Issues and challenges in Decentralized/Distributed Generation

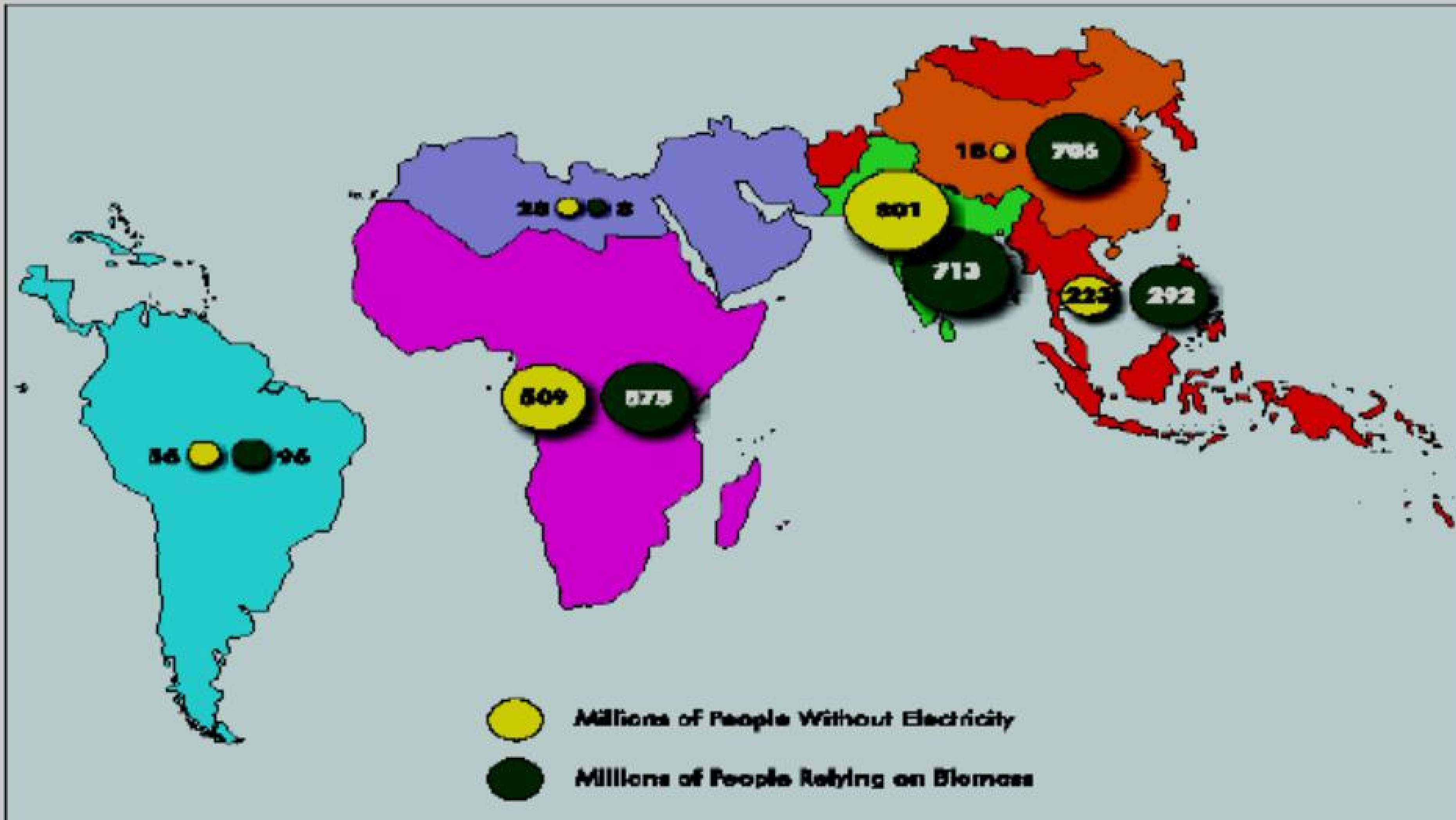
V V N Kishore
Professor & Head, Department of Energy and Environment
TERI University, New Delhi
1-2 January 2010

Distributed Generation

- The developing country perspective
- The developed country perspective

1.6 Billion People with no electricity

Global Energy Poverty

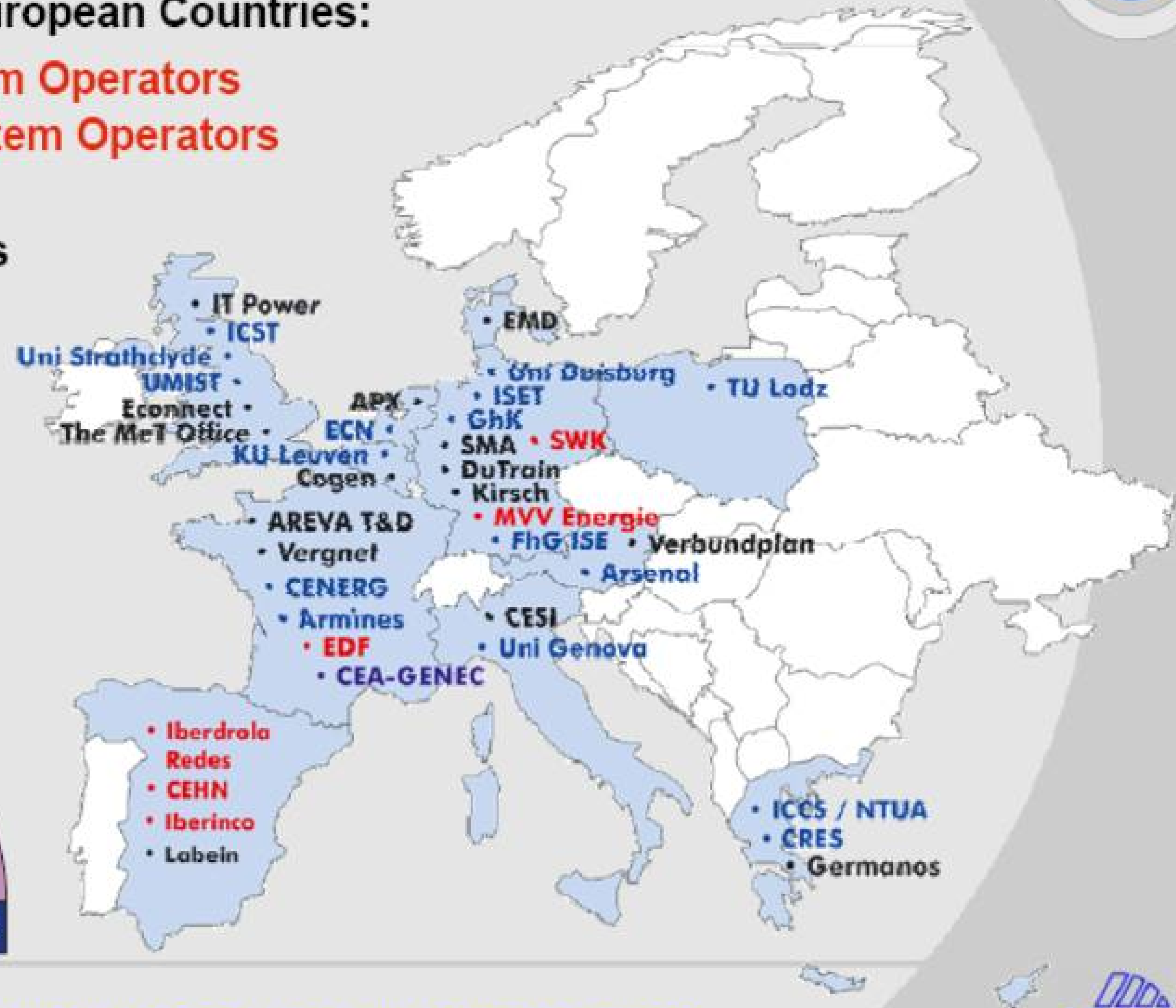


Source: IEA analysis.

