BIHAR RE Resource Assessment (Solar and Biomass)

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Renewable Energy Sources

- Wind Energy
- Solar Energy
  - Solar Photovoltaic
  - Solar Thermal
- Small Hydro (<25 MW)
- Biomass Energy
- Wave/Tidal Energy
- Geothermal Energy

Renewables Suitable For Bihar

- Wind Energy: Large Grid-No Potential, Off-grid: Low Potential
- Solar Energy
  - Solar Photovoltaic: Grid-Moderate Potential, Off-grid: High Potential
  - Solar Thermal: Grid-No Potential, Off-grid: Moderate Potential
- Small Hydro (<25 MW): Moderate Potential
- Biomass Energy: Good Potential Grid + Off-grid
- Wave/Tidal Energy: No Potential
- Geothermal Energy: May be. Needs Exploration

Focus: Solar and Biomass

Solar Energy

Basics of Solar Energy

- Electromagnetic radiation emitted by the sun, Diff. wavelengths, Heat, Light & UV
- 1367.7 W/m^2 outer space, 1000 W/m^2 on earth surface
- Direct radiation
- Diffuse radiation
- Two together referred as global radiation

Solar Radiation Measurements 1/3

- Global horizontal irradiance (GHI): Pyranometer
- Total: Direct + Diffuse
- Useful for PV

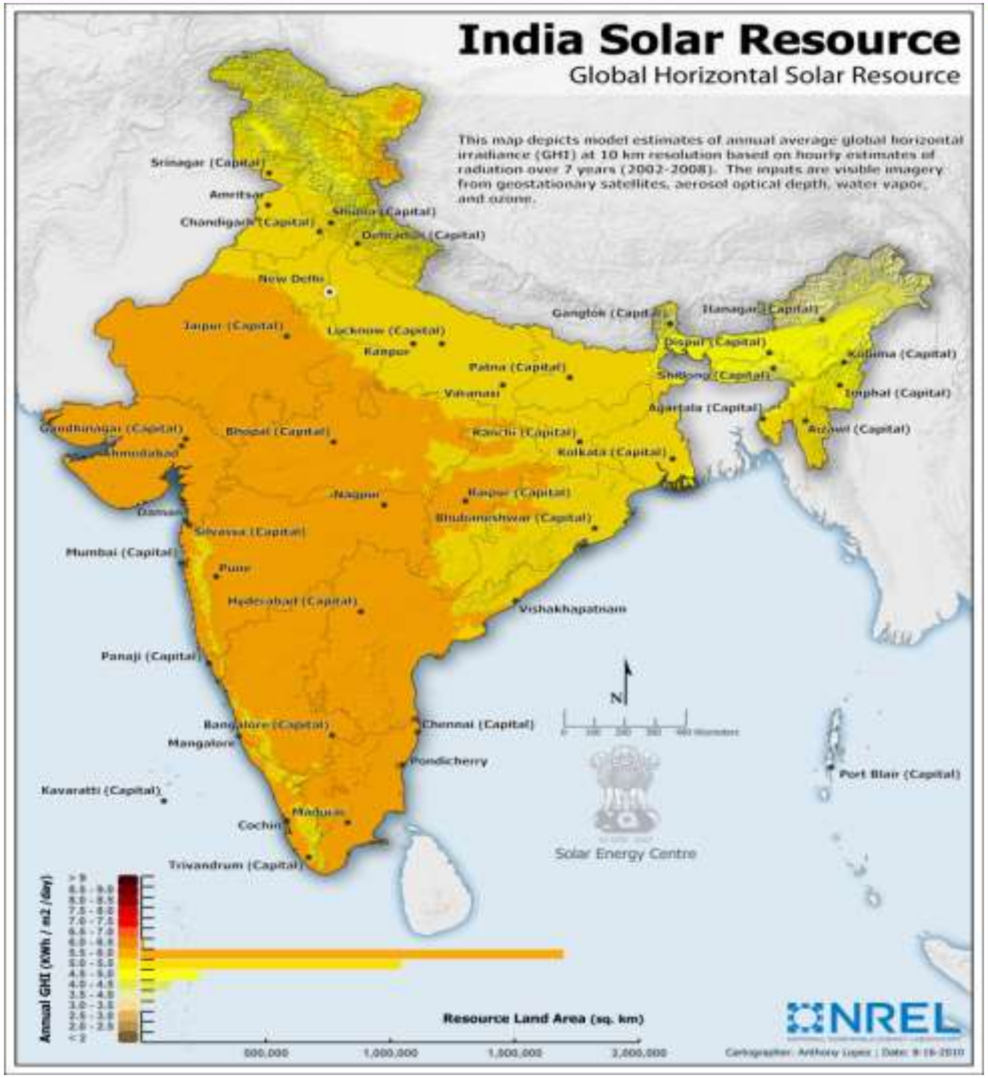
Solar Radiation Measurements 2/3

- Direct Normal Irradiance (DNI): Pyrheliometer
- Direct on perpendicular surface
- Useful for Reflectors, CSP

