Transition to low carbon economies in developing countries. Case Study: Bangladesh

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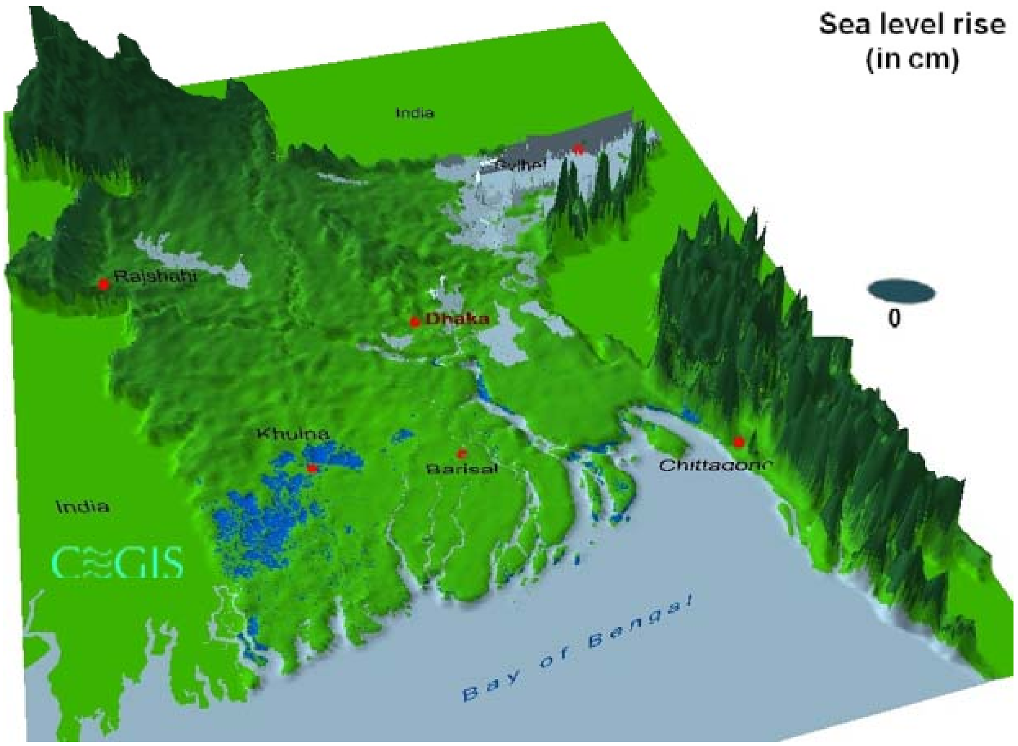
Energy and development

- Economic growth rate has been accelerating over last 5 years (currently ca. 6%)
- Population growth rate fallen to 1.4%
- Therefore, opportunity to become a middle income country by 2020
- However:
  - population expected to grow from 150 million in 2008 to 200 million by 2050
  - Over 80 million people do not have access to electricity, relying on biomass stoves for cooking and kerosene lamps for lighting
  - Remaining 60+ million have access to intermitent electricity
- The World Bank estimate that Bangladesh loses $1 billion each year due to power outages and unreliable energy supplies

Vulnerability to climate impacts with global warming



- ❑Floods
- ❑Changing weather patterns
- ❑Drought
- ❑Cyclones
- ❑Sea level rise
- ❑Increasing salinity

❑Climate change reinforces pre-existing vulnerabilities

❑Means that expanded electricity generation capacity has to be resilient

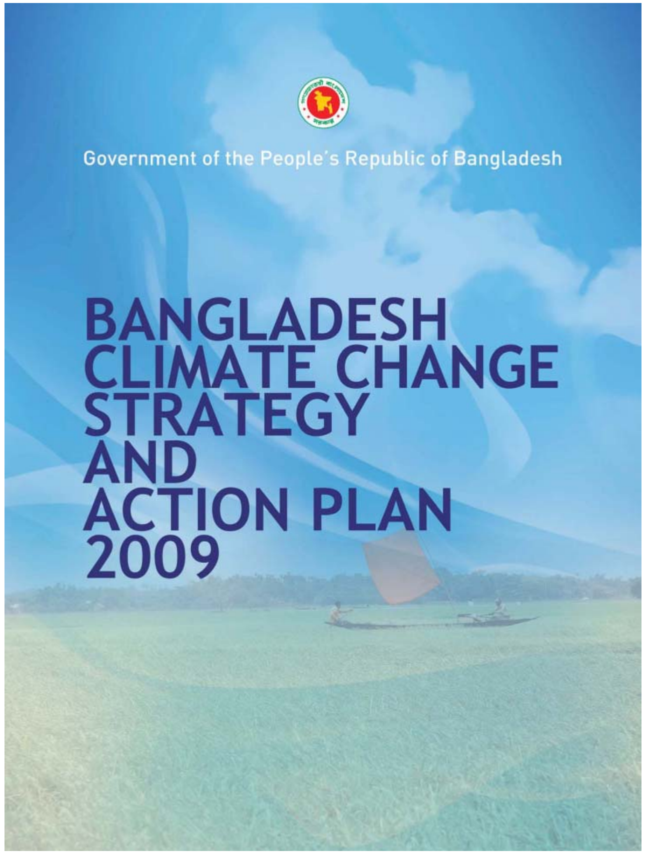
Key questions for developing countries

On the assumption of 'contraction and convergence'

1. What does the energy system look like now?
2. What will it need to look like in 2050?
3. How do we get from here to there?
4. Is low carbon growth achievable?

