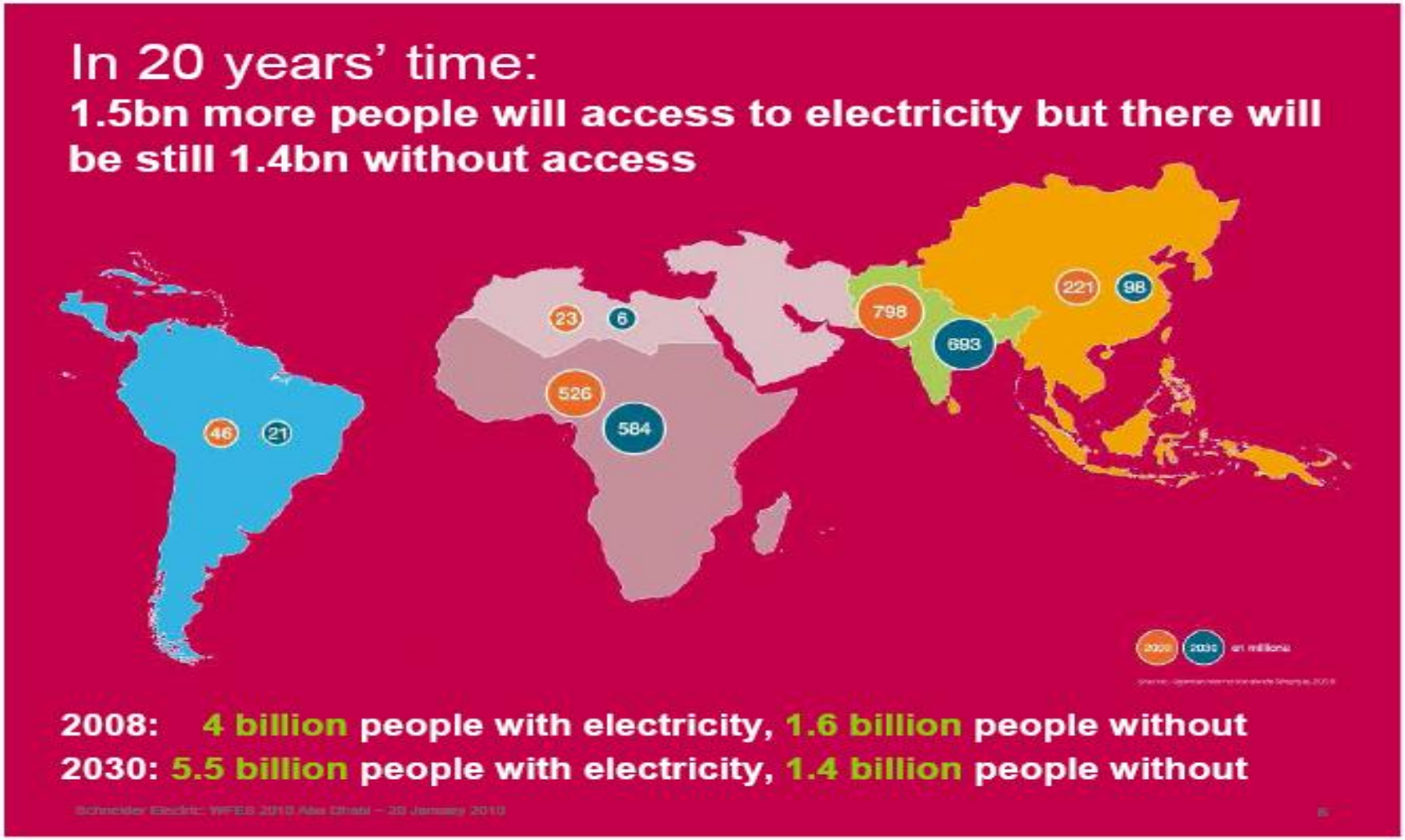
Continued Challenge



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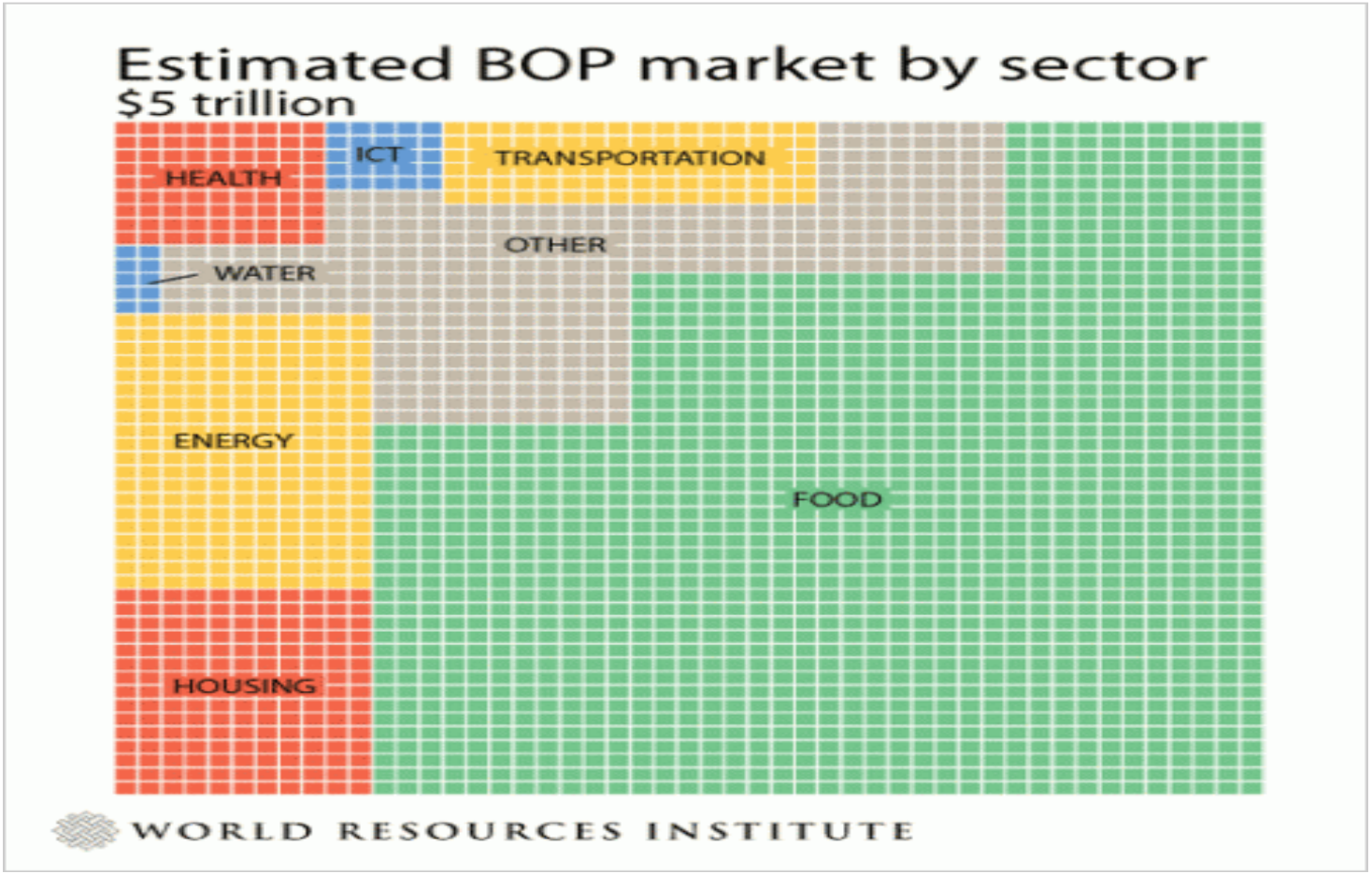
Projected Market Volumes at Base of the Pyramid