Solar Radiation Measurements 3/3

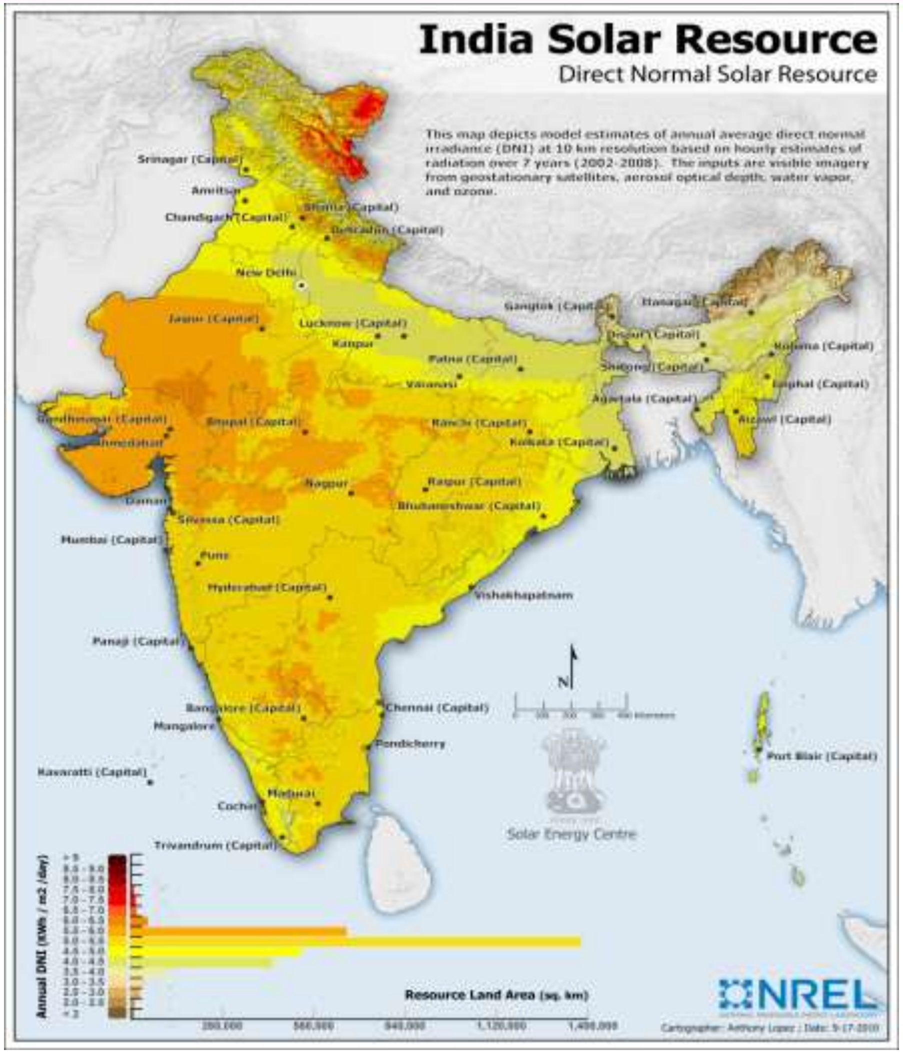
- Solar insolation - total amount of solar energy received at a particular location during a specified time period
- Unit - $kWh/m^2/day$
- Power project :
  - CSP min. 1800 $kWh/m^2/yr$ (Reported)
  - SPV min. 1500 $kWh/m^2/yr$ (Suggested)
- Micro-grid: No standard
- Actual ground data: Not always available
- Derived data: NASA, METONORM, GeoModel

Solar Radiation Map 1/2



Ideal: < 1500 kWh/m²/yr, Bihar: ~ 1800 kWh/m²/yr (Good)

Solar Radiation Map 2/2



Ideal: < 1800 kWh/m²/yr, Bihar: ~ 1600 kWh/m²/yr (Not Good)

Solar Technology Options

- Solar Photovoltaic Electricity Generation
  - » Convert sunlight falling on PV cell into D.C. electricity

- Solar Thermal Electricity Generation
  - » Solar energy is focused through mirrors to heat working fluid
  - » Heated working fluid produce steam
  - » drive a turbine-generator to produce electricity

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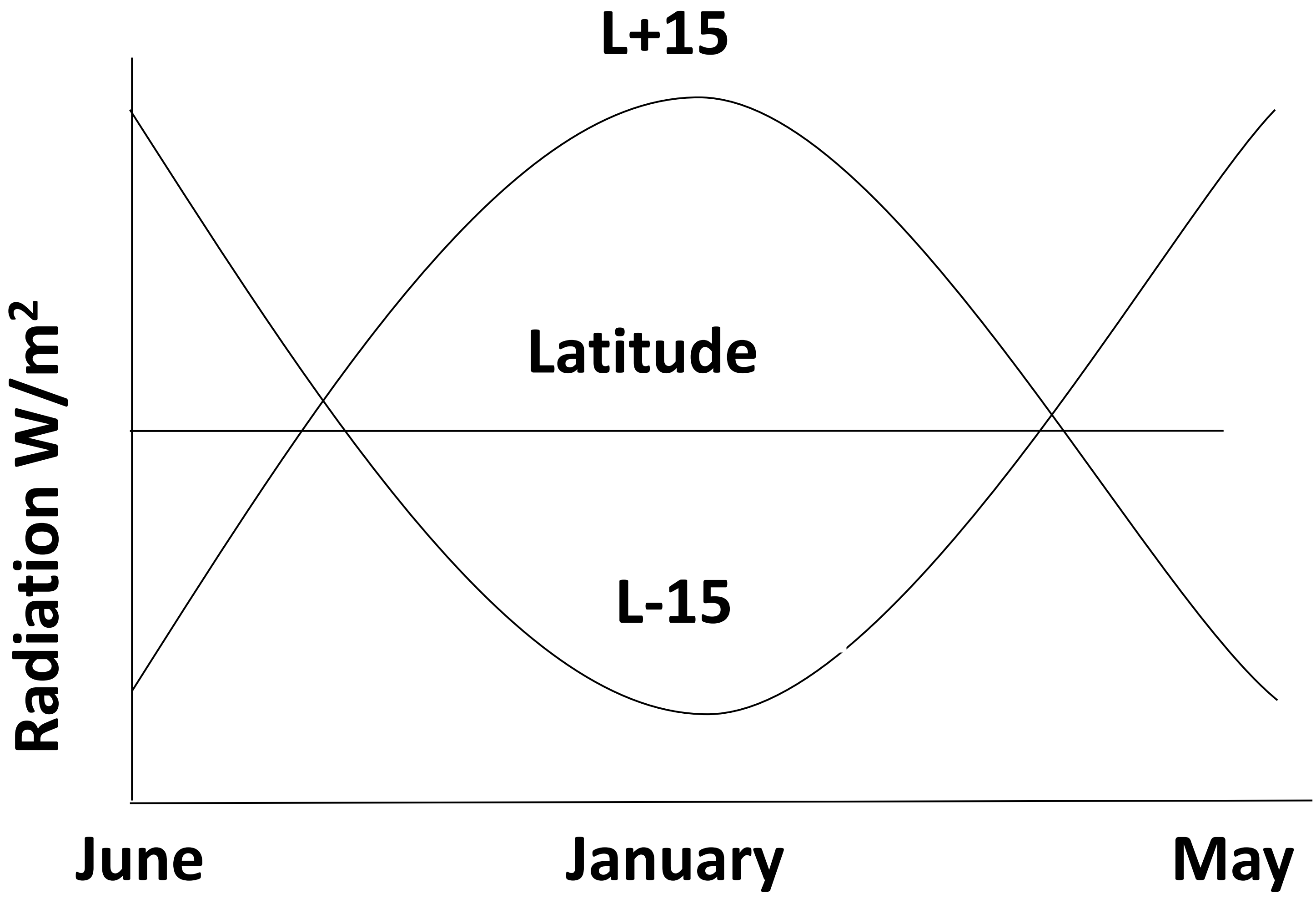
Winter or Summer Optimization