Why 2050 perspective?

- In the context of global action on climate change and need to plan for low carbon development
- In the UK, a 2050 technical feasibility analysis of the energy system has been carried out which seeks to meet the constraint of 80% reduction in GHG emissions
- Whilst under "common but differentiated responsibilities" principle this does not apply to developing countries, it is important to look at how energy demand will be met in 2050 given lifetime of capital assets



Energy consumption by source: current trends

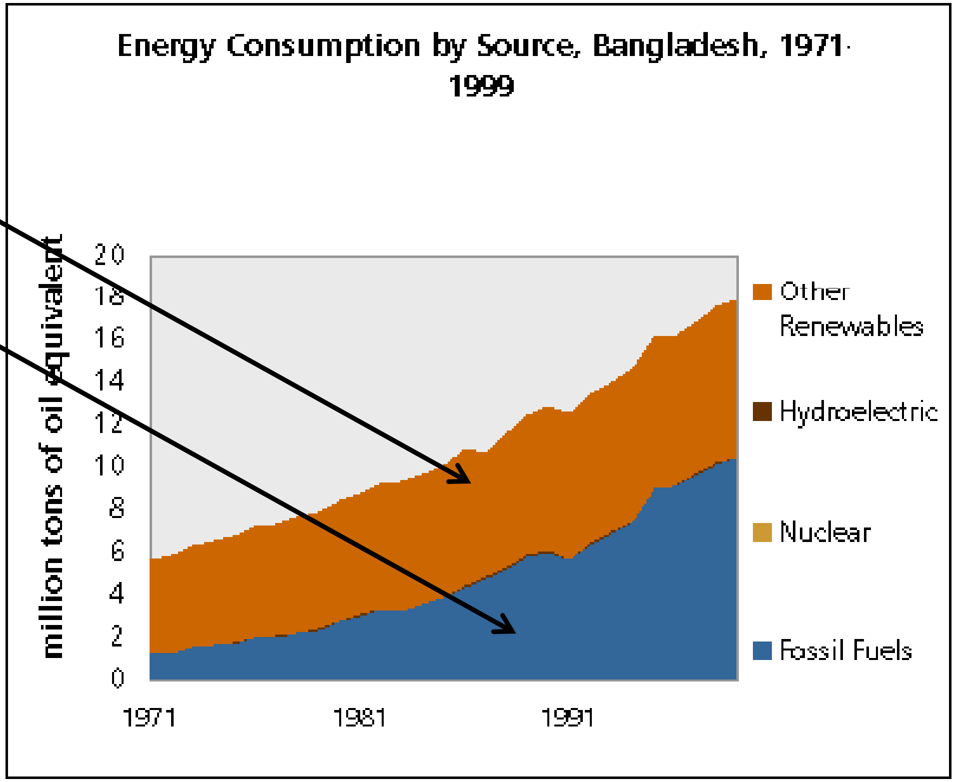
- Biomass
- Gas

Problem

- Gas running out

Options for the future

- Coal
- Nuclear
- Renewables

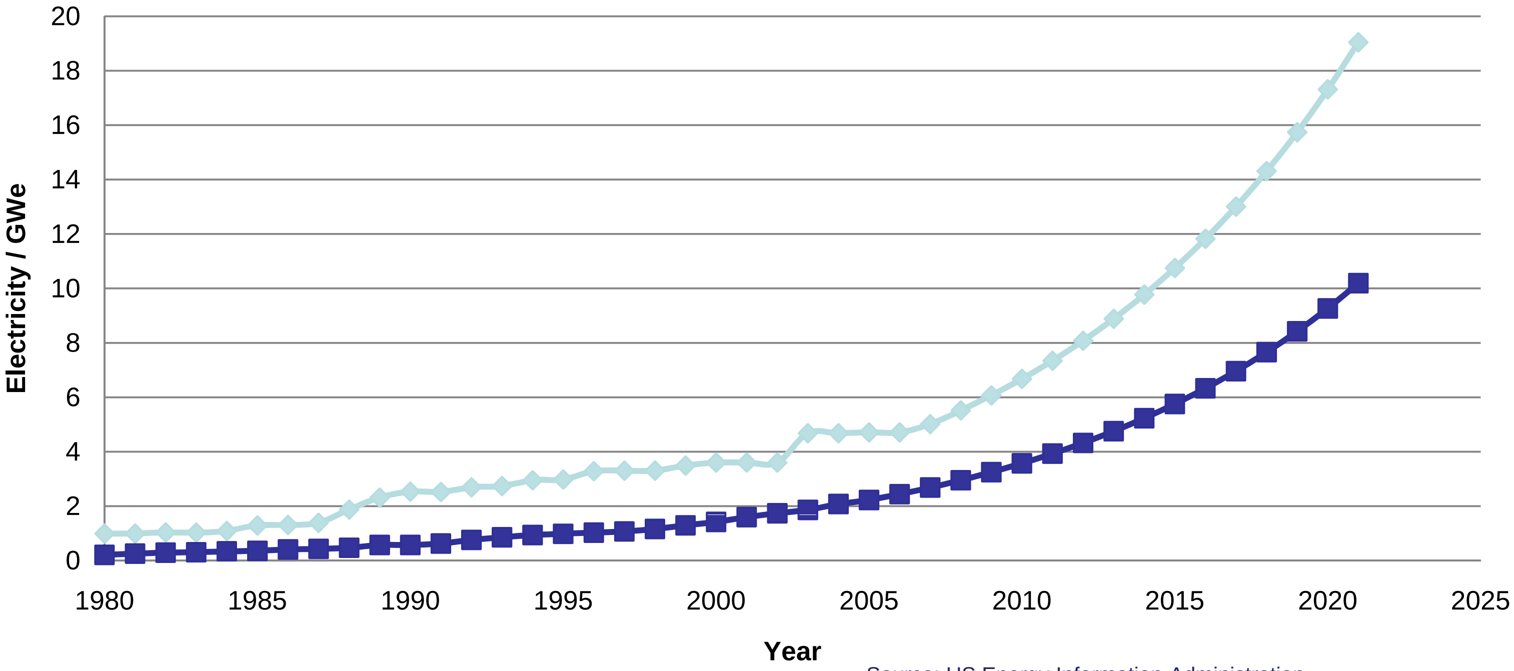


WRI (2010)

Current electricity generation

- Installed capacity 5,430 MW in 2009
- 500 MW from three new publicly owned power stations to come on stream in 2010
- 700 MW from a number of privately owned ‘rental’ power stations to come on stream in 2010
- Further 2,000 MW expected to come on stream by 2014
- Therefore, capacity expected to reach 6,900 MW by 2013
- Joint venture with India to develop 1,300 MW coal powered station
- Agreement for transmission lines from India to import electricity
- Co-operation agreement with Russia for developing nuclear power
- However, demand rising at 10% per year

Projected Electricity Capacity & Consumption in Bangladesh



Source: US Energy Information Administration

Bangladesh: The Scale of the Challenge