Affordable PV products can serve all of the above mentioned sectors

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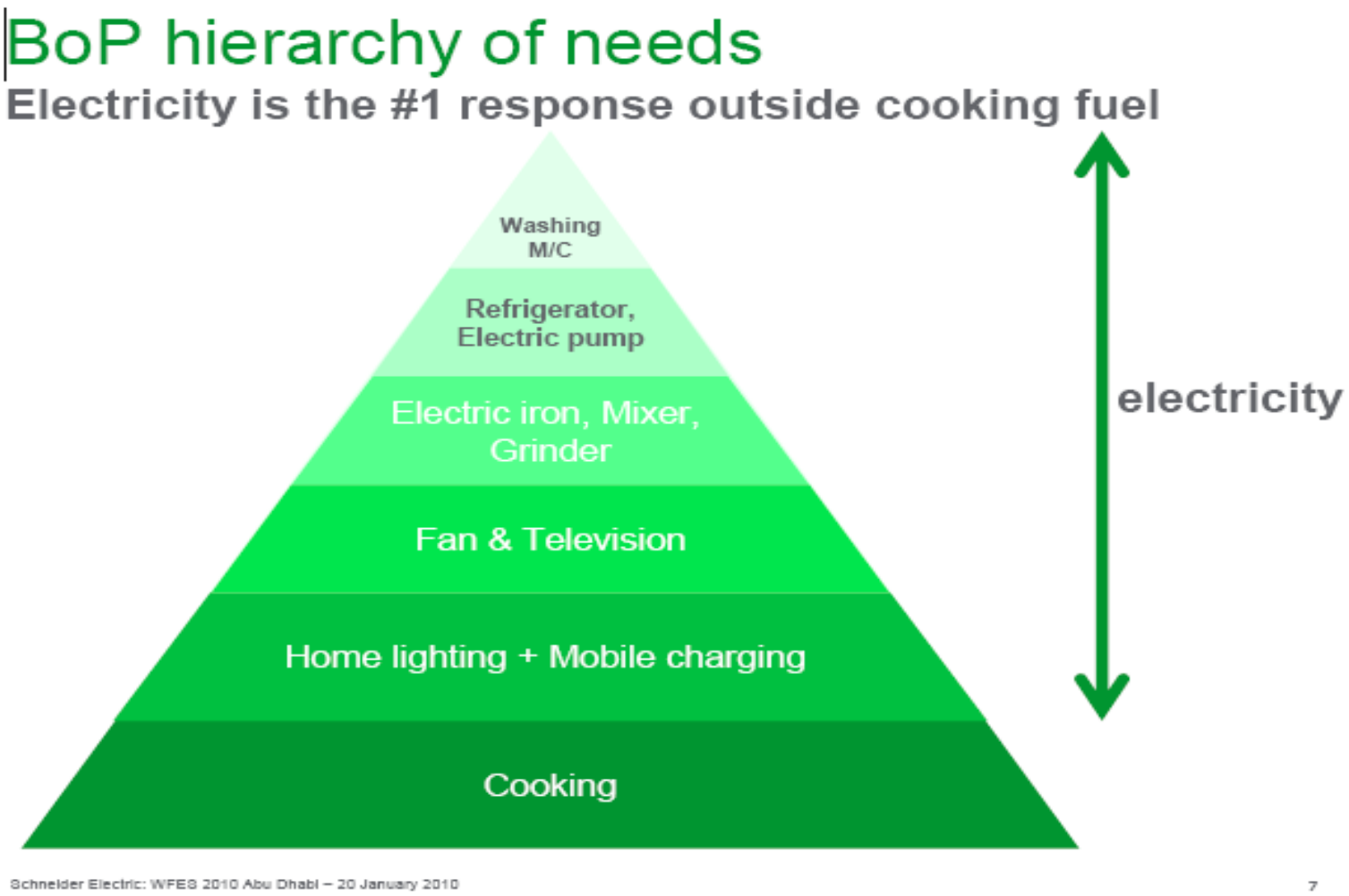
Needs of BOP People