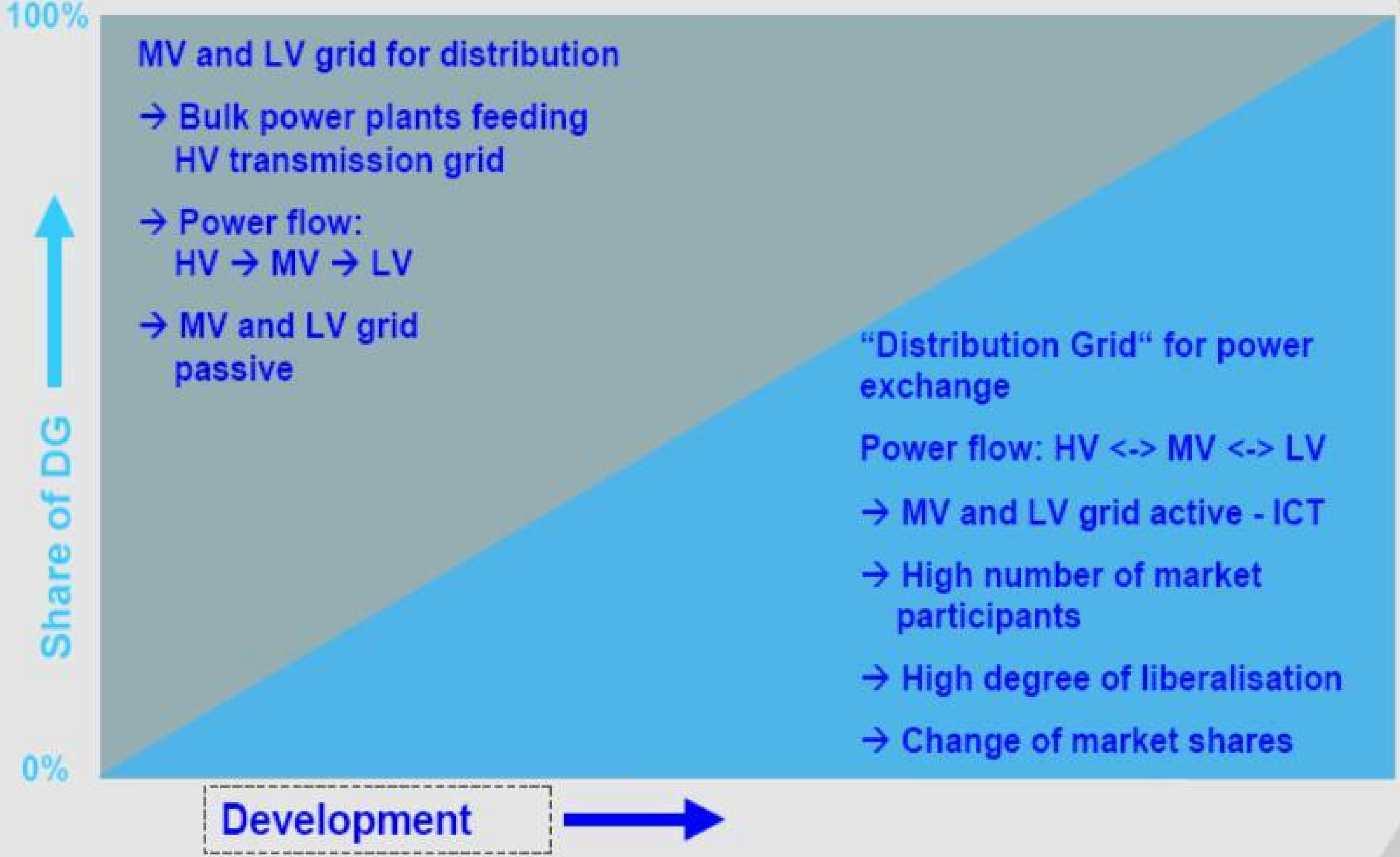
EU-Project DISPOWER: Consortium

38 Partners in 11 European Countries:

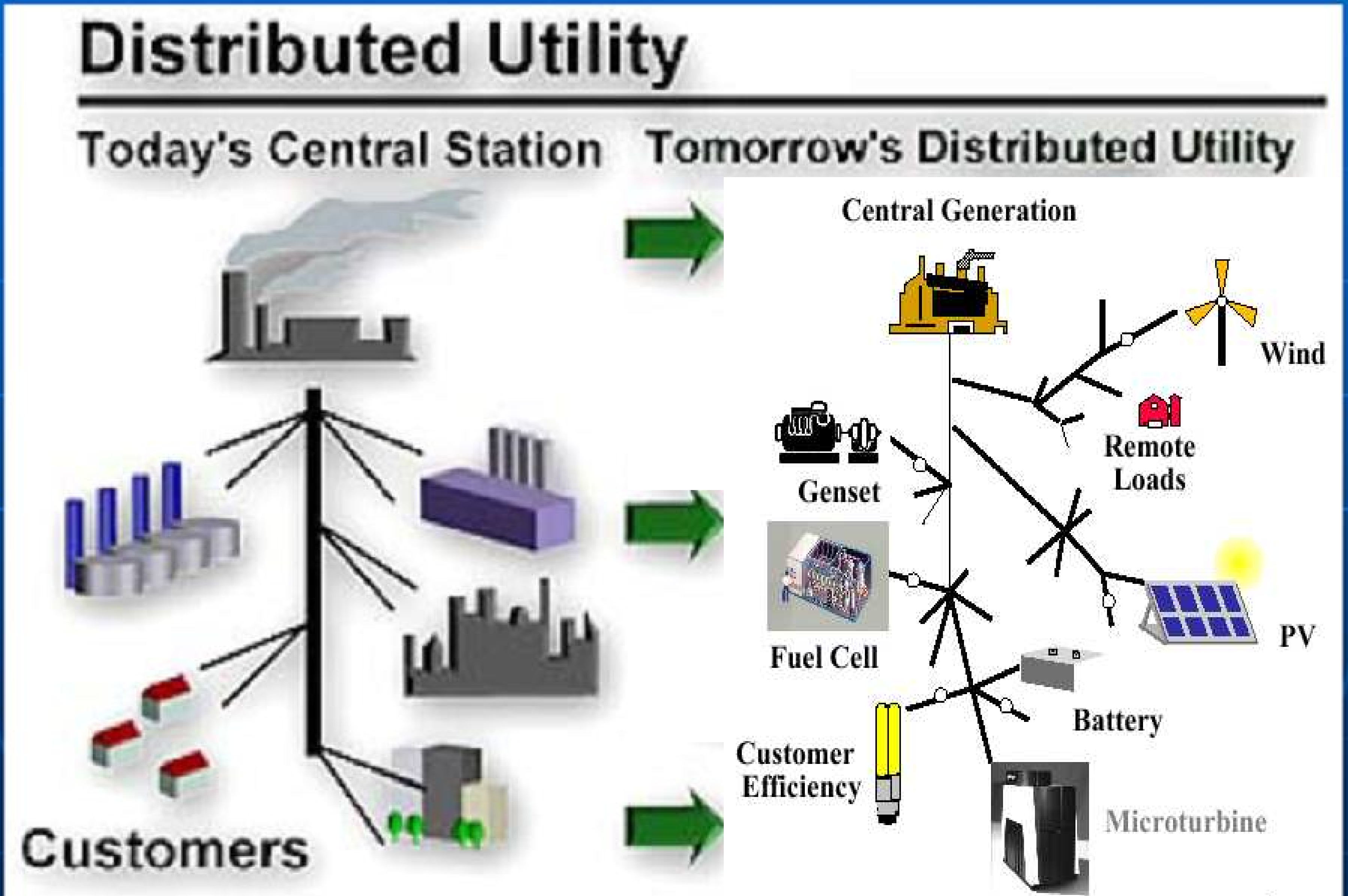
- Distribution System Operators
- Transmission System Operators
- Industry
- Service companies
- Research centres
- Universities



DG Share in Interconnected Electricity Grids



Transition from Central to Distributed



Distributed Generation (DG)

- Small-scale power generation technologies located closer to the load being served than central station generation.
- DG can be connected directly to the consumer or to a utility transmission or distribution system.

Benefits of Distributed Generation

- Allows customers to continuously generate electricity, with or without grid backup.
- Generates electricity on site, reducing electricity demand during peak price periods.
- Creates potential for customers to sell excess energy back to the grid.
- Improves power quality and reliability.
- Broadens market for renewable and other alternative energy sources.

Pros of Distributed Generation

- Flexible
- Modularity
- Rapid startup
- Efficient
- Power quality & reliability
- Reduced transmission & distribution problems
- Opportunities for R&D and Technology Transfer
  - Demonstration Programs

Technologies / Fuels

Conventional

- Microturbines
- Fuel Cells
- Cogeneration
- Internal Combustion Engines

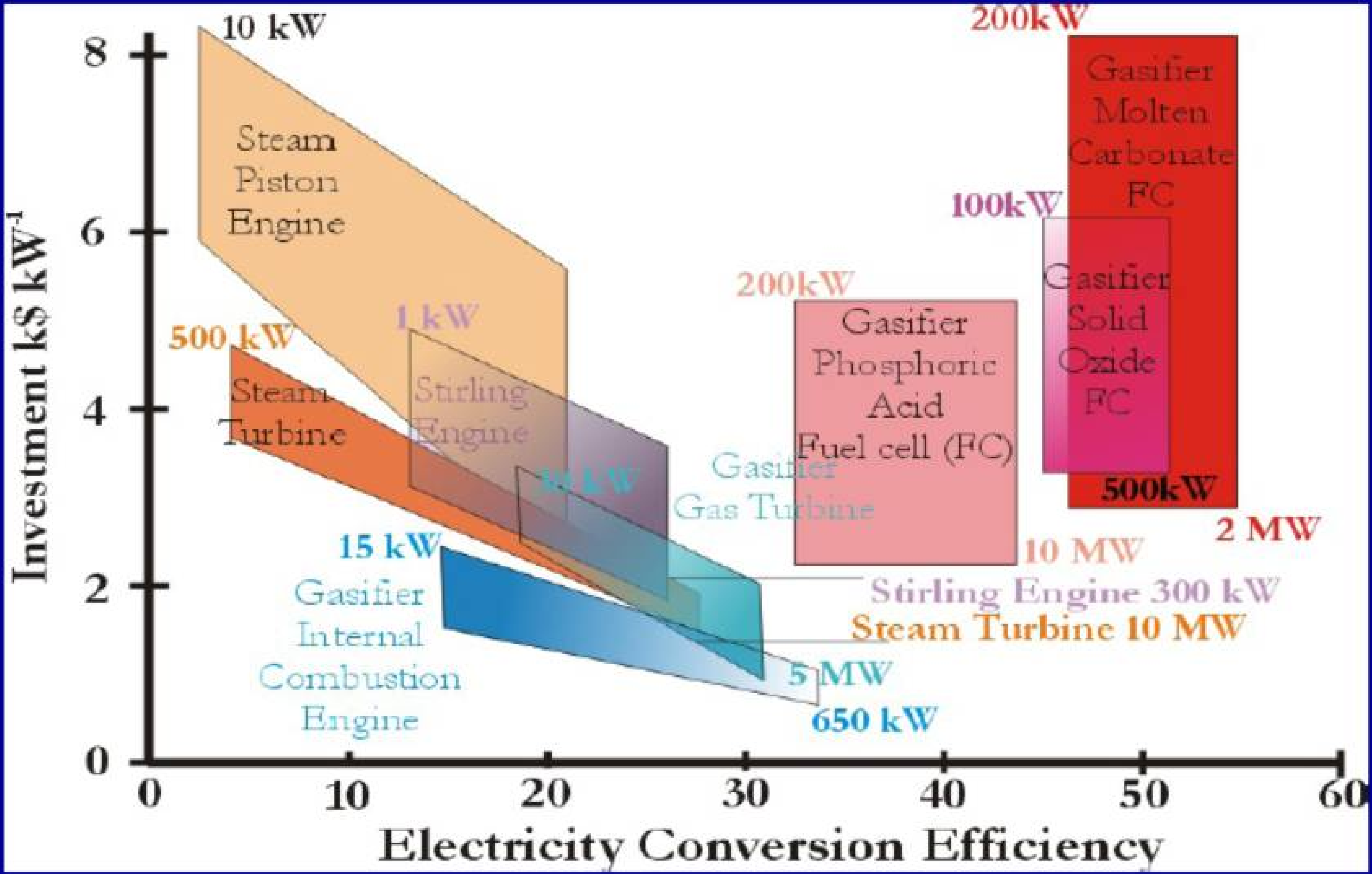
Alternative / Renewable

- Wind
- Solar
- Biomass / Biodiesel
- Wave / Tidal

Energy Efficiency & Demand Side Management !