Metric	2010	2050
Capacity	5.5 GWp	~200 GWp
Demand	40 TWh (4.6 GW)	1,267 TWh (145 GW)
Supply	28 TWh (3.2 GW)	1,267 TWh (145 GW)
Grid	Centralised	Interconnected smart grids
Price	Government subsidised	Liberalised markets
Fuel	Gas Centralised generation	Nuclear and/or Solar Significant distributed generation
Transport	Limited access Expensive Reliant on gas or oil imports	Subways and public transport in urban areas National and regional high speed railways Electric vehicles for private users
Population	160 million	200 million
Electricity access	60 million	200 million
Water access	Limited provision	99+% provision
Sewerage access	Limited provision	99+% provision

Table 1: Key differences between the energy and infrastructure requirements between 2010 and 2050

Bangladesh:Transition Pathway

Year	kWh / person	Population / millions	Total energy / TWh	Electricity / TWh (GW)	Percent electricity	$ / capita
Yearly growth	**6%**	**0.56%**	**[6.6%]**	**10%**	**n/a**	**6%**
2010	2,150	160	344	28 (3.2 GW)	8.1%	$600
2020	3,850	169	651	73 (8.3 GW)	11.1%	$1,075
2030	6,895	179	1,234	188 (21.5 GW)	15.3%	$1,924
2040	12,349	189	2,336	489 (56 GW)	20.9%	$3,446
2050	22,114	200	4,424	1,267 (145 GW)	28.6%	$6,171

A simple scenario is constructed to predict the energy use in 2050 using the following assumptions.

- GDP/capita and energy/capita increase by 6% per year
- Electricity generation increase by 10% per year
- Population increases to 200 million in 2050, therefore grows by 0.56% per year