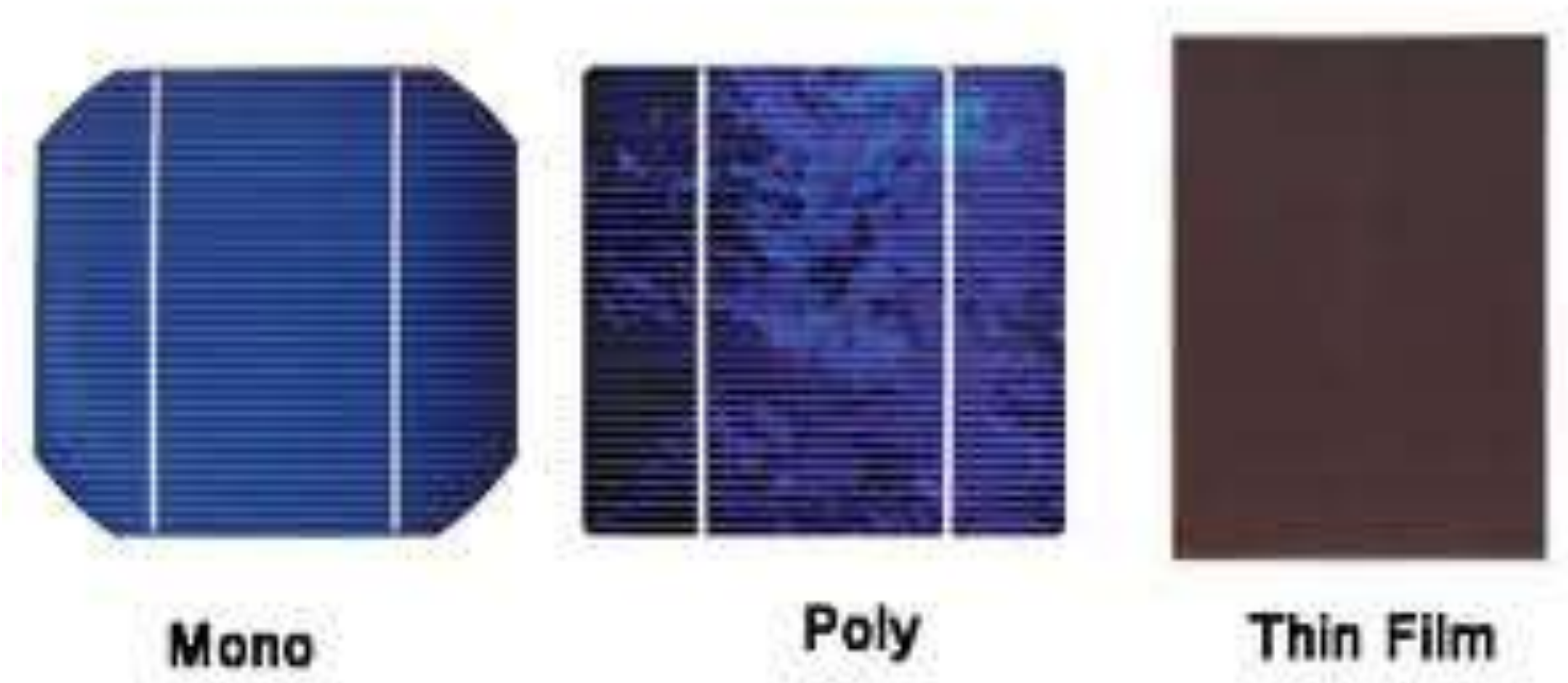


Solar Photovoltaic Technologies

Types of PV Cells

- Crystalline
  - » Mono-crystalline silicon solar cells
  - » Polycrystalline silicon solar cells
- Thin film
  - » Amorphous silicon
  - » Cadmium telluride
  - » Copper indium di-selenide
- Emerging technologies
  - » Gallium arsenide
  - » Organic semiconductors
  - » Dye-sensitized cells
  - » Nanotechnology solar cells
  - » Comparison Study: http://www.wisein.org/pdf/PV_Due_Diligence_Report.zip

Types of PV Cells



Mono-crystalline Silicon Solar Cells

- Majority solar cells manufacturers
- Input material SiO_2
- Principle of Czocharalski process
- Practical efficiencies - 14 to 17%

Polycrystalline Silicon Solar Cells

- Second most common natural substance
- Manufacturing process - simpler and cheaper
- Casting process
- Practical efficiencies - 13 to 15%

Amorphous Silicon Solar Cell

- Requires low process temperature
- Technological capability for large-area deposition exists
- Has low material requirements
- Has larger band gap
- Low energy consumption during manufacture, and
- Possibility of automation of the manufacturing process: Commercialized
- Low efficiency 6-9%, faster degradation, light soaking reduction

Cadmium Telluride Solar Cell

- Highest theoretical conversion efficiency
- Energy gap of 1.44 e.v.
- Efficiency - 6 to 10%
- Technically best among thin films
- Degradation more than crystalline
- Possibility of production hazards
- Environmental pollution
- Commercialized