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Market Overview – Developing World

- **Critical Factors**:
  - Intense Demand for Energy.
  - Unreliable or Unavailable Power Infrastructure.
  - Areas of highest population developing world have an **abundant supply of annual sunshine**.
- **Critical Power Needs:**
  - Battery Charging
    - LED Lanterns
    - Cellular Phones
  - Water Pumping
  - Rural Electrification
  - Medical Supply Refrigeration
- **Primary Competition:**
  - Diesel Generators
  - Kerosene Fuel
  - Disposable Batteries

- *High Market Price Tolerance* for low-wattage **portable** and **remote** PV applications.

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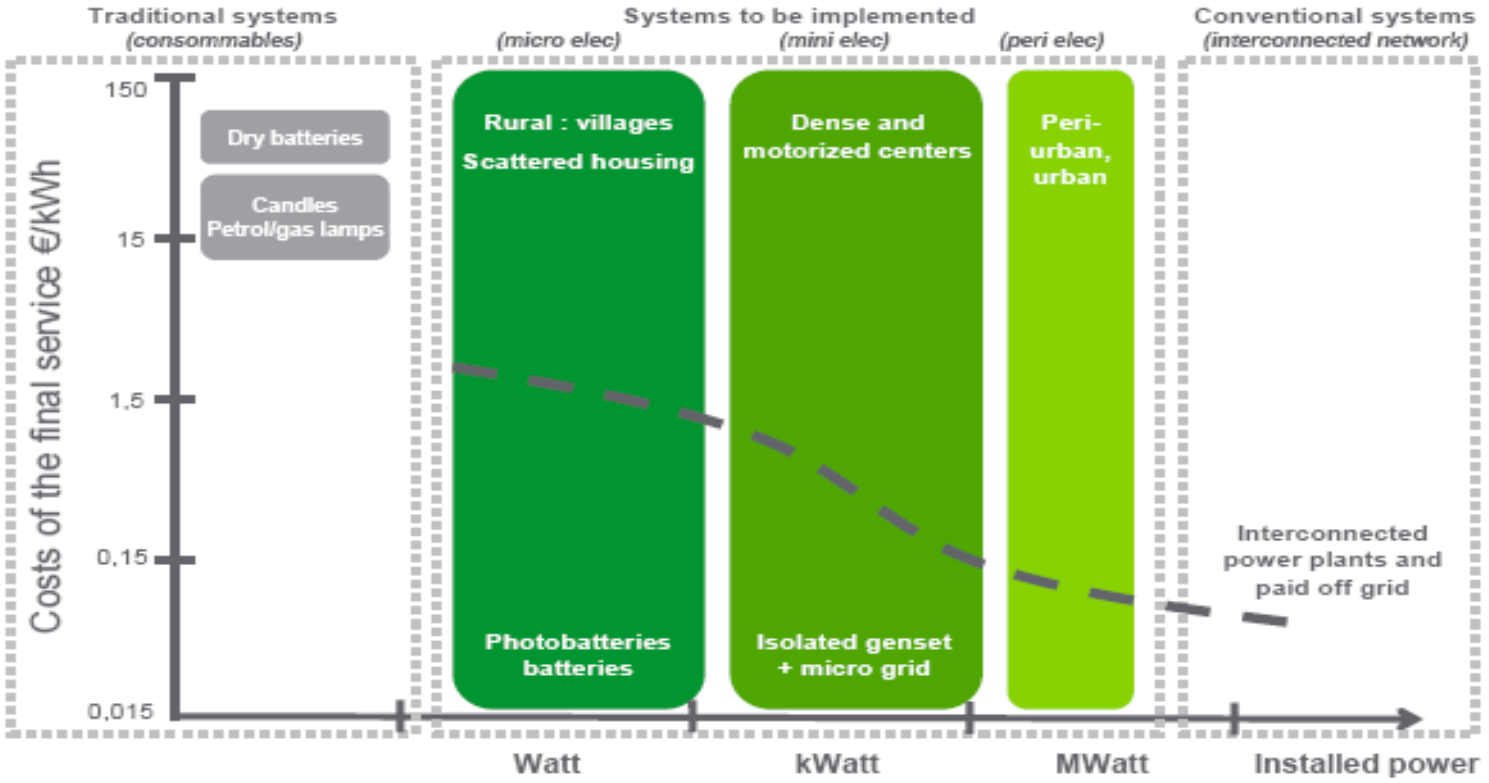
High Price Usage for Very Low Usage of Electricity

Why pay 100x more for 100x less energy?