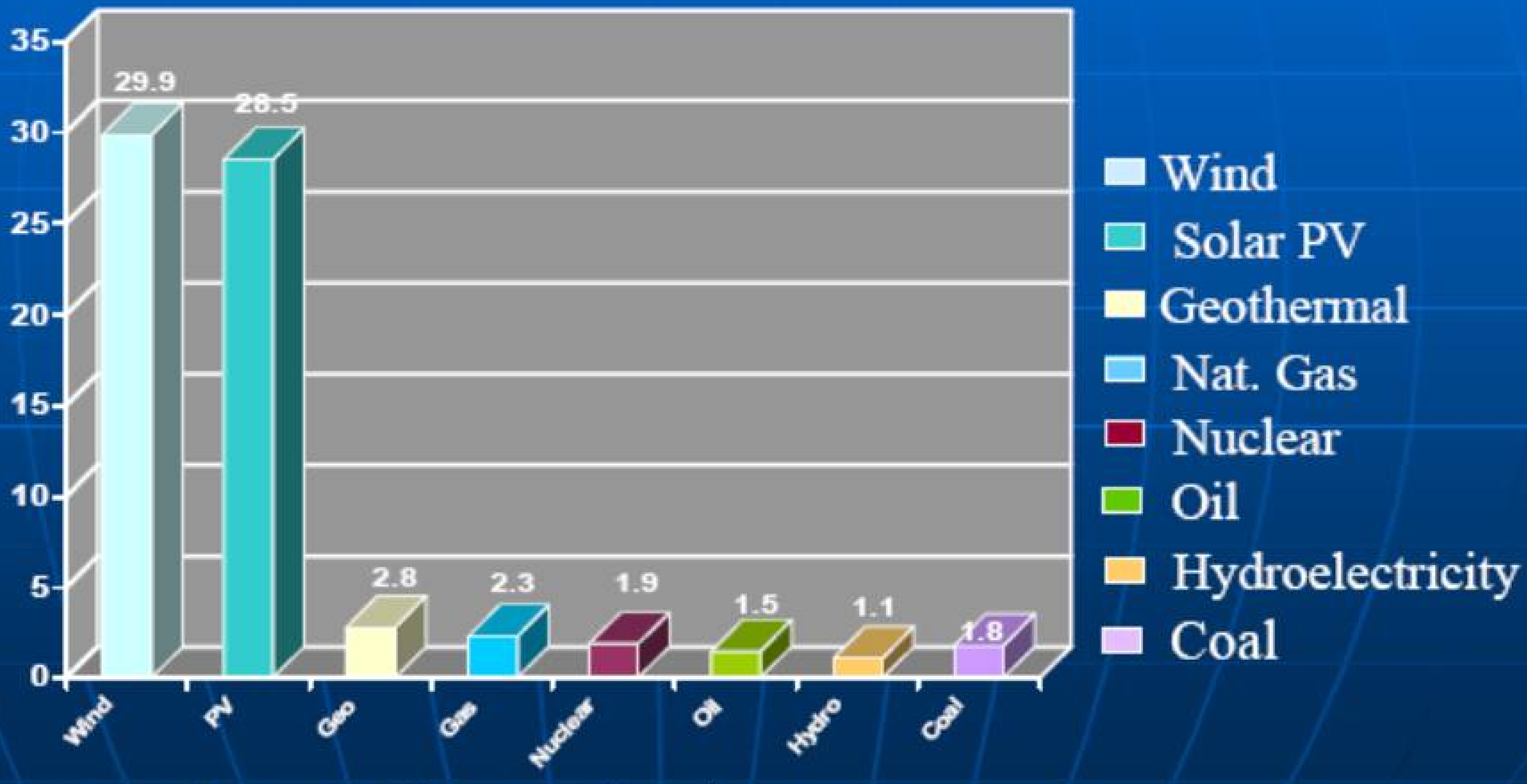
Power Generation Technologies

Technology Performance



Fastest Growing Energy Sources in the World

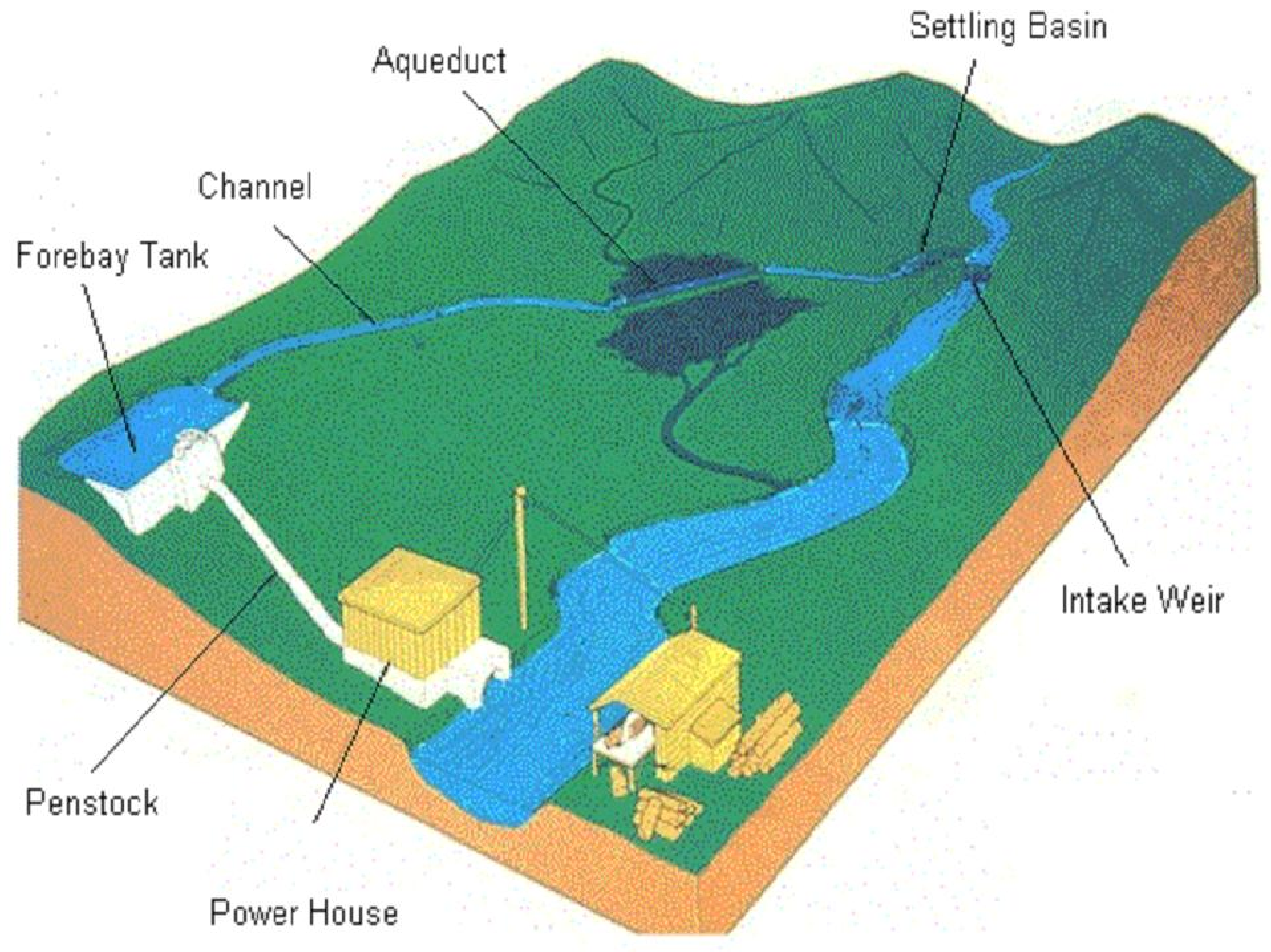
Global % Growth by Energy Source, Annual Average,1993-2003*



Source: Statistical Review of World Energy 2004 (bp.com)
Note: Wind, PV, Geothermal – (installed capacity MW); Gas, Oil, Hydro, Coal, Nuclear – (consumption MTOE).
*PV 1992-2002

Small scale hydropower

Generally up to 25 MW,
Mostly low head,
Does not require large dams,
Flooding impacts are minimal,
Does not impact the watershed,
Equipment is less expensive, widely available


Settling Basin
Aqueduct
Channel
Forebay Tank
Intake Weir
Penstock
Power House

Battery charger (1-10kW)

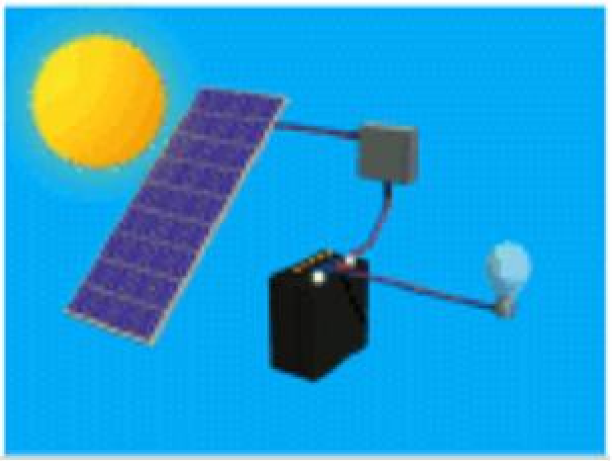
MW level Windfarm in Karnataka

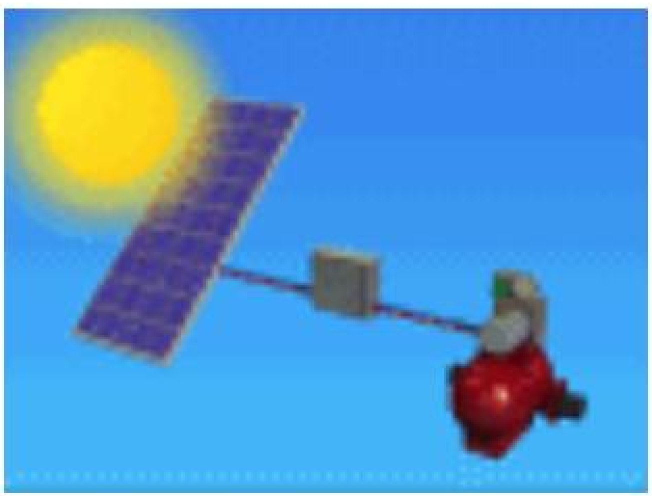
Wind Turbines

Scale	Rotor Diameter	Power rating
Micro	< 3 m	50 W to 2 kW
Small	3 m to 12 m	2 kW to 40 kW
Medium	12 m to 45 m	40 kW to 999 kW
Large	46 m and larger	more than 1 MW