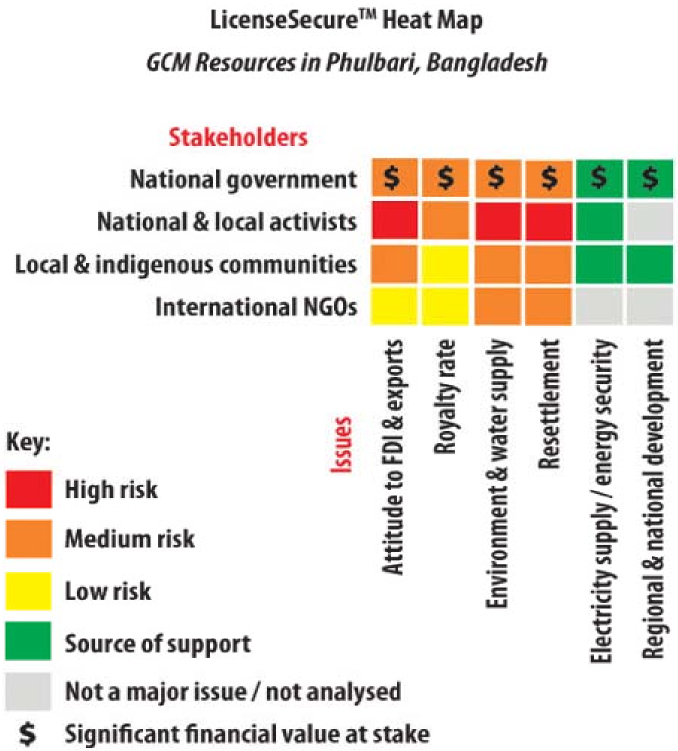
Table 2: Projections for future energy demand, economic and population growth

Current policy

- Focus on conventional approach
  - Gas
  - Coal
  - Nuclear
  - Large scale, centralised grid
- However, the Renewable Energy Strategy (RES) sets a target for 10% of electricity from renewables
- A lot of experience in small scale solar and biomass at household level

Can the conventional approach meet the needs? Coal and Gas

- Demand projections
  - 10 GW (2015)
  - 14 GW (2020)
  - Cannot expand Gas
- Large discoveries coal
  - 2,086 million tonnes (proven)
  - Roughly 450 GW years
  - By 2020 10 GW = 45 years
  - Not without problems!
- Beyond 2020
  - Dependent upon imports



http://www.miningenvironmental.com/special-features/bangladesh-coal-controversy-power-to-the-people

Can the conventional approach meet the needs? Nuclear

- Attractive but…
- Barriers
  - Uranium imports
  - Waste disposal
  - Accidental release could poison agriculture in heavily populated river delta
  - Extreme weather & flooding will limit sites
- New technology
  - Fast breeder or travelling wave may mitigate some barriers

Where is it safe to put them?

What other options are there?

- If we are looking at around 200 GW installed capacity by 2050 and coal can, at best, provide ca 10 GW and nuclear power is problematic, what are the alternatives?

Real options

Energy Sources	Viability	Available practical resource / year
Solar	Very attractive long term option, Bangladesh has excellent solar radiation. Viable technology and already being installed, albeit at modest rates. Barrier is finance.	Estimated at least ~860TWh (100GW)
Wind (small, onshore)	Viable, technically feasible now, viable with wind speeds above 5 m/s, average is 4.5 m/s so enough sites should exist.	Estimated ~2.3TWh (0.26GW)
Wind (large, onshore)	Unknown, technically and economically feasible but large capital costs and requires grid connections.	Unknown theoretical potential
Wind (large, offshore)	Unknown, technically and economically feasible but large capital costs and requires grid connections.	Unknown theoretical potential
Hydro (small)	Viable, technically and economically feasible.	Unknown theoretical potential
Hydro (large)	Viable, technically and economically feasible but large capital costs and requires grid connections, also potentially large environmental impacts.	Estimate ~2.2TWh (0.26GW)
Marine (small, tidal)	Viable, technically and economically feasible now, coastal regions and islands.	Unknown theoretical potential
Marine (large, tidal)	Not yet viable, expensive technology	Unknown theoretical potential
Marine (wave)	Not yet viable, expensive technology	Minimum 1TWh (100MW) Unknown theoretical potential
Biomass	Viable, currently being used extensively but mostly in non-optimised systems.	Presently 80-90 TWh of biomass burning, efficiency could probably be doubled. Waste biomass resource indicate at least 45 TWh of biogas could be generated.
Geothermal	Unknown	Unknown theoretical potential
Imports	Significant resources elsewhere in the region make electricity imports accessible	Effectively unlimited regional solar resources and considerable hydroelectric resources
Coal	Viable technology. Highest CO_2 emissions. Considerable barriers and environmental and political challenges associated with domestic coal mining. Imports possible.	Domestic production 80 TWh (10 GW) For 40-50 years With CCS 68 TWh (8.5 GW) For 40-50 years
Nuclear	Viable technology but with significant barriers and risks. New technologies may mitigate some risks.	Limited by access to Uranium and/or new technologies

Can renewable energy sources fill the gap

- Solar will need to provide the lions share of domestic electricity generation by 2050
- Biomass (and biogas derived from anaerobic digestion of biomass) will be a substantial part of the energy mix and be used in electricity generation
- Energy self-sufficiency will not be attainable by 2050 with known technologies and therefore there will need to be significant imports of energy

Solar

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- Solar PV existing plans
  - Mid 2009 – 0.025 GWp solar-PV
  - 2012 – 0.050 GWp (1 million)
  - Approx $30 million a year
  - Mostly rural and aid agency funded
  - Would reach 0.163 GWp by 2020
  - 0.4% electricity consumption in 2020
- Compare to global ambition
  - 2008 = 5.5 GW installed
  - Bangladesh ~0.1% global market
  - Only barrier = large scale finance
- 5% of electricity consumption 2020
  - Approx $500 million a year
  - 0.06 m^2 per person by 2020
  - 2.3 GWp = 20 TWh by 2020
  - Self financing likely by 2020
  - Exponential growth thereafter?
- Beyond 2020
  - Concentrating Solar Power (CSP) is likely to be available at scale
  - And probably cheaper than Nuclear!
  - An area of 4-8 km^2 would be required to generate roughly 8 TWh (1 GW)