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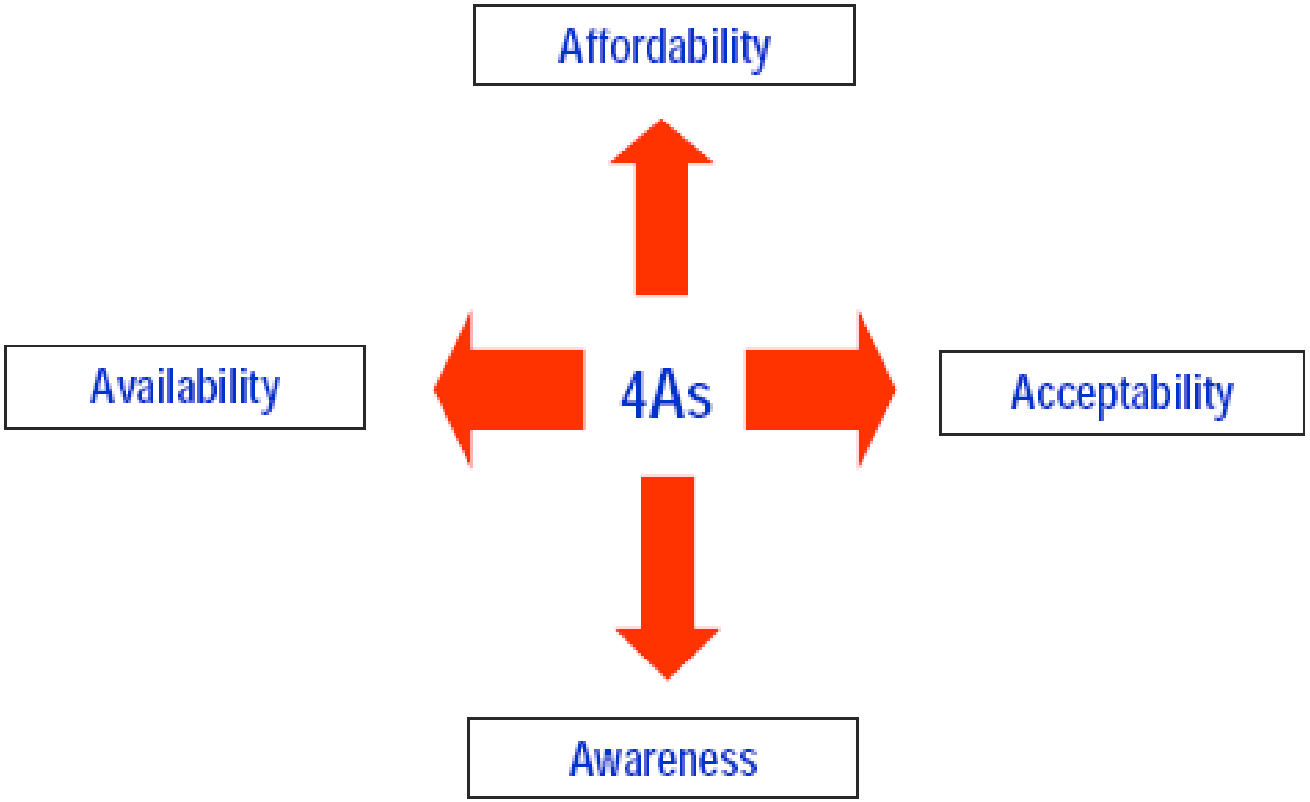
Introduction of PV Products in the Developing Countries



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Providing Access to Electricity in Developing Countries

ISET's Technology for Manufacturing Affordable and Customized CIGS modules

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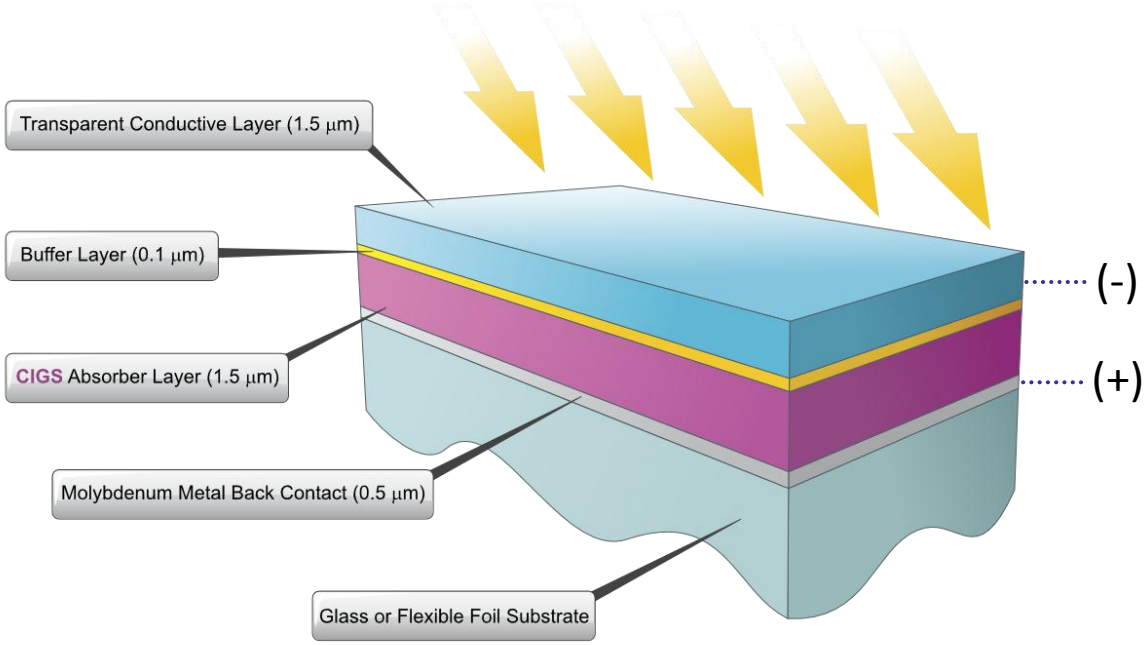
ISET's Cell Structure