SPV systems

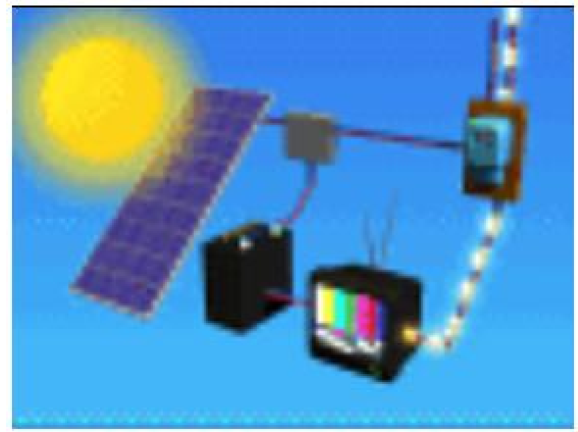
Stand alone system



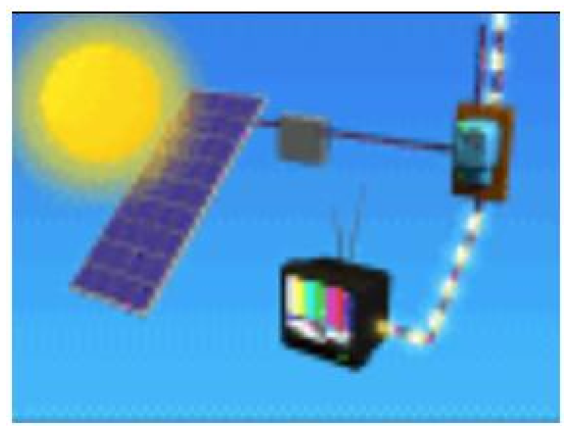


SPV pump system

Grid connected systems



With battery storage



Without battery storage

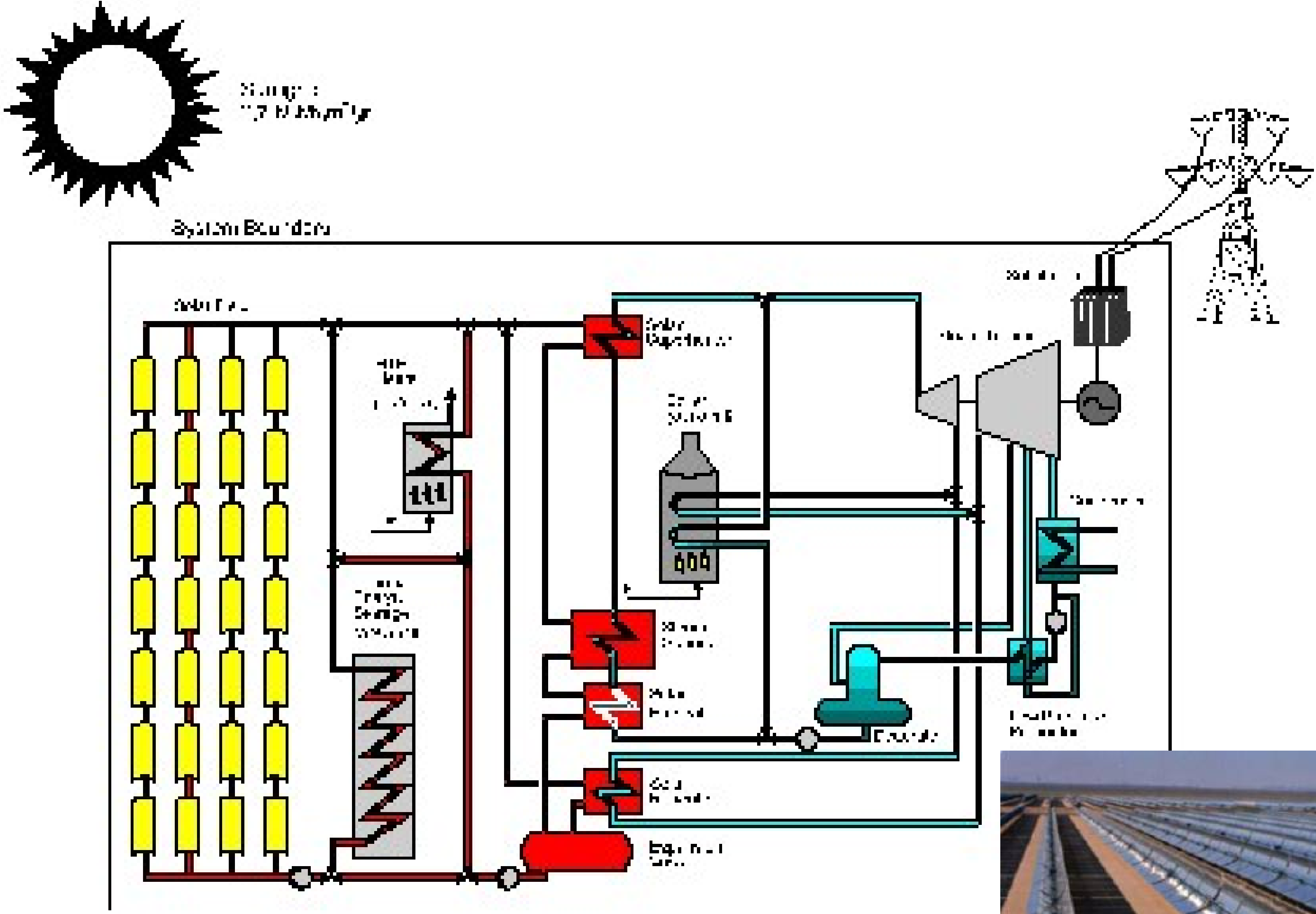
Building integrated photovoltaic

- Energy can be produced using untilised roof area.
- Solar PV modules become part of building thereby reduce the ‘add on’ cost of the system
- Promoted in many countries for grid feed type systems

PV Cell Efficiencies

PV Cell	Efficiency
Si (crystalline)	24.7
Si (multi-cryst.)	19.8
GaAs (crystalline)	25.1
GaAs (thin film)	23.3
CIGS (cell)	18.4
Amorphous-Si	12.7
GaInP/GaAs (multi)	30.3

Measured under global AM 1.5 spectrum (1000 w/m^2) at 25 deg C



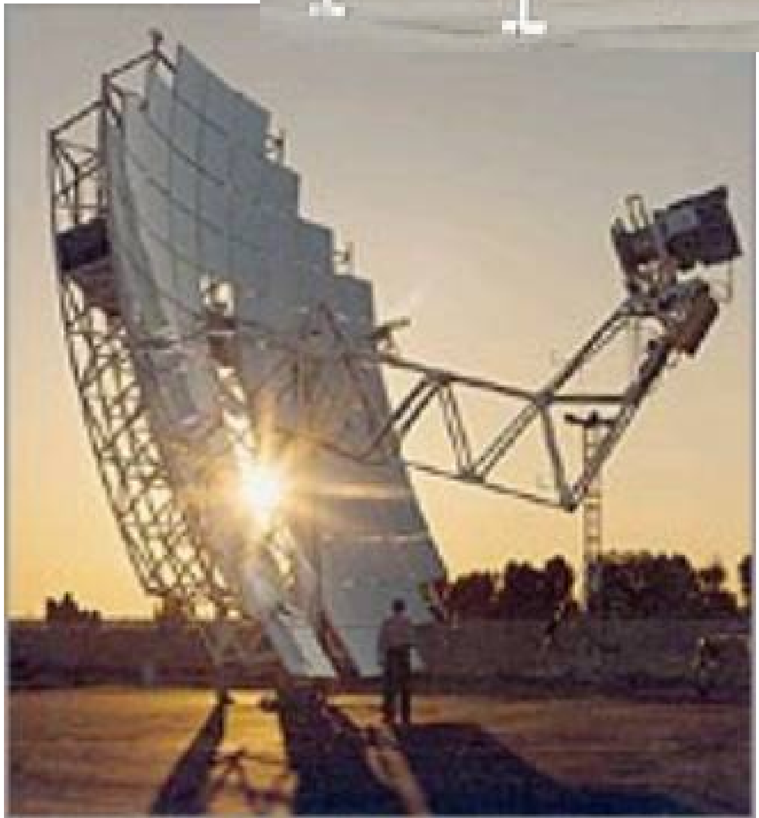
PTC plant diagram

Solar Tower technology

- 1,926 sun-tracking heliostats (mirrors)
- molten salt thermal storage system
- tower (300 ft) with central receiver
- conventional steam driven turbine and generator
- produces about 10 MWe, enough power to serve 10,000 homes with electricity
- costs about 40 million US$

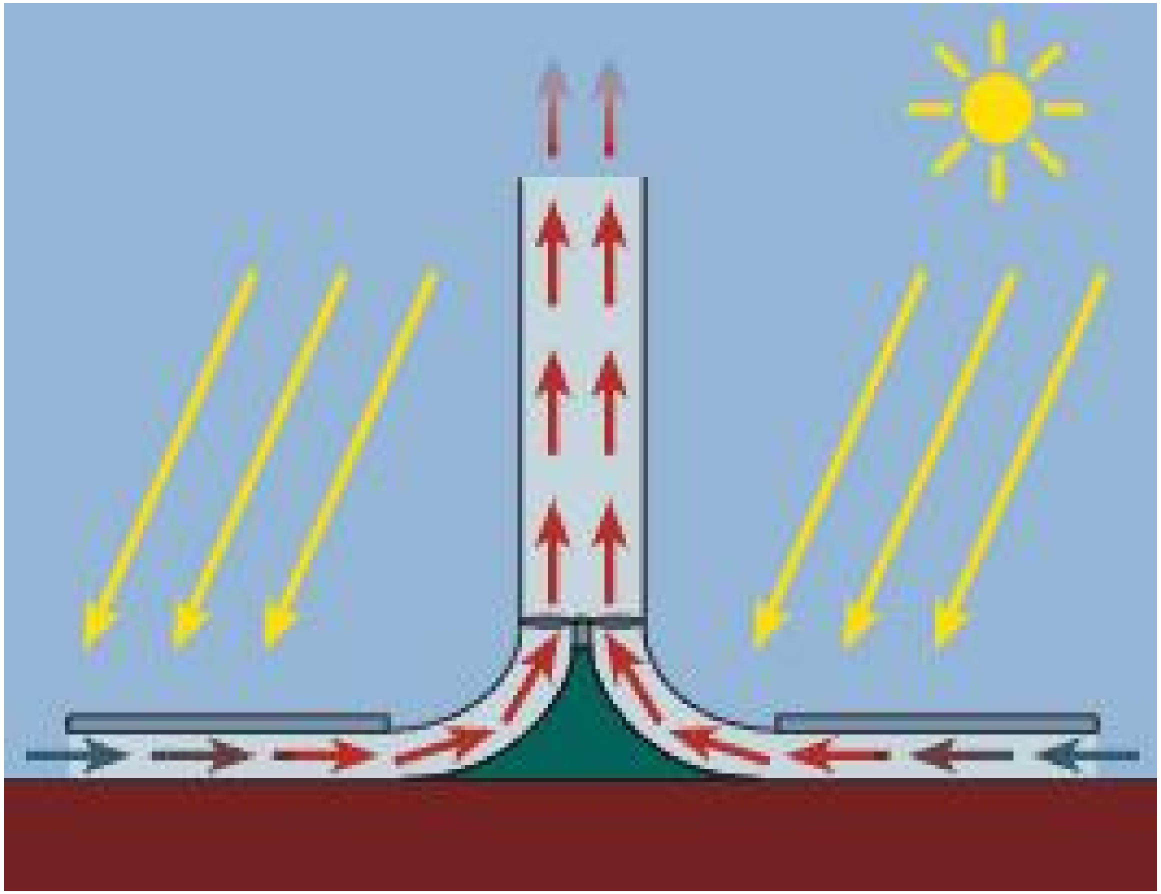
Solar dish – Stirling engine

This Science Application International Corporation/ STM Power Inc. 25 kW Dish-Stirling System is operating at a Salt River Project site in Phoenix, AZ.