Copper Indium Diselenide Solar Cell

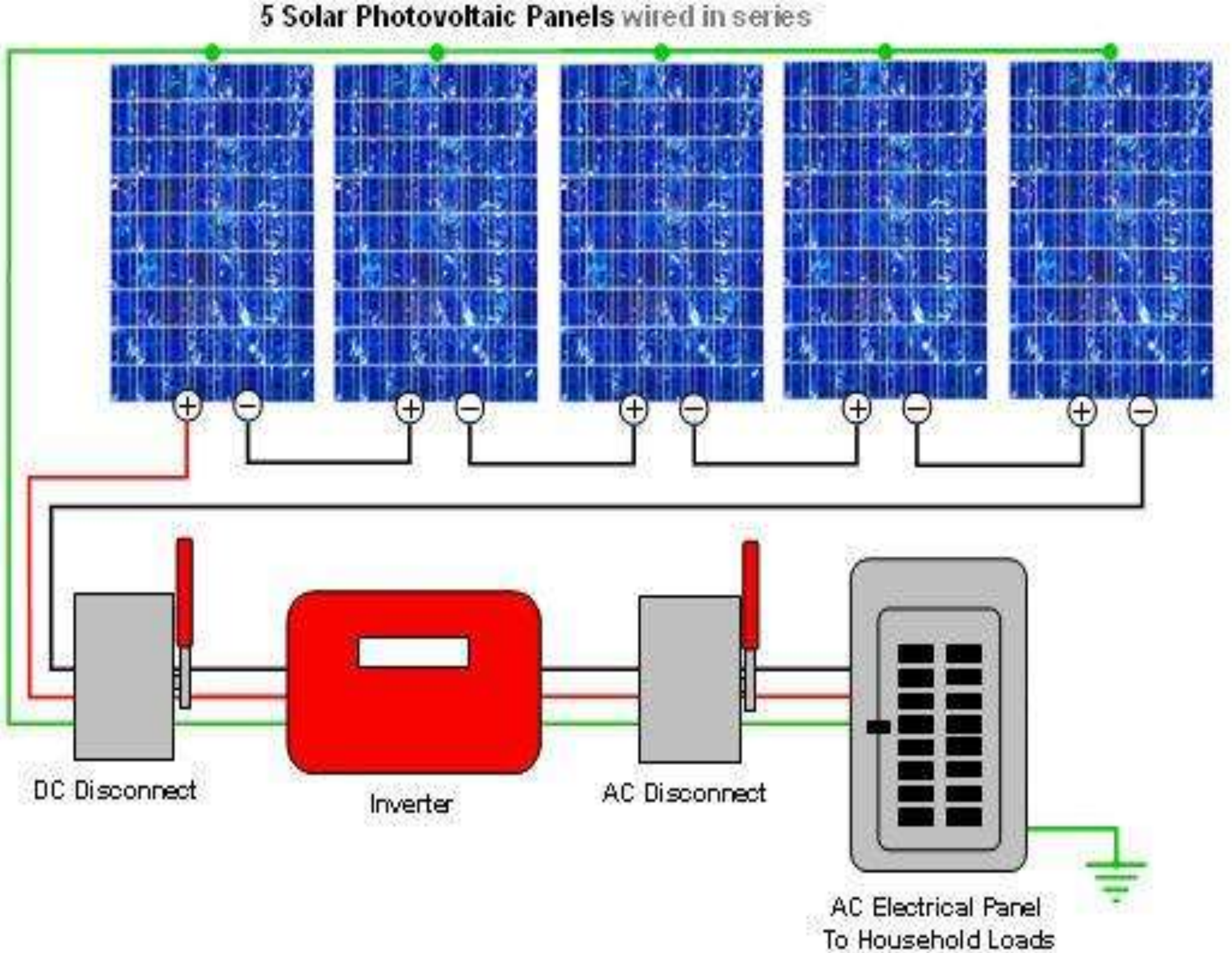
- Ideal material photovoltaic application
- Band gap of 1.53 ev
- Efficiency 11.4%
- Number of alloy components makes the multiple processes extremely complex
- Expensive and rare metals - cost of manufacturing increase
- Not commercialized

Gallium Arsenide

- Used in space application
- High cost
- Most efficient solar cell
- Cell efficiencies -about 30 to 34%
- Too expensive for terrestrial applications

Suitability for Micro-grid Applications

- Use the poly-crystalline SILICON modules solely because
  - Slight cost advantage,
  - Relatively easier availability with vendors
  - Good efficiency
  - Least degradation
  - Local availability and
  - Better life