**Active device thickness approximately 1/15th the diameter of a human hair.*

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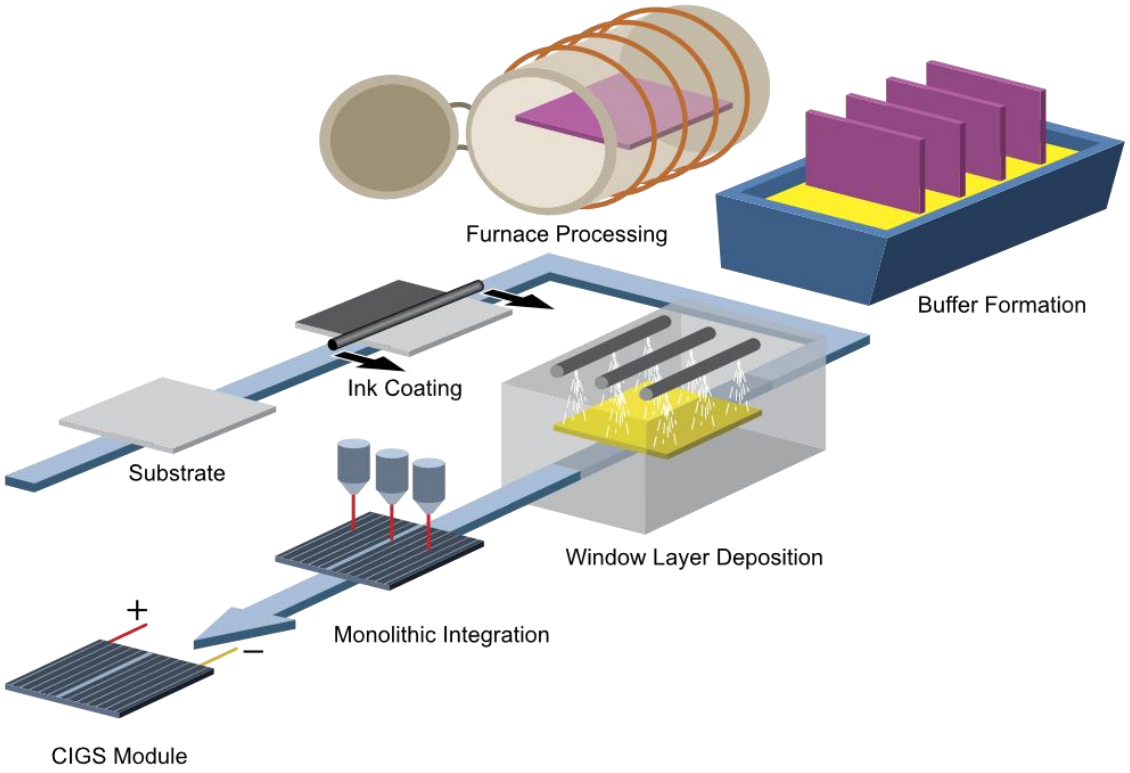
ISET's Complete CIGS Process



- ***H2O-based inks printed onto rigid or flexible substrates.***

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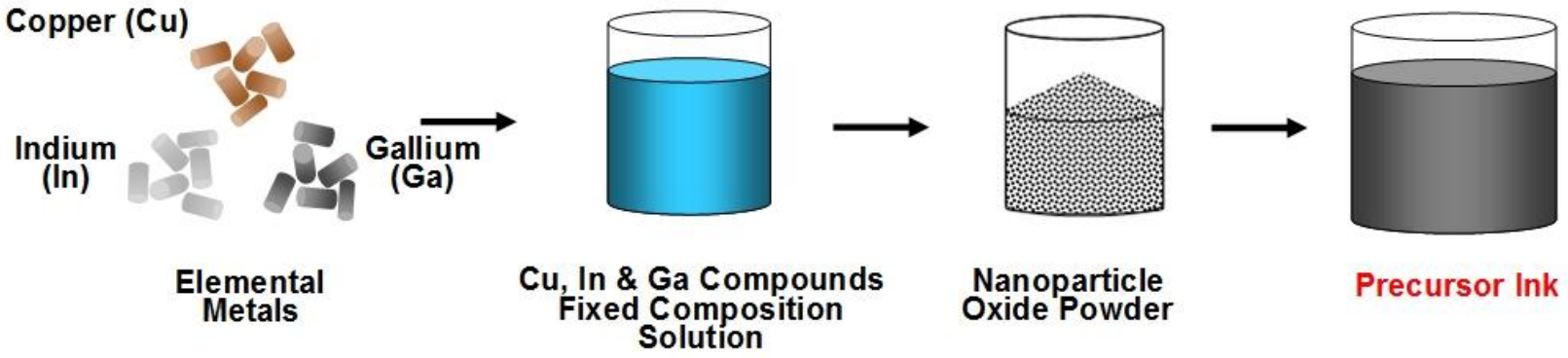
ISET's CIGS Nanoparticle Ink



1.45 MW of PV Panels

ISET's Ink

55 Gallons (280 Kg)

***Total Cost:* $60K.**

vs.