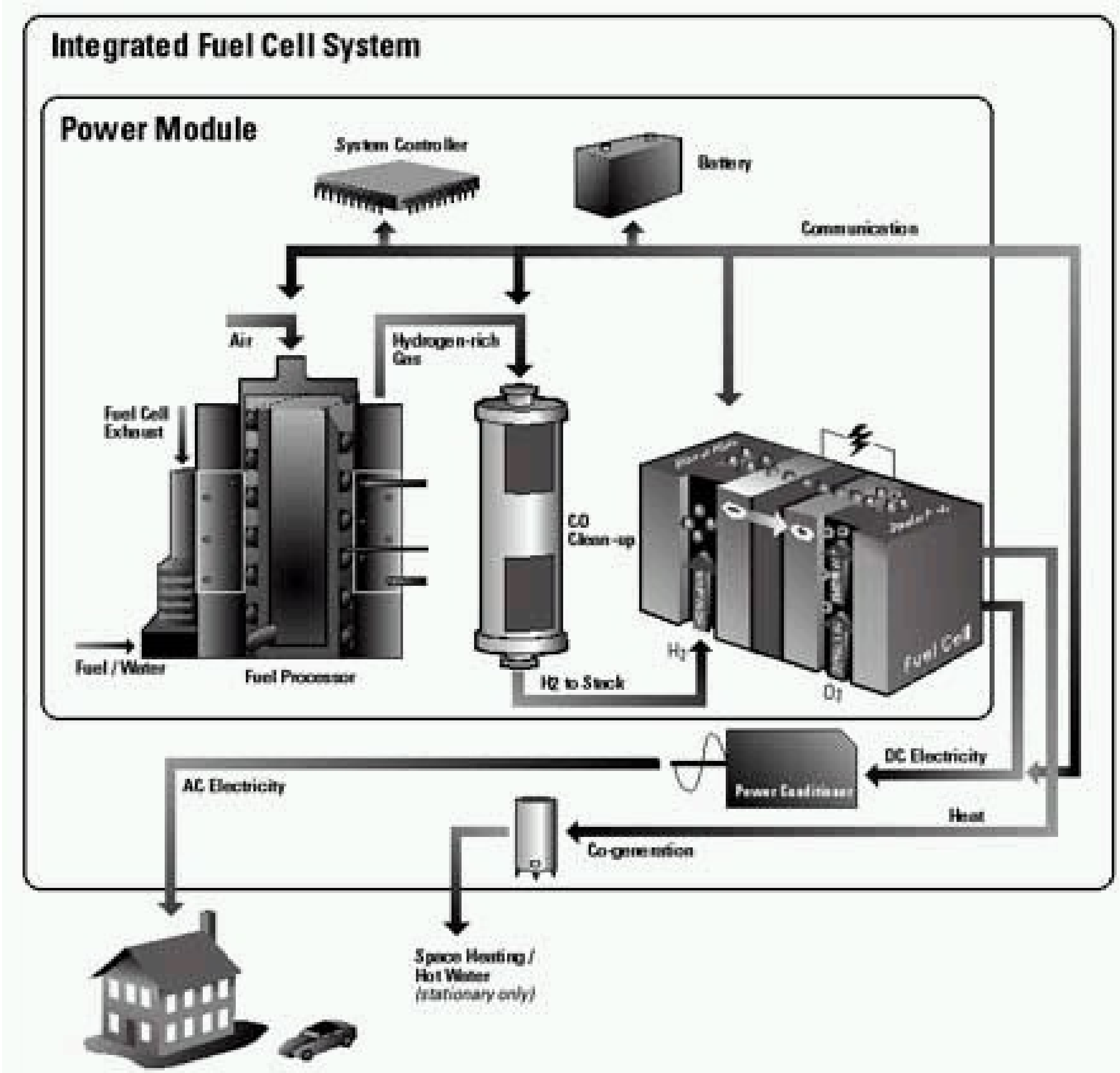


Salinity gradient solar pond

Solar chimney



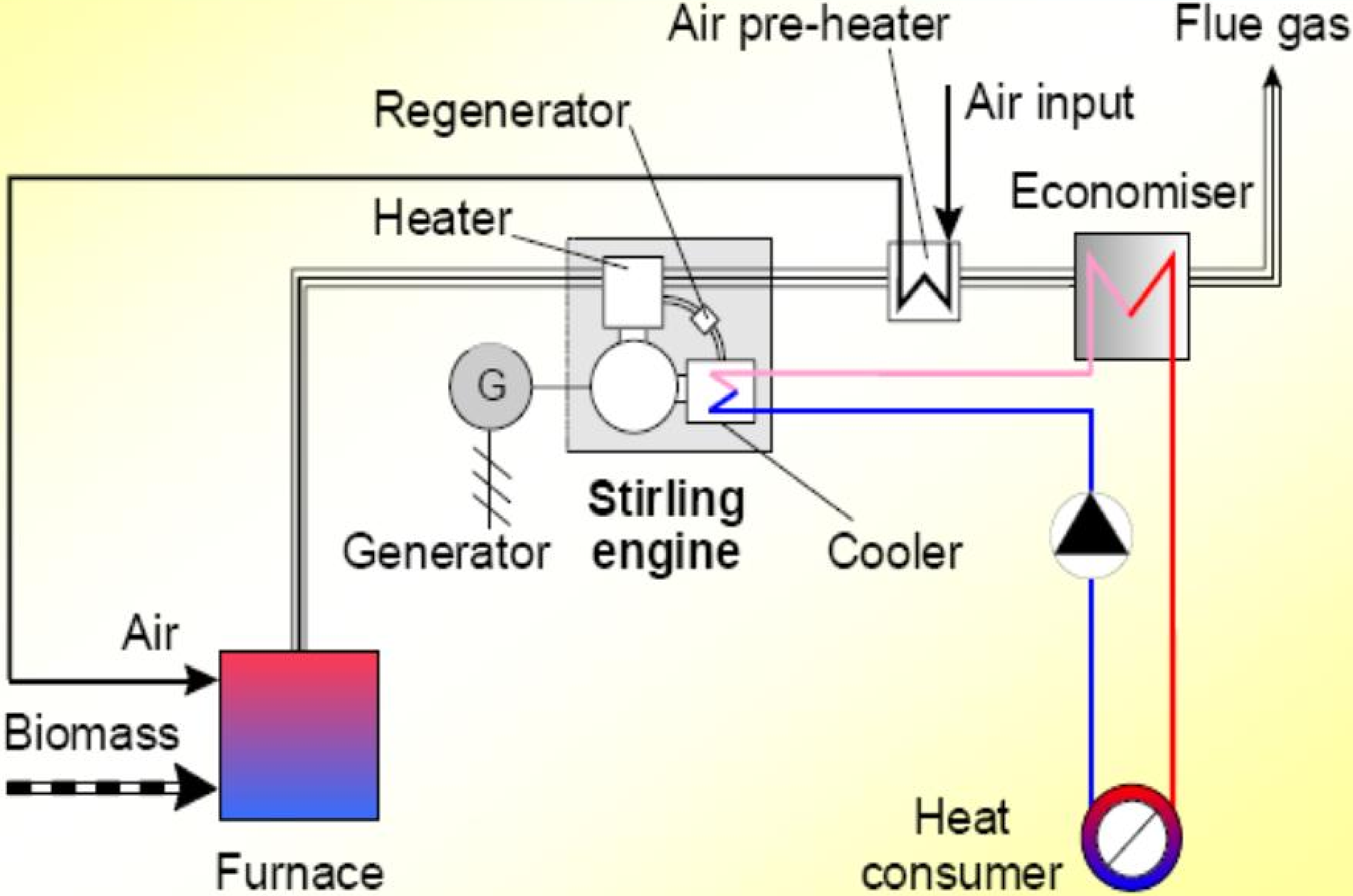
Nuvera fuel cell power plant schematic



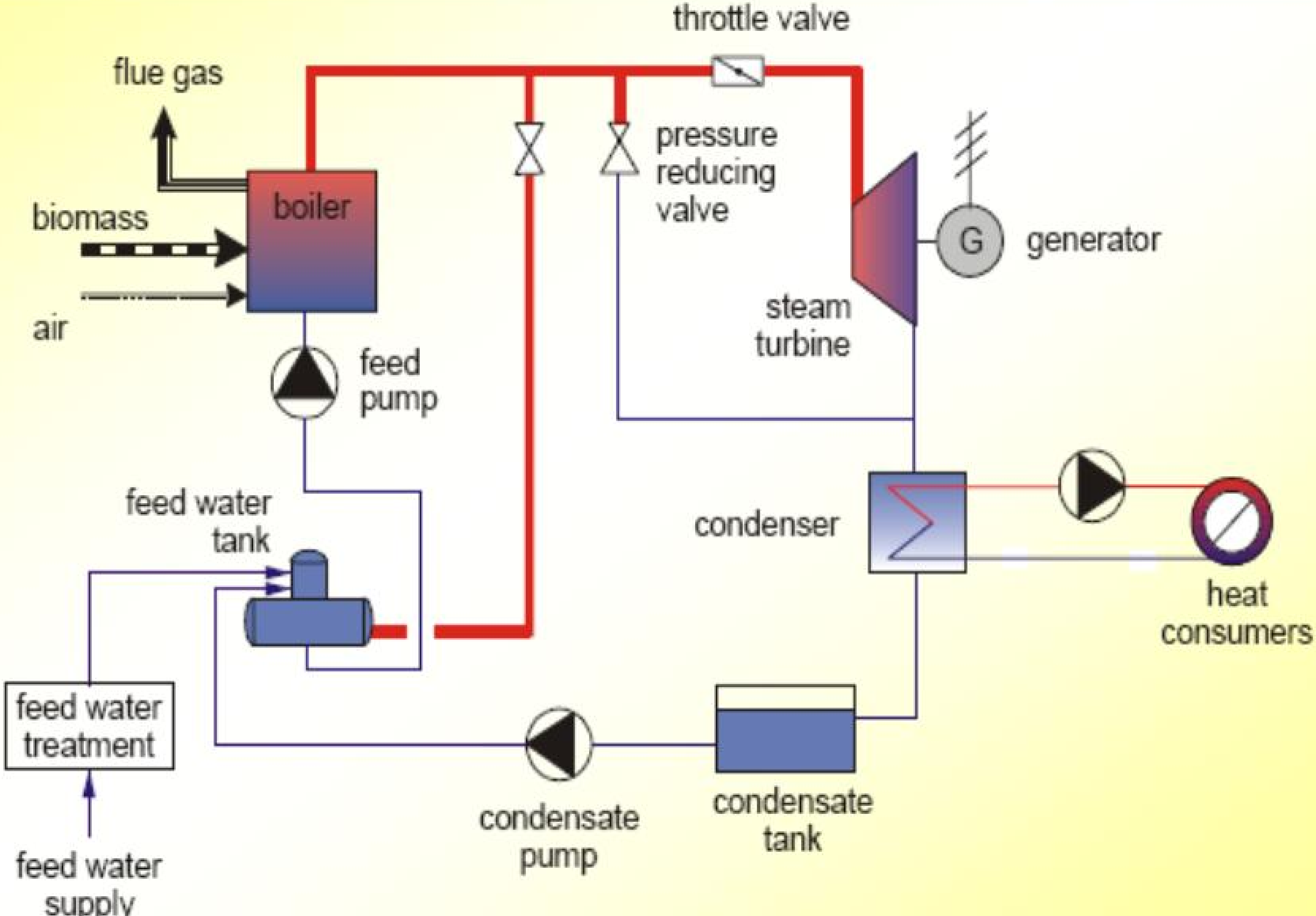
Electricity from Biomass

- **Mid Term**
  - Modular Systems (village power)
  - Micro turbines, Stirling engines
  - Simple to operate in remote locations
- **Long Term**
  - Integrated Gasification Combined Cycle, ~40+% eff.
  - Advanced gas turbines, fuel cells
  - Demonstrations in U.S. and Europe

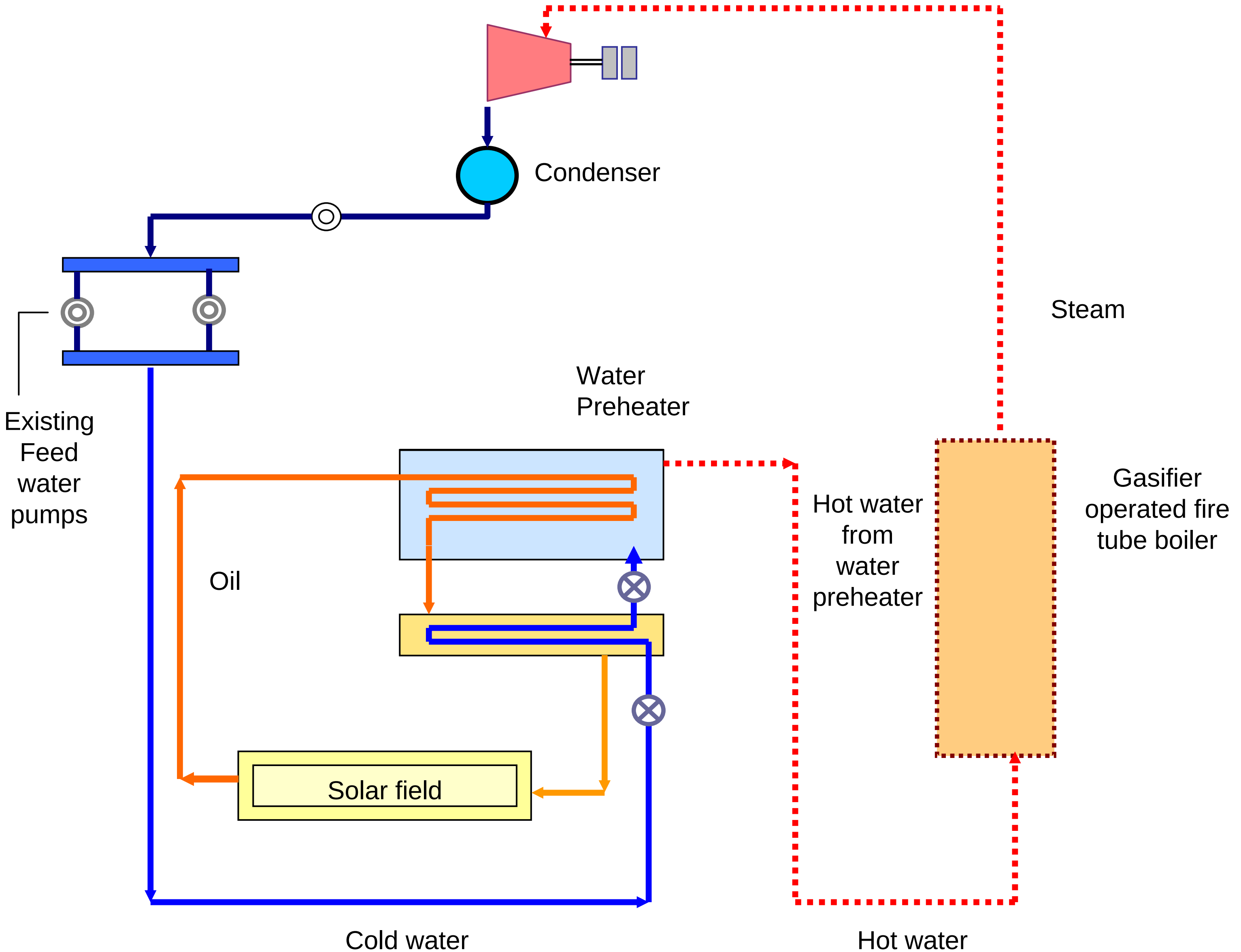
Small-scale biomass CHP pilot plant based on a Stirling engine - scheme