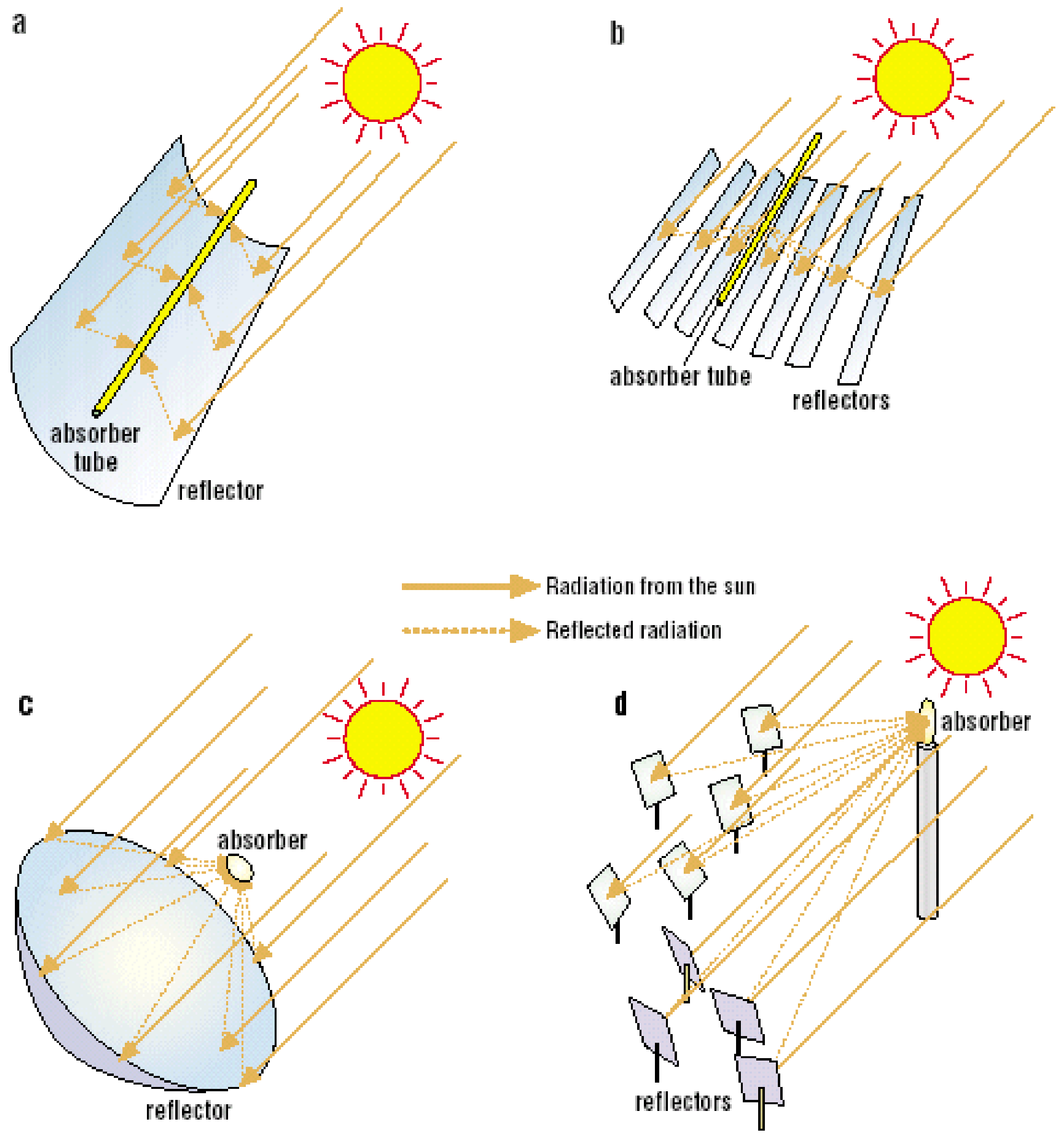
Photovoltaic Micro-grid

Solar Thermal Technologies

Types of Solar Thermal Technologies

- Parabolic trough solar thermal system
- Compact linear fresnel reflector (CLFR) solar thermal system
- Parabolic dish solar thermal system
- Power tower solar thermal system

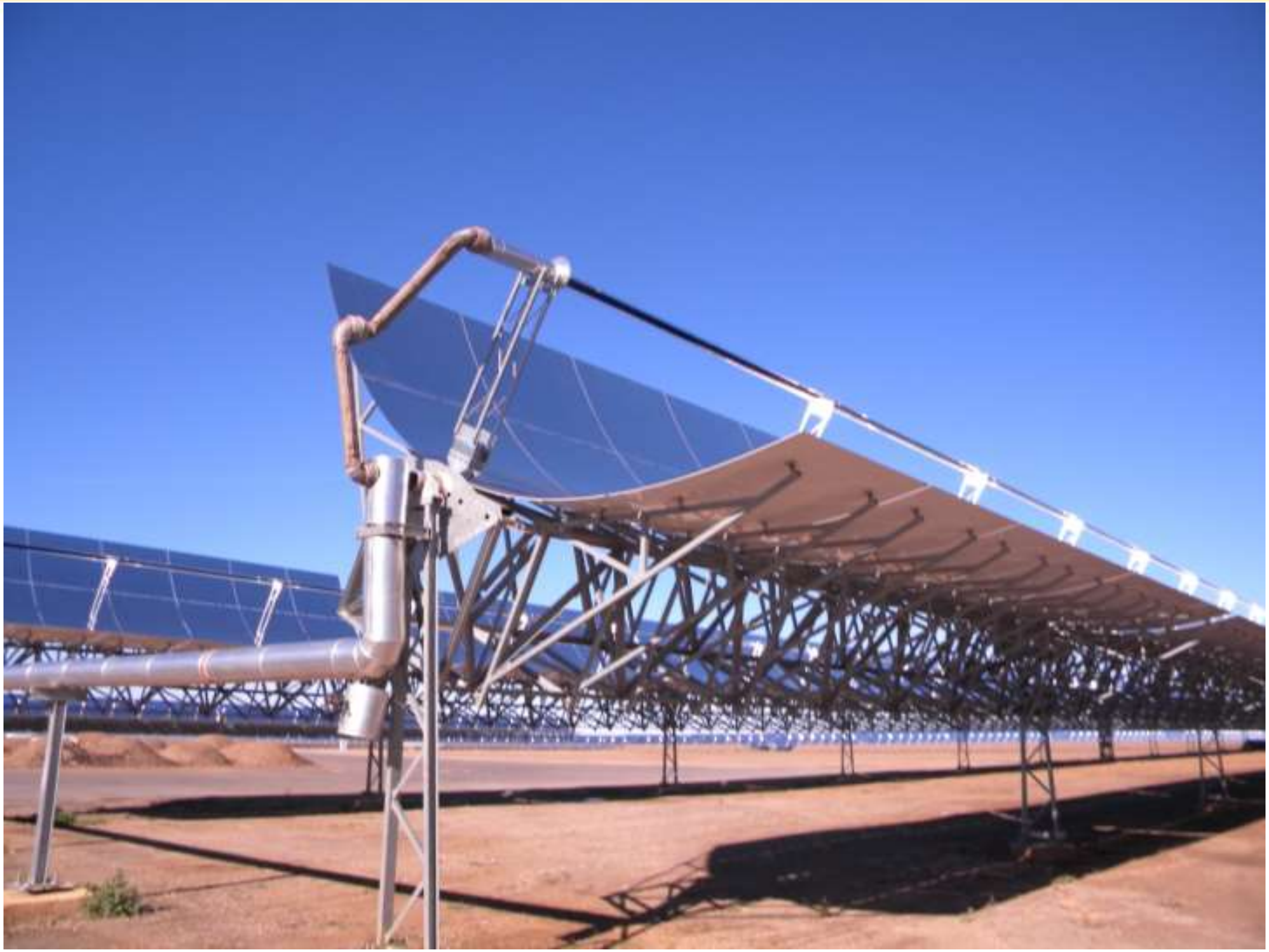
Types of Solar Thermal Technologies



Parabolic Trough Systems

- Parabolically curved, trough–shaped reflectors
- Run in a north–south direction and track the sun from east to west
- Absorber pipes consist of a metal pipe which contains HTF surrounded by a glass pipe
- Hot HTF is used to generate steam
- Steam used to power a steam turbine to turn an electric generator to produce electricity

Parabolic Trough Systems –Andasol, Spain



Parabolic Trough Systems –Andasol, Spain

Compact Linear Fresnel Reflector (CLFR)

- Line focusing system
- Array of nearly flat reflectors
- Flat segments of rectangular shaped mirrors are arranged horizontally in a north–south direction
- Track the sun from east to west

CLFR- Kogan Creek, Australia

Parabolic Dish

- A parabolic–shaped point focus concentrator
- Reflects solar radiation onto a receiver mounted at the focal point
- Concentrators are mounted on a structure with a two axis tracking system
- Collected heat utilized directly by a heat engine (sterling engine)

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Parabolic Dish

Power Tower

- Called central receivers
- Utilizes a two axis sun-tracking mirrors called heliostats
- HTF heated in the receiver
- Used to generate steam in the steam generator
- Steam is used to power steam power cycle to turn steam turbine to generate electricity