Crystalline Silicon

6.5 Metric Tons
@$50/Kg

***Total Cost:* $326K**

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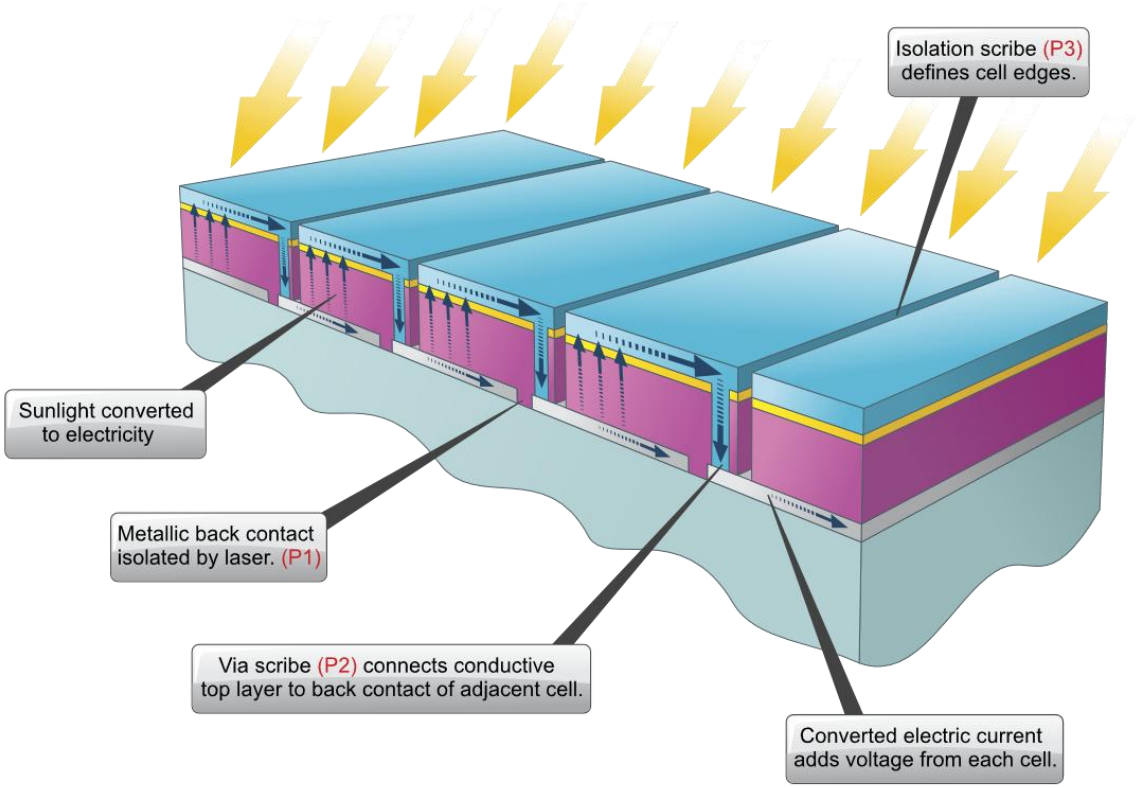
ISET's Integrated Module Structure

- **Monolithic Integration:**
  - Creates many interconnected cells on a single substrate.
  - Cell patterning may be optimized for best power output.



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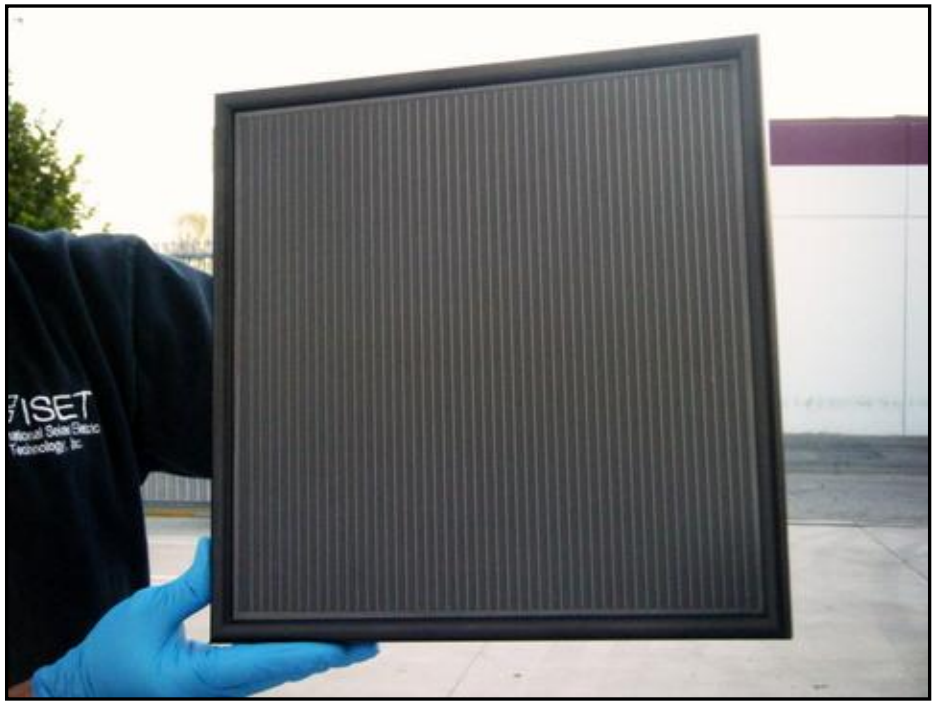
ISET's Integrated Module Structure

Benefits

- No wiring together of individual cells, saves assembly costs.
- Fine pattern lines maximizes collection area, increasing power output.
- Voltage output adjusted by changing # of cells in pattern.
- Same function for large utility power panels as well as for small handheld battery chargers.