There is no technical reason why greater than 10% electricity in 2020 could not be achieved, the only barrier is access to finance $$$

Rate of installed Concentrated Solar Power is doubling every year

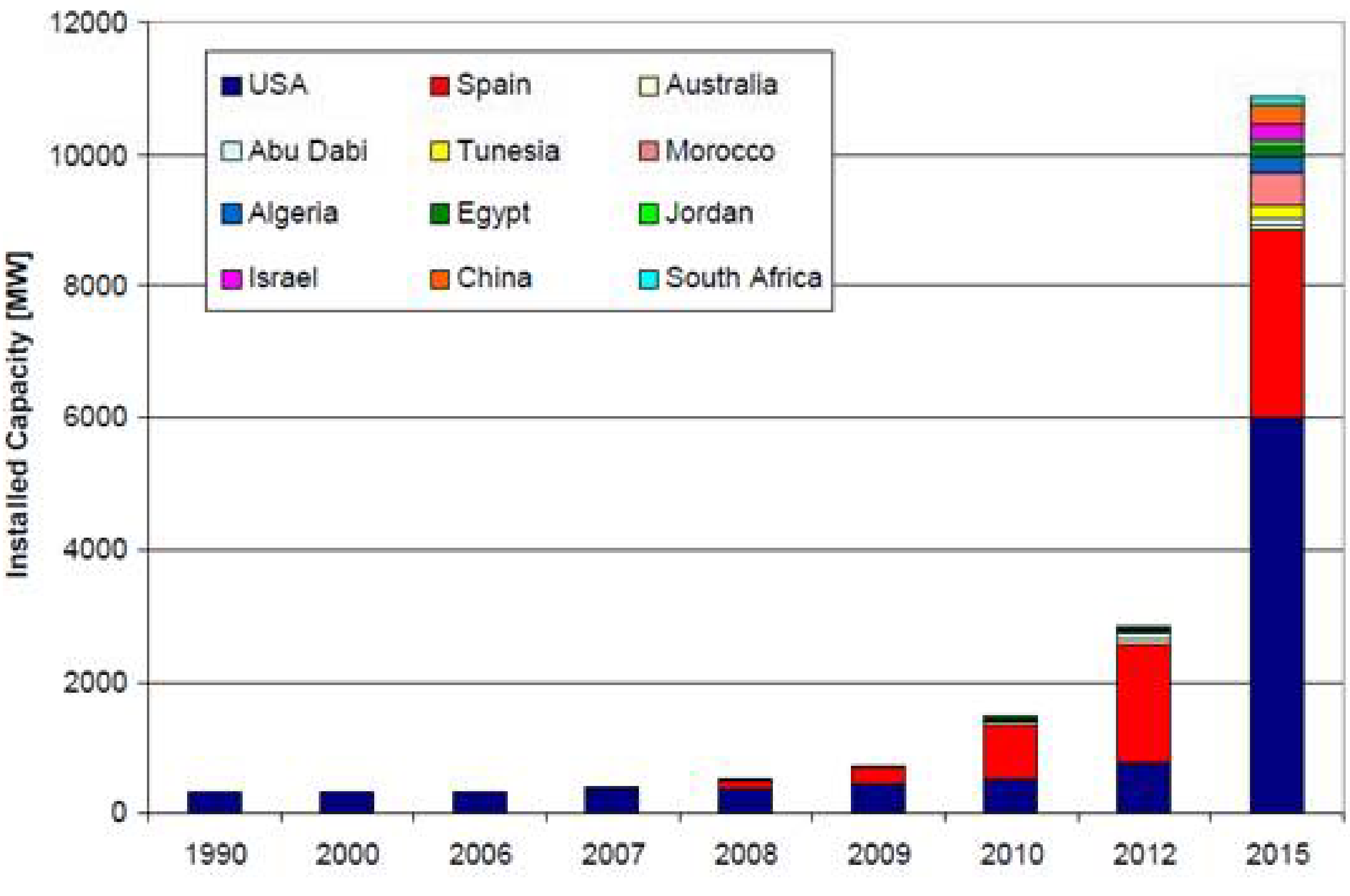


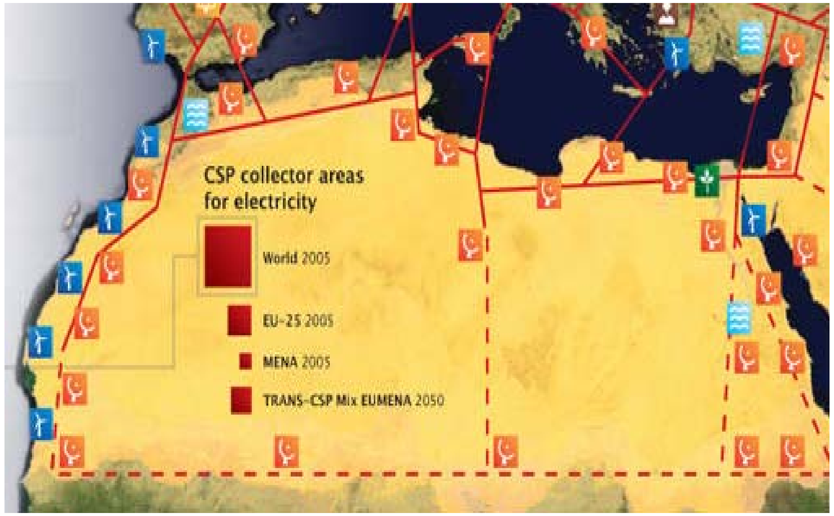
Figure 1: Installed and planned Concentrated Solar Thermal Electricity Plants

Biomass

- Traditional stoves
  - Very inefficient
  - Air quality & health problems
  - Currently 80-90 TWh biomass consumed
- Efficiency
  - Improvements likely
  - Diversion biomass then possible (<50%)?
  - ~40-45 TWh for AD or combustion
- Waste biomass streams
  - Underutilised, at least ~45TWh expected