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Power Tower- Abengoa, Spain

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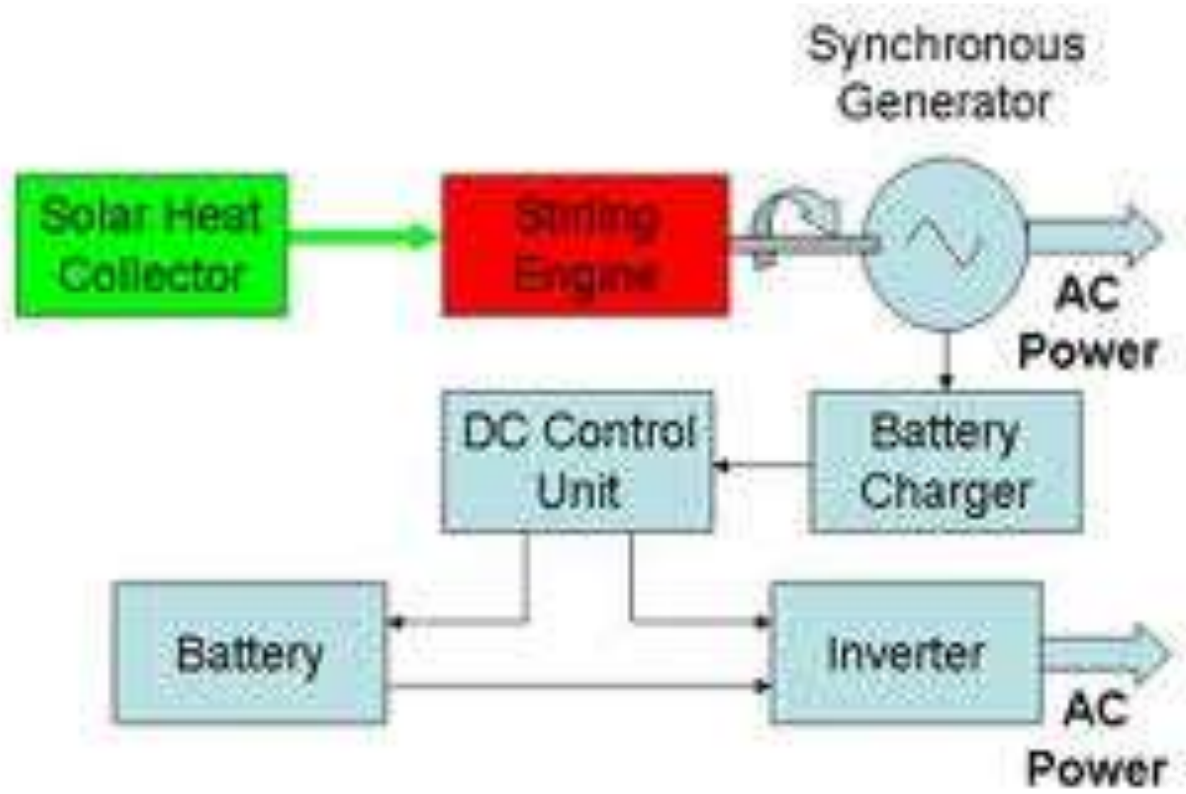
Suitability for Micro-grid Applications

- Parabolic trough systems, CLFR systems & solar tower systems **not suitable** for small application
- Parabolic dish systems **only suitable**



Small Scale Electric Power from Solar Thermal Energy

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Grid Solar PV Power Potential

Technology	potential with 1% of Utilizable waste land	potential with 2% of Utilizable waste land	potential with 3% of Utilizable waste land
Solar PV (MW)	2564	5128	7692
CSP (MW)	286	571	857
Total (MW)	2850	5699	8549

Source: Renewable Energy Potential Assessment of Bihar (WISE Report 2011)