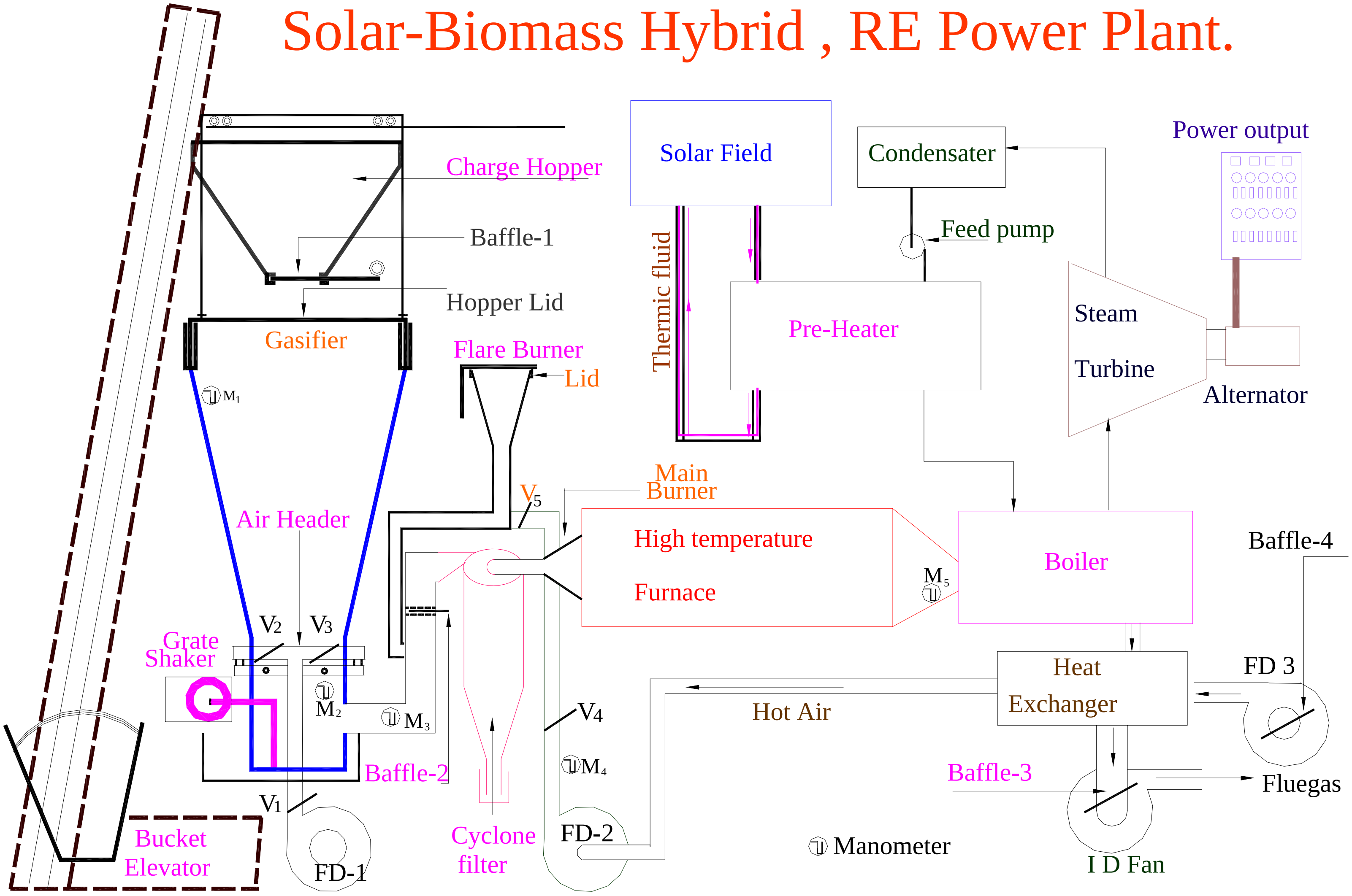
Steam turbine process - scheme



Schematic of integration of Solar Water Preheater and Gasifier-Boiler at SEC

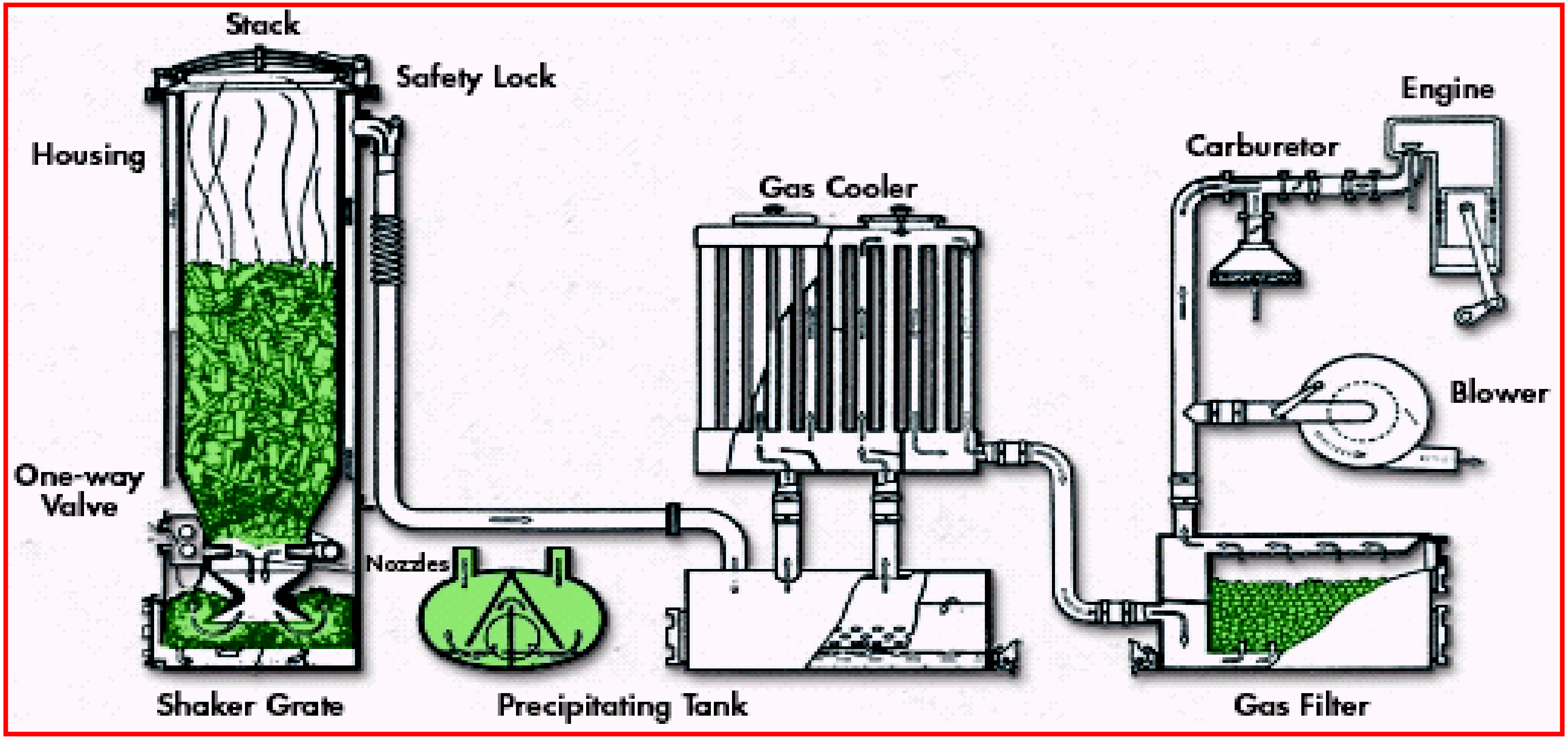


Solar-Biomass Hybrid , RE Power Plant.

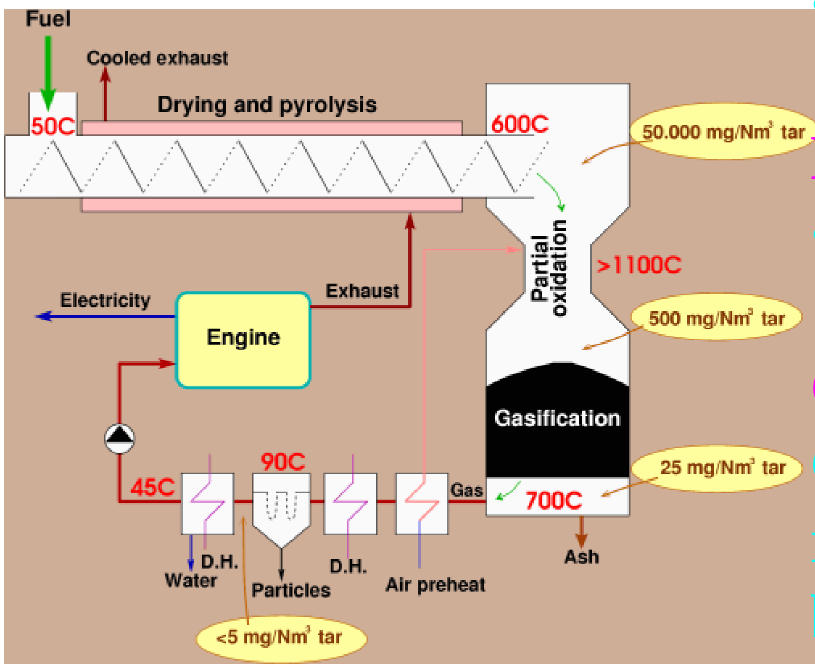


Hybrid (solar thermal+biomass gasifier) renewable energy power plant

Basic layout of biomass gasifier based power plant



DTU-Viking two stage gasifier



- pyrolysis & gasification in two separate reactors with high temperature intermediate tar cracking zone
- <25 mg/Nm3 tar content even in raw gas without cleaning

Pyrolysis zone:

- biomass heated to 600 c using engine exhaust (BRT 30-60 min)

Partial oxidation zone:

- maintained at 1200-1400 C to crack tars: 99% tar elimination

Coke bed:

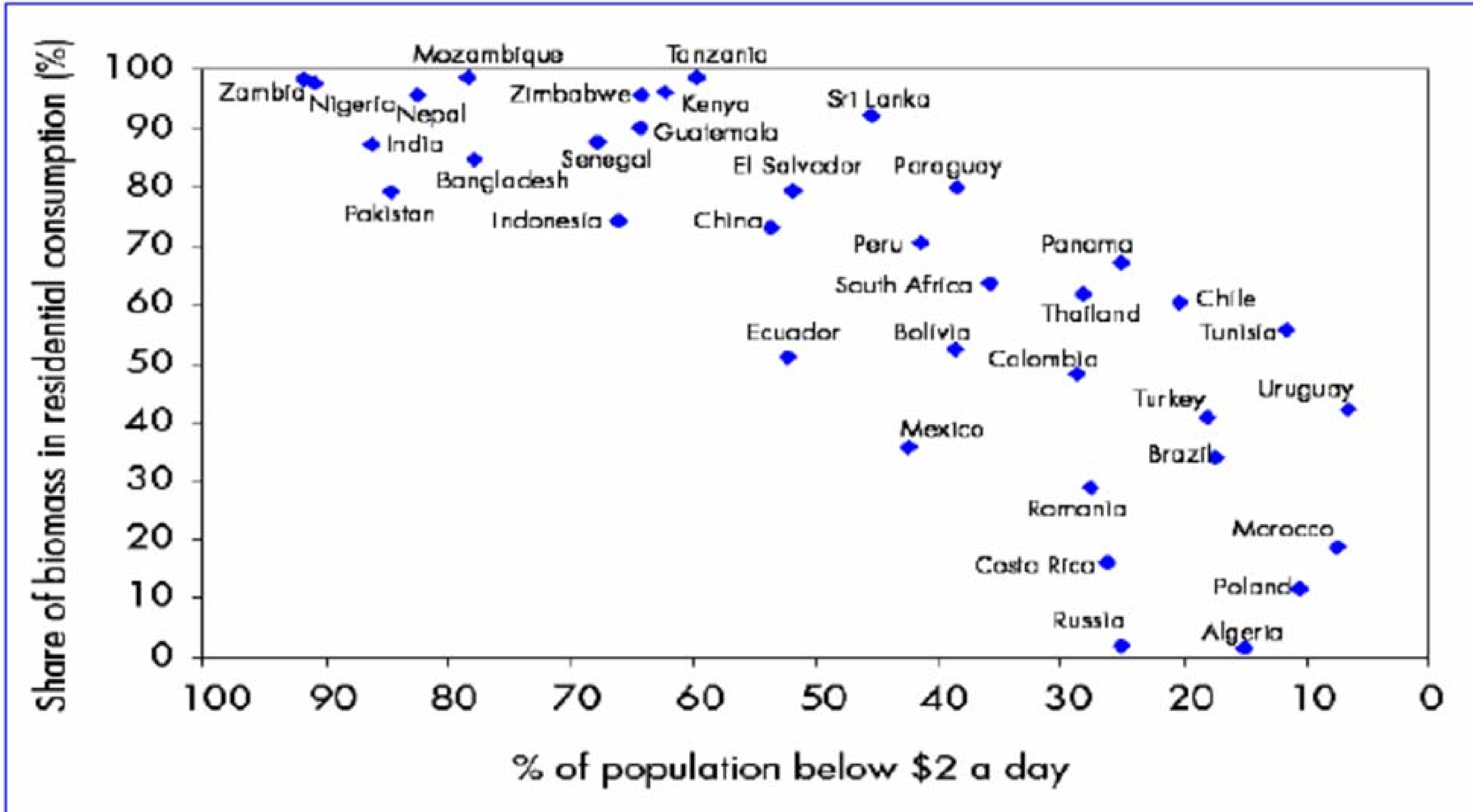
Glowing coke bed at 600-700 C further reduces tar through gasification below 25 mg/Nm3

Other feasible options

- Bio-diesel (based on Jatropha etc.) generators
- Generation based on biogas produced from organic wastes (animal dung, agro-wastes, MSW etc.)
- Hybrids such as wind-biodiesel, wind-pv-battery, wind-biogas etc.

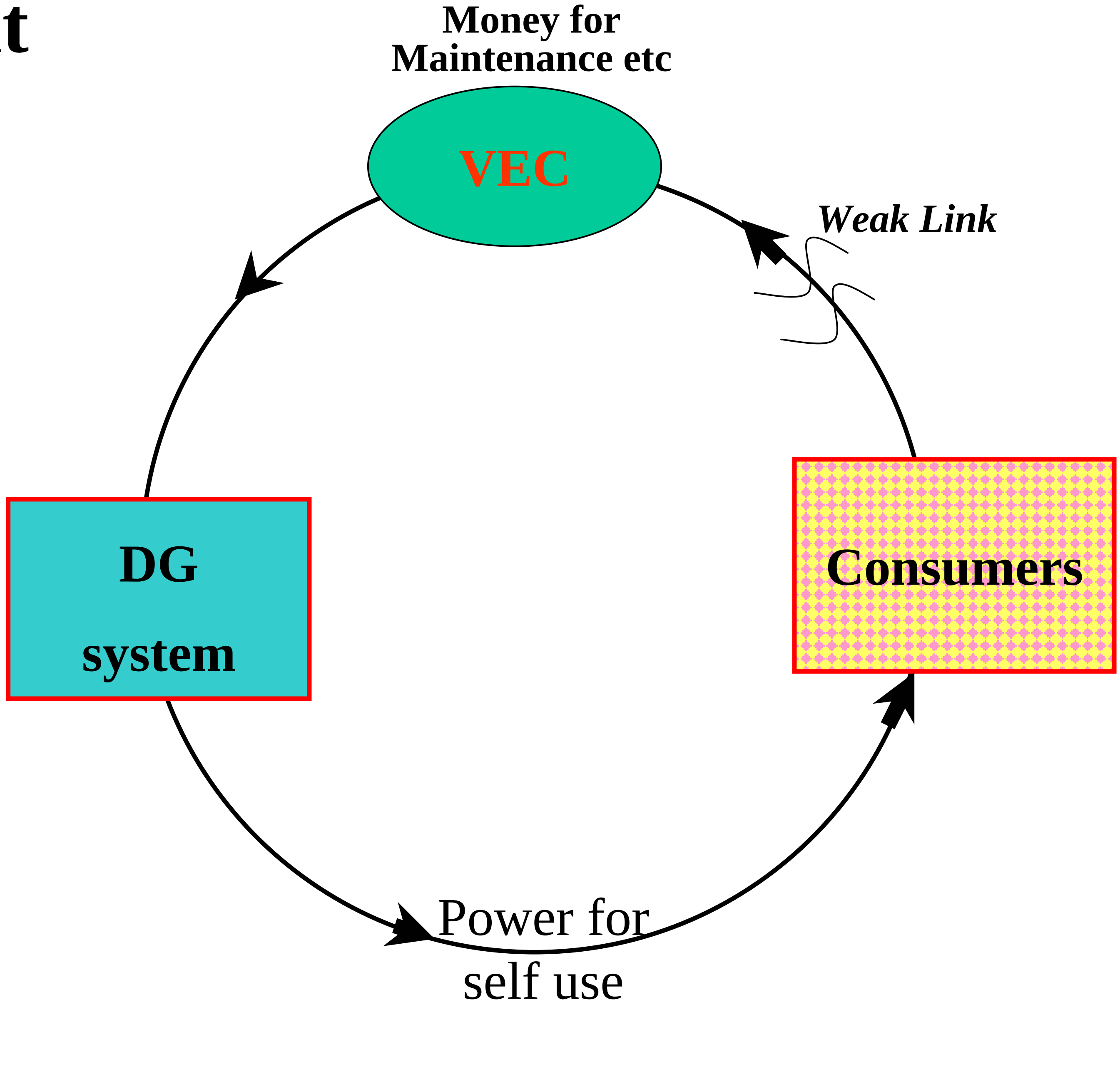
Social issues

The Link between Poverty and Share of Traditional Biomass in Residential Energy Consumption



Source: IEA analysis and the World Bank's *World Development Indicators* for income statistics.