Electricity imports

- Regional hydroelectric resource
  - Nepal ~83 GW
  - Myanmar >108 GW
  - India ~150 GW
  - Bhutan
- Regional solar resource
  - Desert regions in neighbouring countries



Desertec Concept, showing area needed

Bottom-up vs. Top-down

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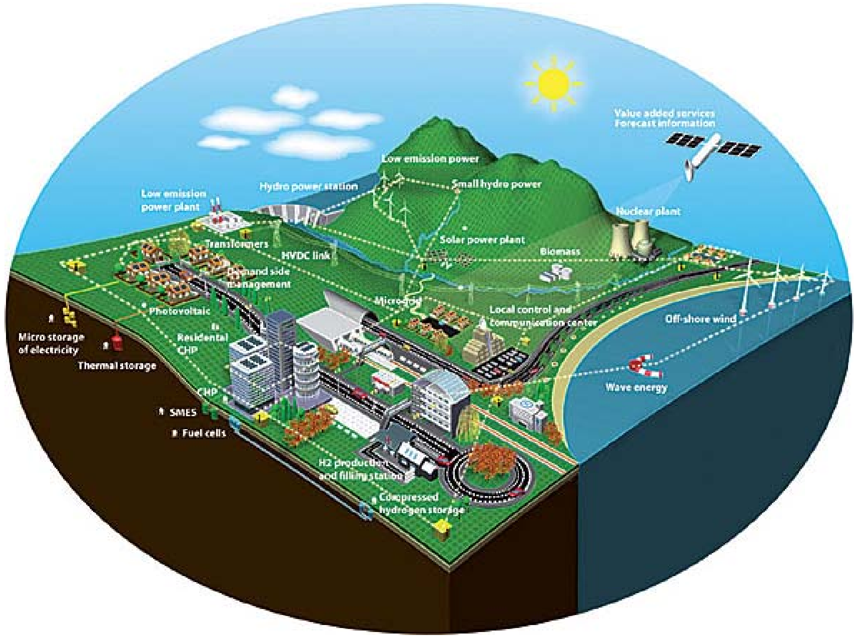
- Solar energy
  - Distributed renewable energy source
  - Solar-PV on rooftops
  - Some large CSP
- Biomass
  - Distributed renewable energy source
  - Distributed Anaerobic Digesters, EfW and biomass combustion
- Both benefit from a different type of grid
  - Distributed generation
  - Smart Micro-Grids