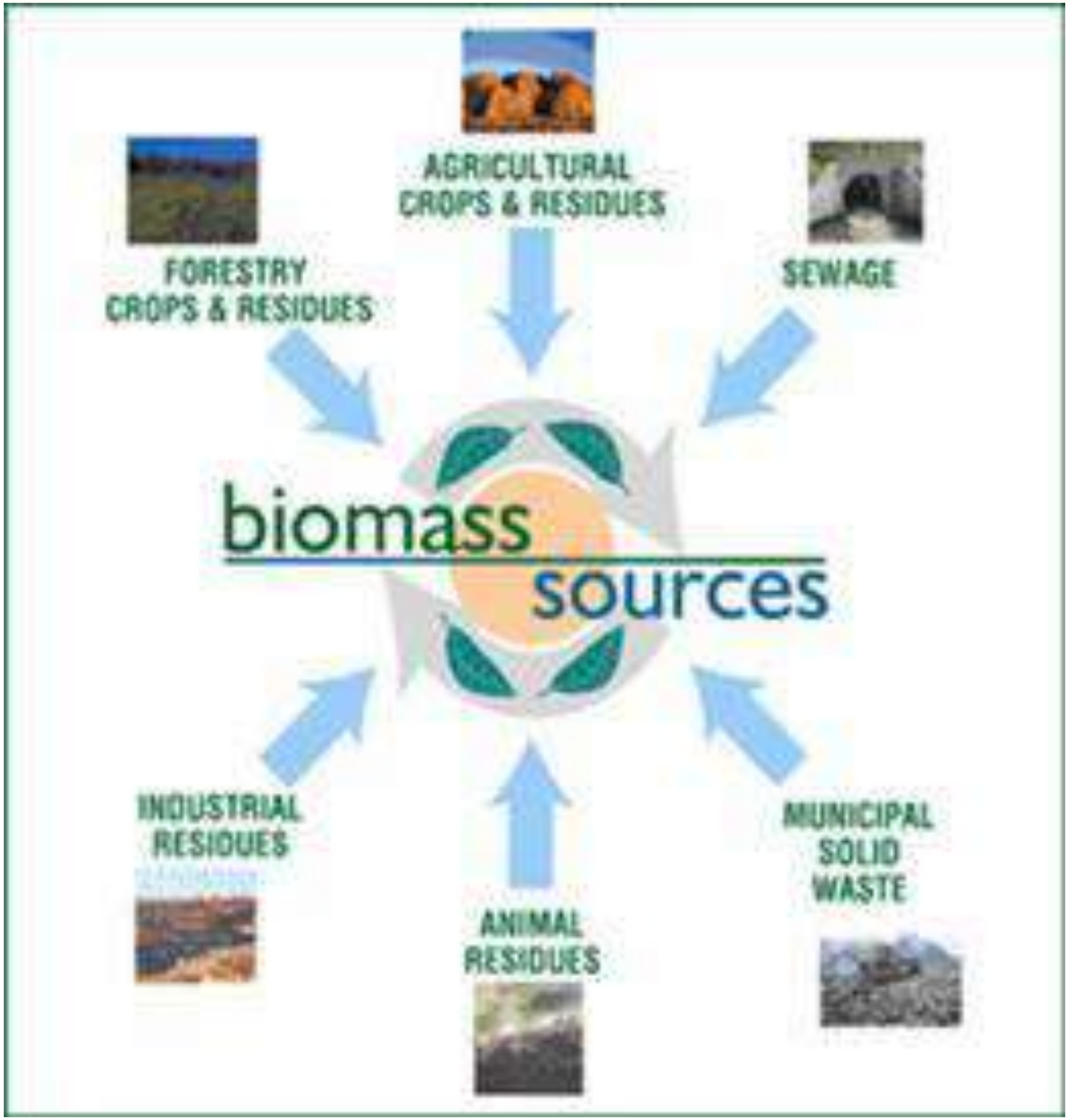
Off-grid Solar PV Potential

Technology	Potential	Unit
Roof-top PV	3936	MWp
SPV pumps	2665	MWp
Solar street lights	282	MWp
Solar powered hoardings/boards	472	MWp
Solar power packs	3122	MWp

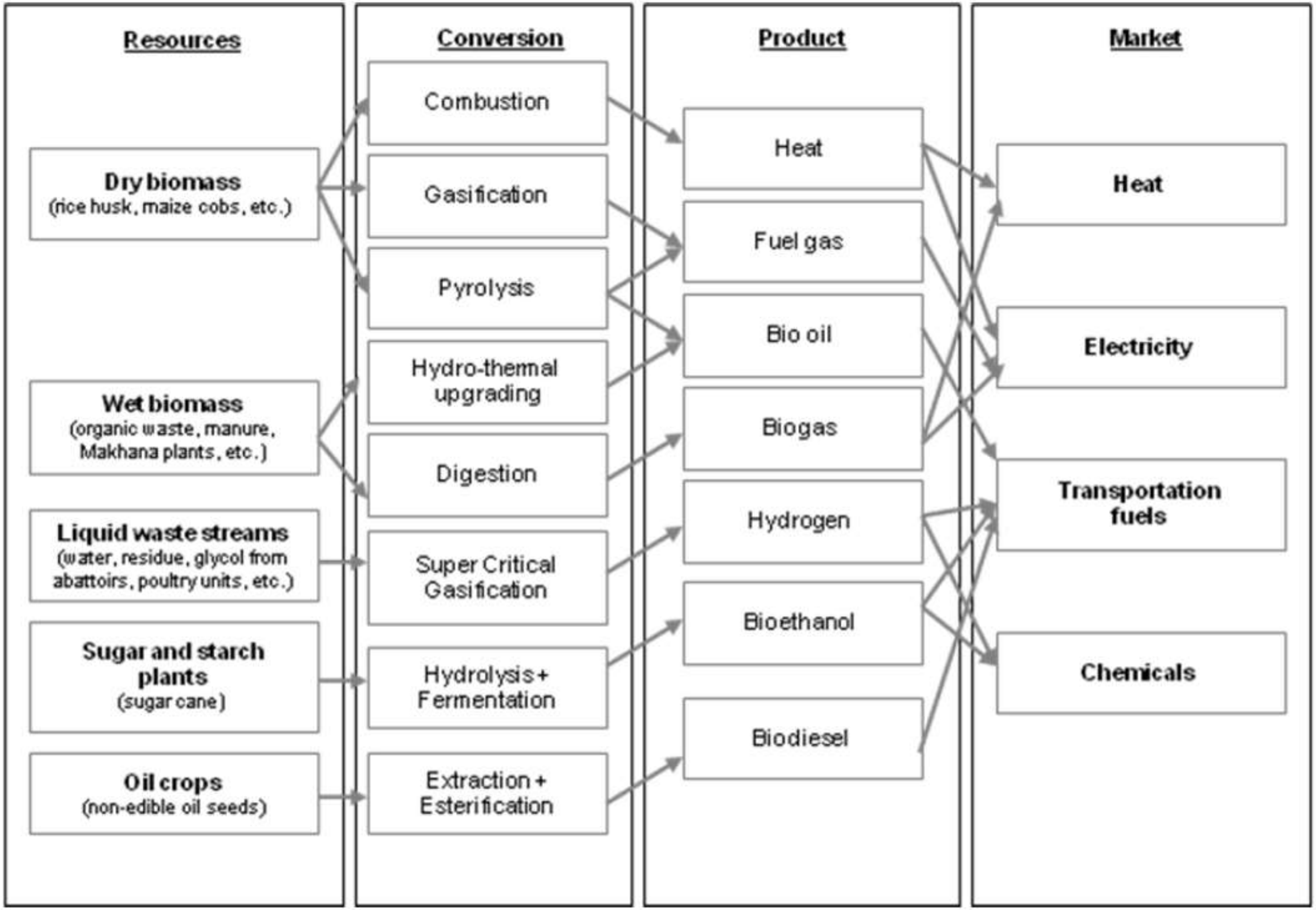
Source: Renewable Energy Potential Assessment of Bihar (WISE Report 2011)