Present


Money for
Maintenance etc
VEC
Weak Link
DG
system
Consumers
Power for
self use

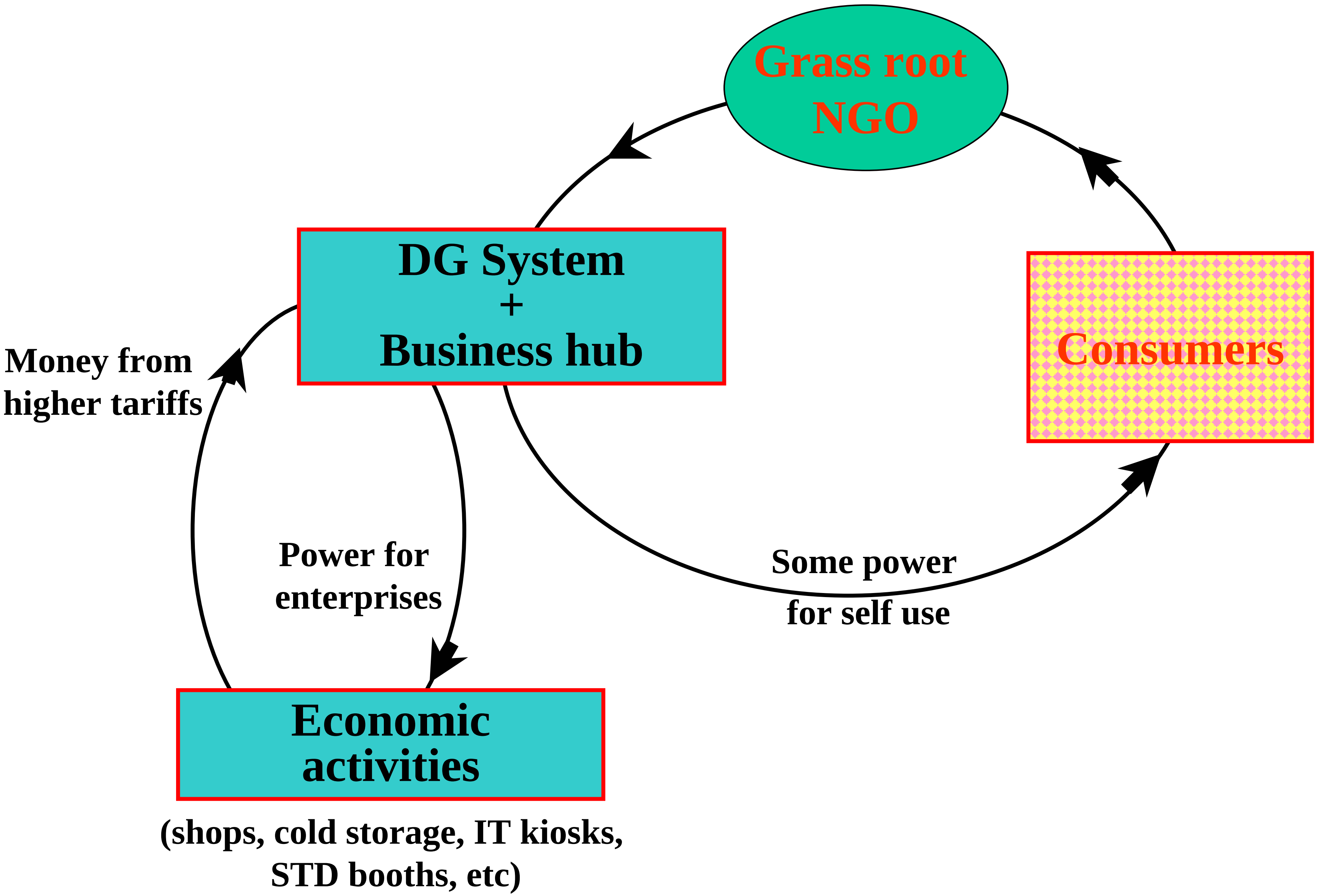
- Remote villages do not have cash

economics

- VECs are quick-fix work solutions
- High expectations of unlimited power

at subsidized tariffs or free power

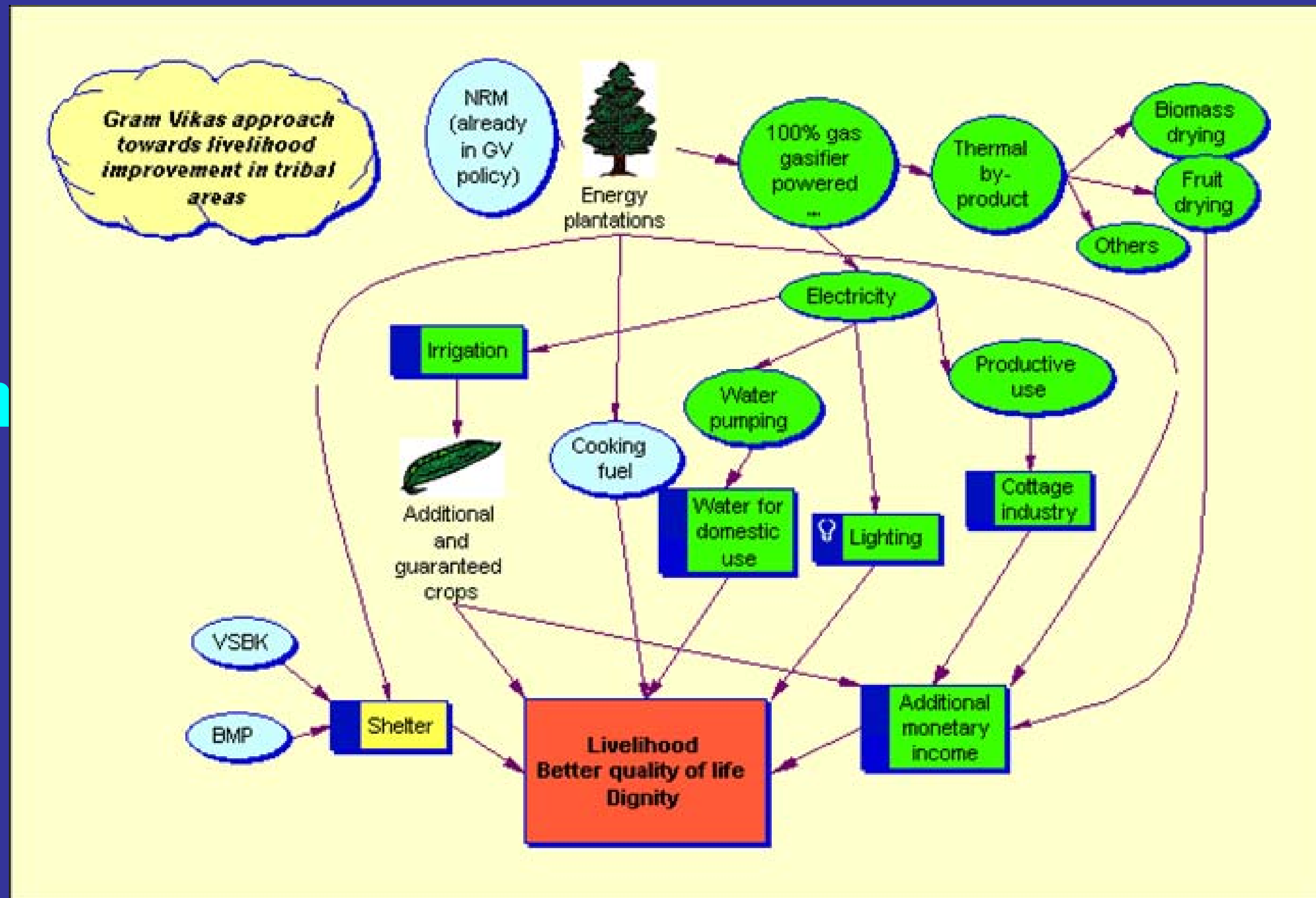
Suggested


Grass root NGO
DG System + Business hub
Consumers
Money from higher tariffs
Power for enterprises
Some power for self use
Economic activities
(shops, cold storage, IT kiosks, STD booths, etc)

teri GV

LIBERA

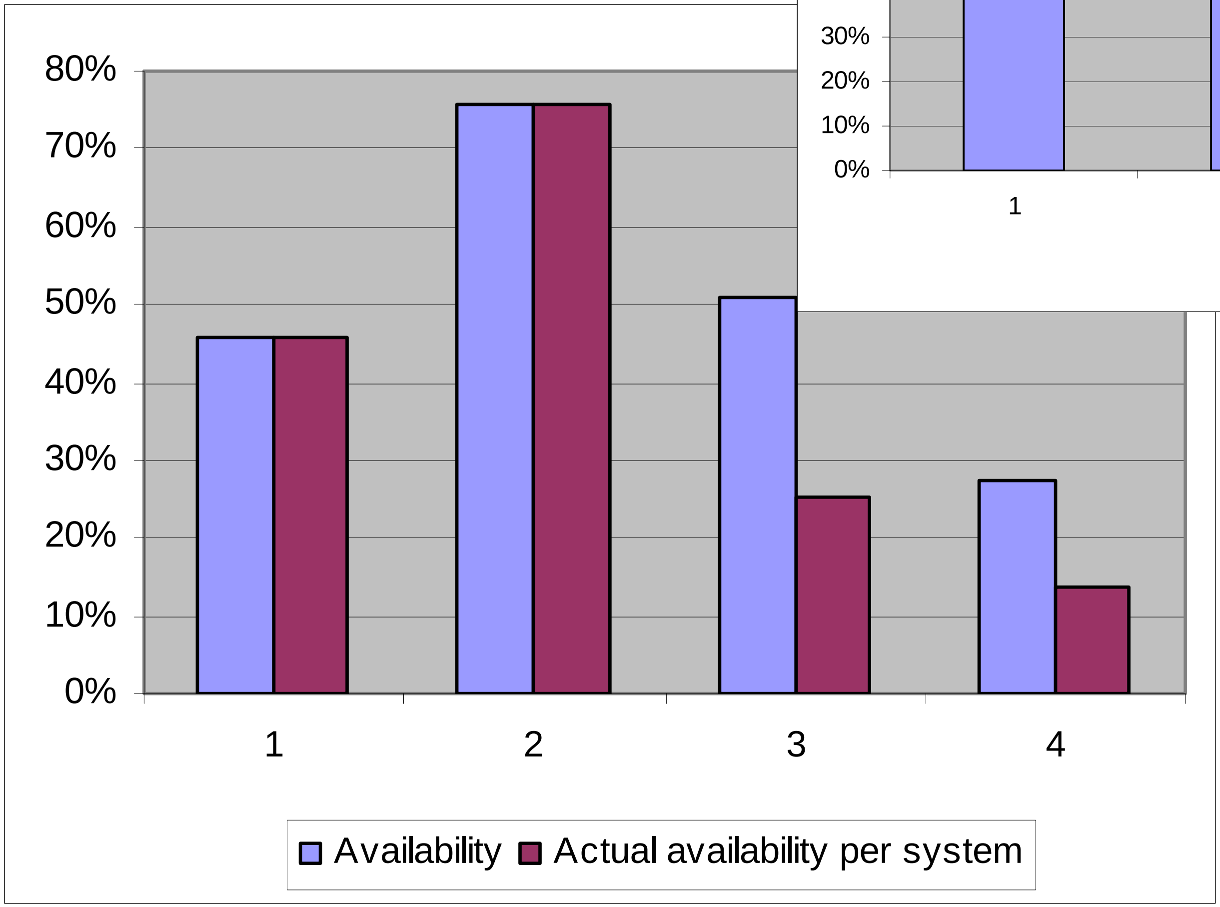
Livelihood
Improvemen
through
Biomass
Energy in
Rural
Areas

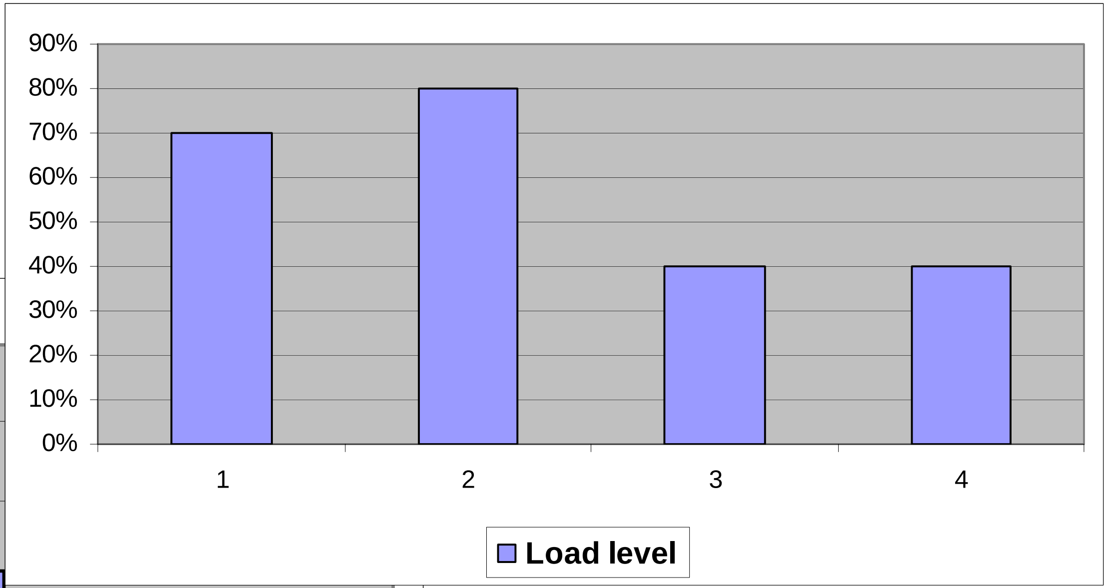


Project sponsored by

SWISS AGENCY FOR DEVELOPMENT AND COOPERATION SDC

Field performance of some gasifier based power generation units





Off-grid Access Systems for South Asia (OASys SA)

Financed by EPSRC-DfID

A collaborative project of CEPMLP (Dundee), TERI, TERI University, Manchester and Edinburgh Napier University

Call specifics

- Joint EPSRC-DfID call
- Specifically for
  - decentralised off-grid option
  - South Asia and Sub-Saharan Africa
- Collaborative initiative
  - With at least one partner in the beneficiary region
- Includes a demonstration component

Proposed Research

- Knowledge gap
  - Research so far considered technical aspects and general cost-effectiveness
  - Two main gaps
    - Business Models and institutional arrangements for delivery rarely considered
    - Limited project scale-up and project sustainability experience

2 main Research questions

- Are there cost-effective, secure and reliable local off-grid electricity supply solutions that can meet the present and future needs and are socially acceptable, institutionally viable and environmentally desirable?
- Do these local solutions have the scaling-up and replication potentials and can these solutions be brought to the mainstream for wider electricity access in the developing world?

THANK YOU