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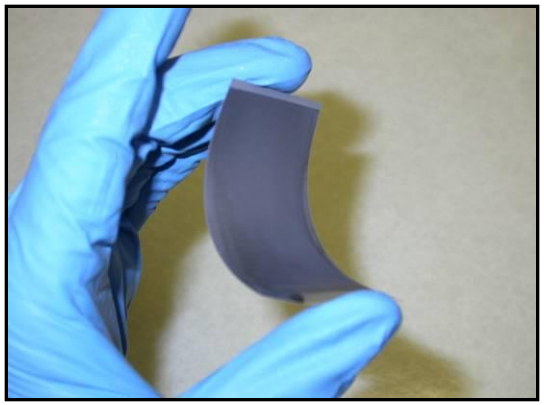
Product Configurations

Customized Printed PV Modules



Flexible Printed Solar Cell

Module Prototype - 30cm x 30 cm

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Product Configurations

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ISET Competitive Advantage

- **Simple and Elegant Technology.**

- **High Materials' Utilization:**
  - Greater than 95% of Active Materials in Ink are used.
- **Low CapEx:**
  - Less than $1.00/Watt for 50 MW production capacity.
- **Very Low Cost of Production.**

- **Versatility:**
  - Compatible with both Rigid and Flexible modules.
  - Grid-Connected Power and Portable Applications.
- **Mixed Market Approach offers high profit margins.**

- **Simplicity allows technology deployment in regions of market growth in Developing Countries.**

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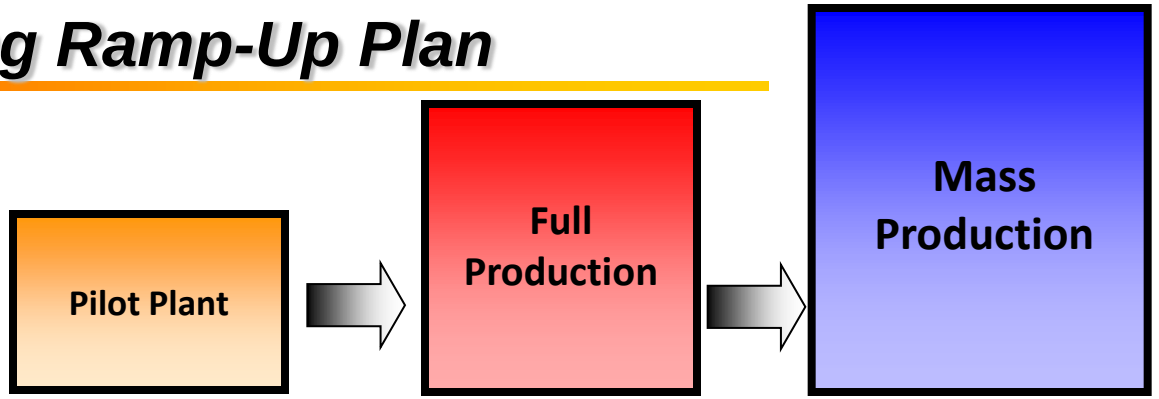
Manufacturing Ramp-Up Plan



Timeline	2010	2011-2012	2012-Beyond
Capacity	3.0 MW	30-50 MW	100-200 MW
Products	Portable Modules; Customized Solar Products	Portable and Power Modules	Portable and Power Modules
Customers	N/A	Residential & Commercial Rooftop Installers; Utilities, OEM's of Off Grid Products	Solar Farms; Utilities; All Markets
Development Plan	Streamline Manufacturing Process	Revenue Generation	Global Expansion of Low-Cost PV
Target Manufacturing Cost per Watt	N/A	$0.70	$0.65-$0.50

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Manufacturing Cost Estimates

Estimated Manufacturing Costs at 50 MW/yr Capacity

Direct Materials Costs	**Cost ($/m^2)**
Active Device Materials	$15.00
Lamination and Sealant Materials	$20.00
Frames, Junction Box	$7.50
Total Materials Cost:	**$42.50**
Direct Labor with Fringes	$5.00
Capital Equipment Depreciation (St. Line 7 yrs.)	$10.00
Factory Overhead & Management	$7.50
TOTAL ESTIMATED COST per m^2:	**$65.00**

- Output at 10% Module Conversion Efficiency: **100 Watts / M^2**
- Resultant Estimated Cost: **$0.65 / Watt**