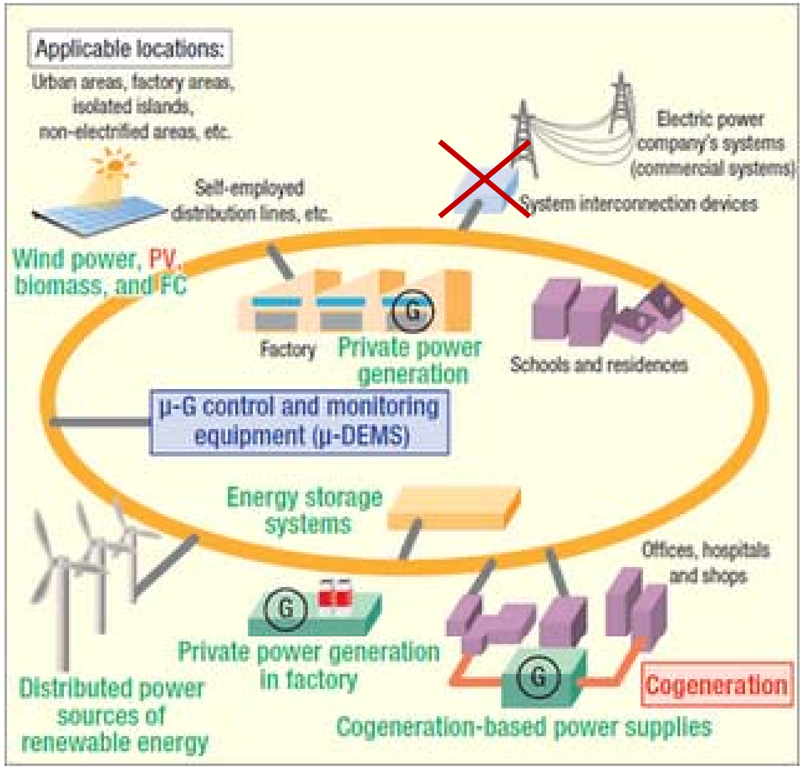
Challenge & Opportunity

- **Situation**
  - Current grid is **geographically limited**
  - Daily per capita **electricity use is low** 1-2 kWh (and zero for some)
- **Challenges**
  - **Private capital investment required** to expand traditional centralised power system to un-served population
  - Development is hampered by **lack of purchasing power** and low levels of average consumption in un-served population
  - Chicken & Egg situation, **low return on investment**, stalled deployment *
- **Opportunity**
  - **Micro-Grids**
  - Even in non-remote locations, autonomous micro-grids is a preferred option to extend electricity to populations with limited purchasing power
  - Electricity supply key enabling factor for **education, healthcare & trade**, therefore **often increasing purchasing power**
  - Therefore micro-grids **actually facilitate** rather than preclude **macro-grids**

* Notwithstanding additional barriers due to costly large scale generation infrastructure, running costs and supply chains

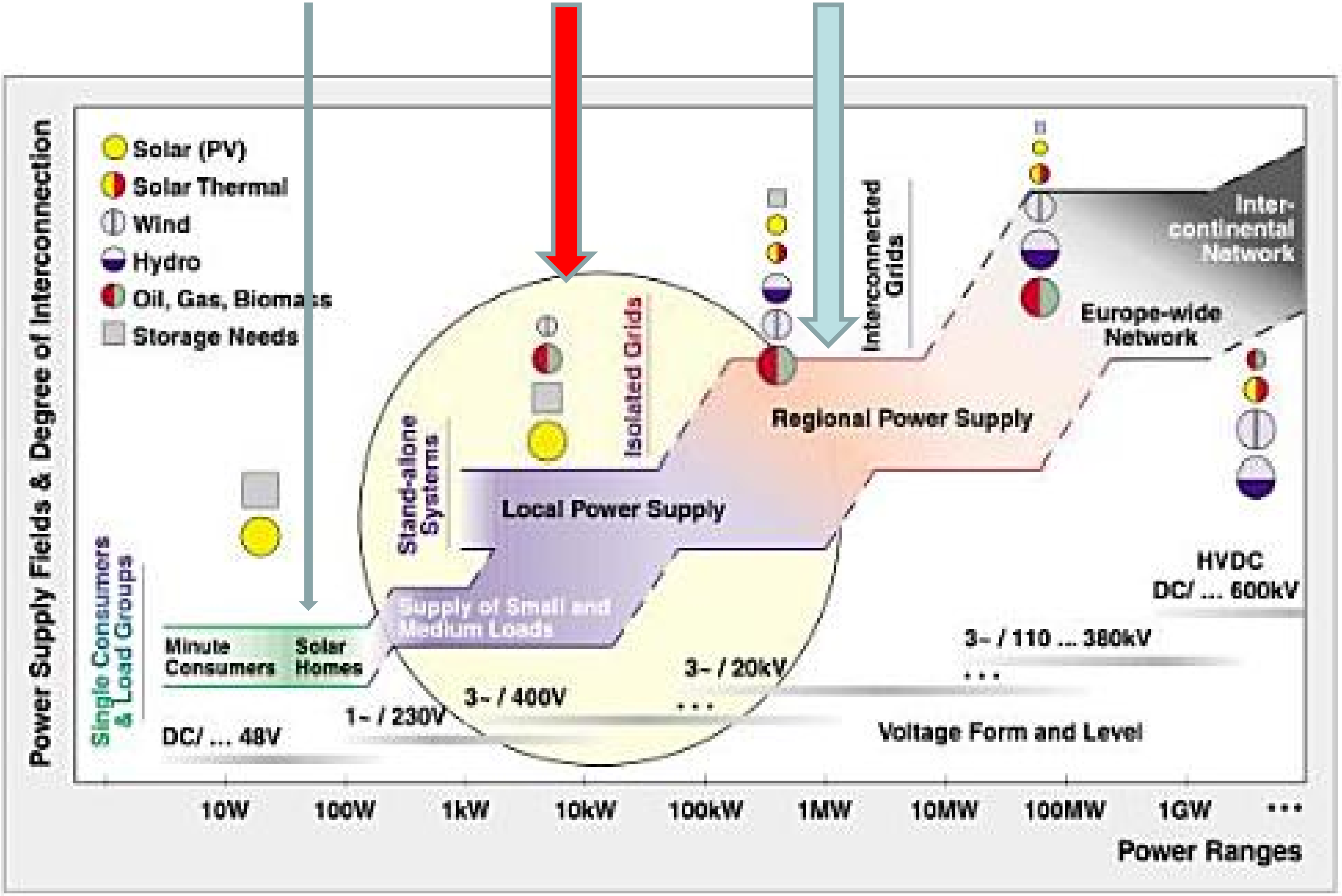
Micro-grids

- ❑ Micro-grid is similar to distributed generation
  - However a micro-grid can also be **isolated** from and operate separately from the macro-grid
  - Or may have no grid connection at all