Biomass Energy

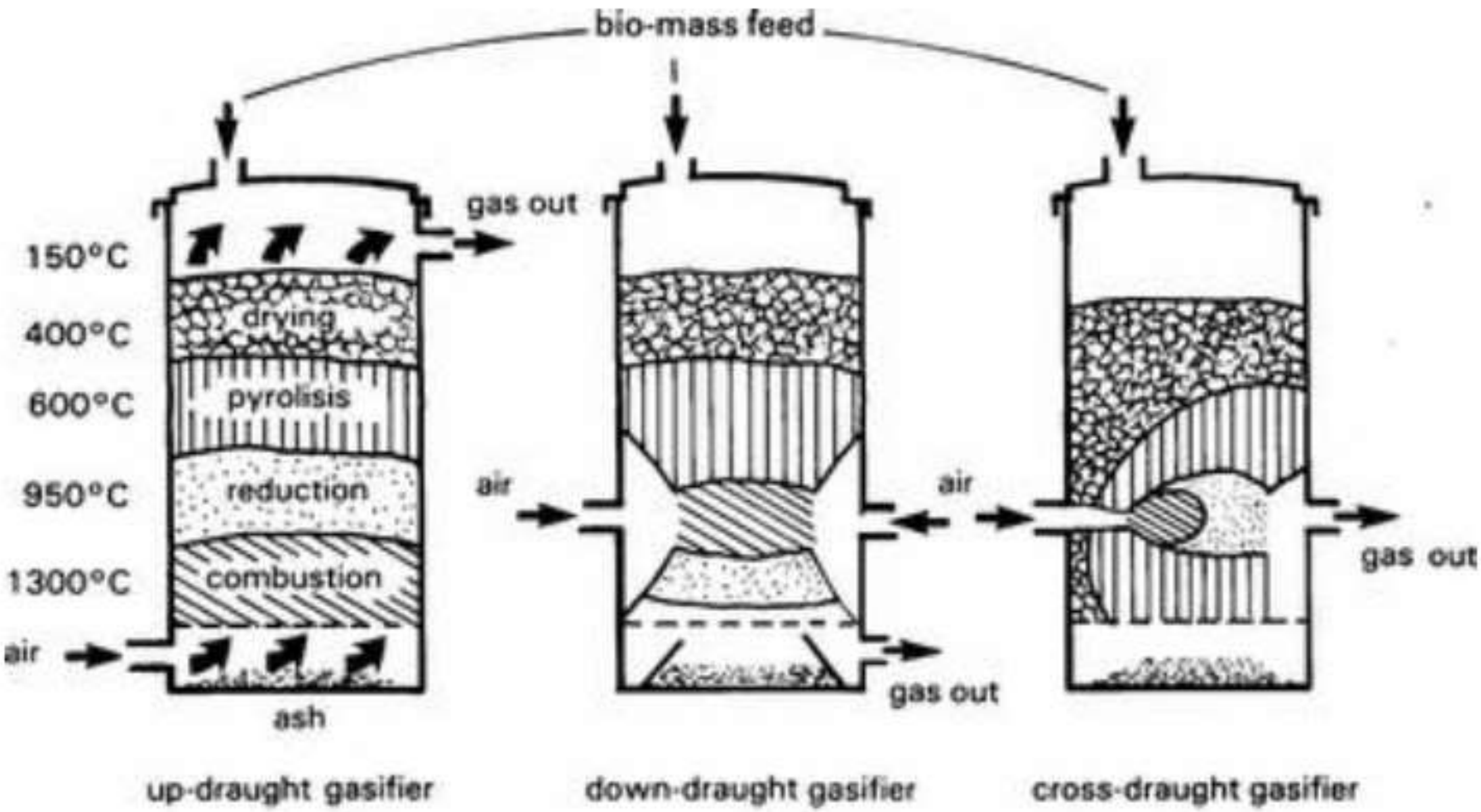
Biomass Types



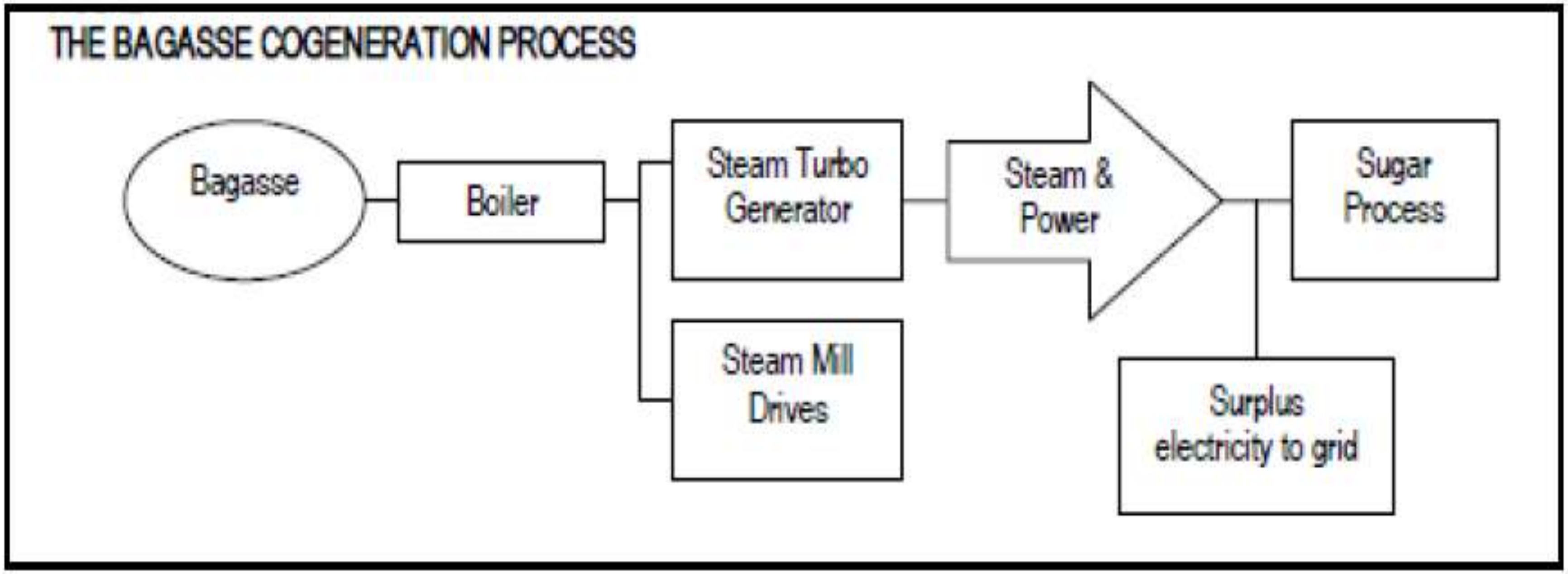
Biomass Conversion



Biomass Gasifier



Bagasse Gogeneration



Biomass Power Potential

S. No	Energy Source	Power Potential (MW)
	Agro Residues	
1	Rice husk (50% availability)	180
2	Rice husk (100% availability)	360
3	Rice straw (50% availability)	1335
4	Maize cobs (50% availability)	87
5	Sugarcane bagasse	300
Sub total		1902 to 2082
	Urban Waste	
6	Municipal Solid Waste (thermochemical conversion)	26
7	Municipal Solid Waste (biochemical conversion)	17
8	Municipal Liquid Waste (Class I & Class II Cities)	21
Sub total		38 to 47
	Other Industrial Wastes	
9	Distillery (spentwash)	13
10	Dairy (washings, whey)	0.2
11	Sugar (waste water, pressmud)	4.6
Sub total		17.8
Total		**1950 to 2150**

THANK YOU

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