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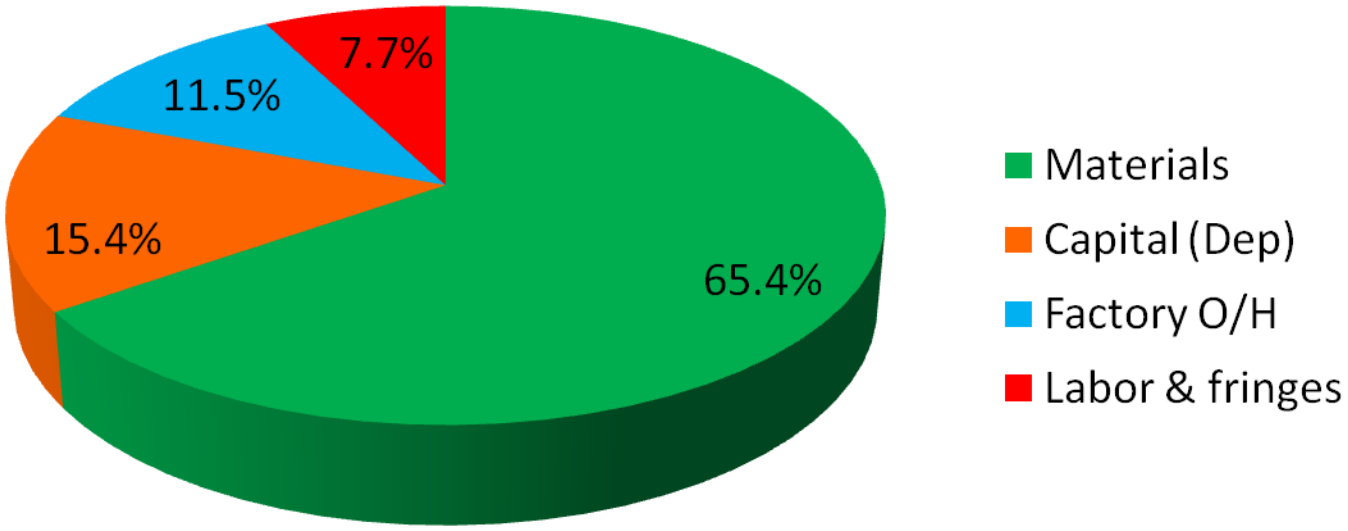
Manufacturing Cost Estimates



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CIGS Module Production Plant Requirements

Requirements	50 MW/Yr Turnkey Line	250 MW/YR Cluster System
Capital, $ Million	$55-60	175 - 200
Factory Area , Sq. Feet	40,000 -45,000	200,000 – 250,000
Number of Direct Employees	130 -150	600 - 700
Projected Cost of Manufacturing $/Watt	0.65 -$0.70	0.55 – 0.60
Time for Factory Operation, Months	12 -18	24 - 30

ISET's 'Ink Based ' Technology is affordable and can be made readily deployable in various global markets

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ISET's Plans for Manufacturing

- **Develop 50MW/YR 'Turn-Key' production line**
  - Complete Supply Chain
  - Rapidly-Deployable
- **Install a 50MW/Yr solar panel manufacturing line in ISET's current facility**
- **Manufacturing of PV Products**
  - Grid-connected applications (USA)
  - Customized panels for exports to emerging markets in developing countries
- **International Business Growth**
  - Technology Licensing
  - Sales of 'Turn-Key' production lines

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Marketing Plan

- **Grid Connected Systems in the U.S.:**
  - Collaborate with local utilities and Real Estate Developers for solar installations
  - Partner with PV system developers offering complete solar solutions.
- **Portable and Remote Power PV Applications:**
  - Collaboration with PV systems developer and distributors in India other developing countries.
  - Establishing connections within the consumer electronics industry.
- **Dissemination of Low Cost PV Manufacturing via Technology Licensing**
  - Joint Venture partnerships with established companies in countries with market potential.

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Population and Watts per Capita

Population in Millions	>1000	>100	100 – 30	30 – 10	10 – 1	<1
No. of Countries	2	9	27	45	72	68

Watts per Capita	>1000	1000 - 750	750 – 500	500 – 250	250 – 100	100- 50	<50
No. of Countries	14	11	20	24	43	24	55

Global Average Watts per Capita = 297 watts

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Energy Availability Gains provided by 250 MW/YR Cluster

Country	Population Millions	Current Usage KWH/Capita	KWH/Capita Gain in 5 years	Change (%)
El Salvador	6.88	768	218	**28.4**
Bhutan	2.16	1922	644	**36.1**
Angola	15.9	214	94.3	**44**
Nepal	27.1	93.5	55.3	**59.1**
Laos	5.9	284	254	**89.4**
Cote d'Ivoire	18.2	90.7	82.6	**91.2**
Cambodia	14	81	107	**132**
Fiji	0.85	1010	1769	**175**
Burkina Faso	13.2	42.7	114	**266**
Eritrea	4.4	55.7	341	**612**

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Accelerating PV Growth

- Install ***affordable*** 250 MW/Yr manufacturing clusters
  - countries with population ~ 10 million
  - replicate 50 MW/Yr turnkey lines
- Promote a sense of ***availability*** of low cost energy
- Improve ***quality of life***, productivity resulting in ***economic growth***
- Train ***local talent*** in manufacturing, product design and technical support.
- Encourage communities to adopt PV generators
  - Agriculture
  - clean water
  - Telecommunication
  - Education
  - Medical Facilities
  - transportation fields.
- Create ***awareness and acceptability*** of PV generators in the local social structure

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Summary

ISET's 'Ink Based' technology for manufacturing low cost, affordable, flexible PV modules can be a catalyst for global adoption of PV technology in the near future.

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THANK YOU FOR YOUR ATTENTION

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