Bangladesh's Energy System

Current Efforts Opportunities Current Efforts



Is this actually new?

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- Isolated electricity grids exist
  - Small power stations frequently with Diesel back-up units
  - These grids often correspond to a small geographical area with a population centre
  - Large distances makes interconnects unfeasible
  - Where reliability is poor and electricity is present only a few hours per day
  - Bangladesh has plenty of expertise in this area already!
- Not modern Micro-Grids
  - They are designed to be top-down demand led
  - But many similarities and opportunities

Hybrid Micro-grids

- Flexible
  - **Future-proofed,** devices can be added as needed, scalable, expandable, merge-able
  - **Technology neutral,** any generation or storage device
  - **Efficient,** close to consumer, lower losses, demand for heat
  - **Entrepreneurial,** engage with communities, create jobs and local wealth

Urban

Rural

Hybrid Micro-Grid Experiences

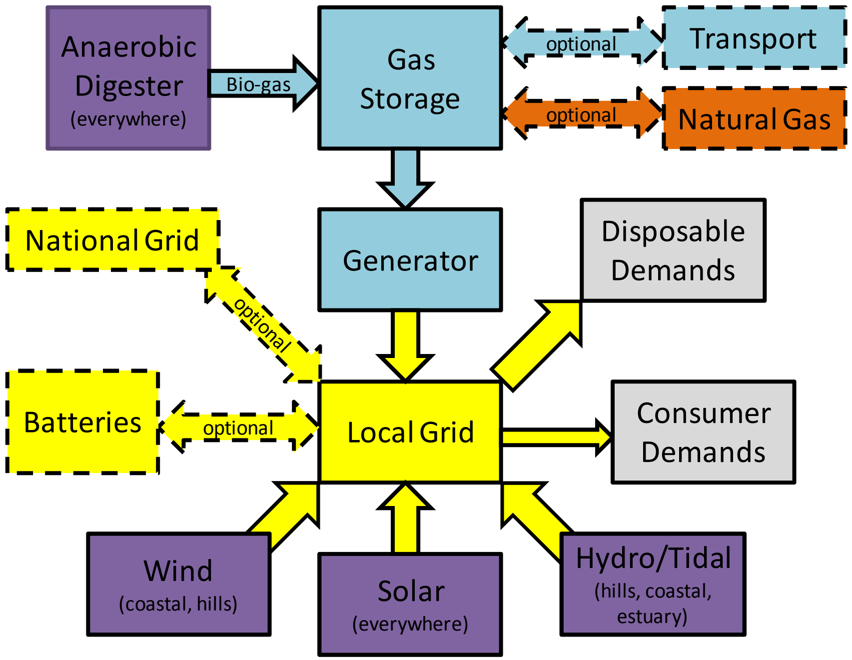
- Largely:
  - Rural
  - Beyond reach of national grid
  - Developing country contexts
  - Retrofitting/ with diesel
  - Micro scale
  - ‘Poor man’s’ solution
- Beginning/burgeoning:
  - Urban
  - Developed country contexts
  - Where a national grid exists
  - Multiple renewables
  - Larger scale
  - **‘**Cutting-edge**’**
  - **LEAP FROGGING cf mobile phones**

Possible 2020 vision

- Solar PV
  - 20 TWh electricity
  - 0.3m^2 per person
- Biomass
  - Double efficiency existing feedstocks
  - ~40-45 TWh energy
  - ~13 TWh electricity or transport fuel
- Energy from Waste
  - Estimate ~40-45 TWh energy
  - ~13 TWh electricity or transport fuel
- Wind
  - At least 2.3 TWh
- Hydro
  - Up to 2.2 TWh more

- Total = ~50 TWh
  - End-use renewable energy
  - Technically possible

- CSP could be a game changer
  - Demo costs now approaching nuclear



Further expansion in renewable energy production beyond 2020 would require massive increases in **solar deployment** and/or developments in less mature technologies.

For comparison 2009 electricity supply = 28 TWh

Conclusions

- Solar will need to provide the lions share of electricity generation by 2050
- Biomass (and biogas derived from anaerobic digestion of biomass) can be a substantial part of the energy mix and be used in electricity generation
- Energy self-sufficiency will not be attainable by 2050 with existing technologies and therefore there will need to be significant imports of energy
- Cutting edge hybrid micro-grids provide an opportunity for Bangladesh to ‘leapfrog’