February 2014

Energy Efficiency and GHG Mitigation in Bangladesh

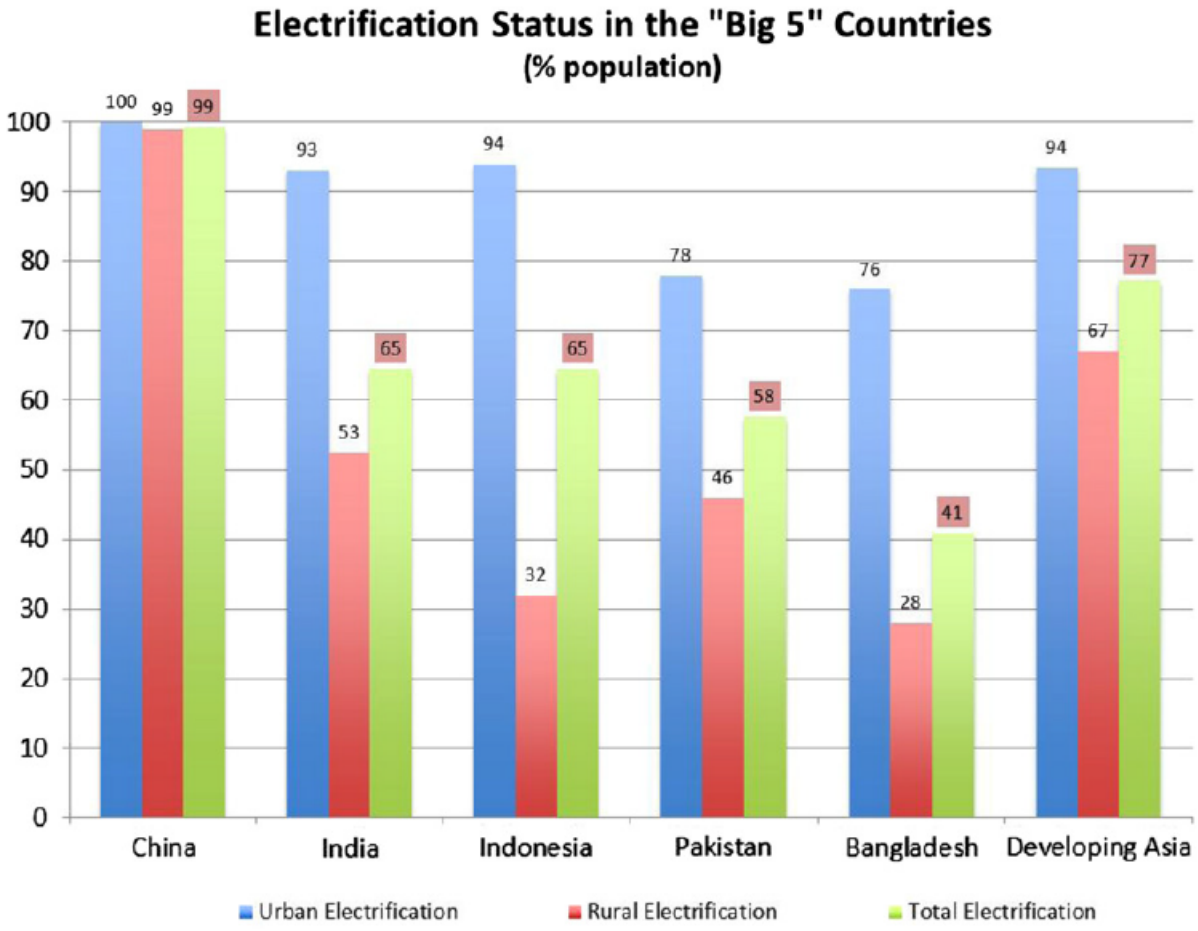
Asia-Pacific Regional Initiative on Energy, Environment and Ecosystem (3E) Nexus for Sustainable Development

24 – 25 February 2014
Hulhule Island, Maldives

Summary of Primary Energy Supply in Bangladesh in 2011-12

Fuel Type	Original Unit	(TJ)	(%) of Total	(%) Without Biomass
Natural Gas	800 BCF	733600	42.04	67.62
Oil	5.8 million Tons	258100	14.79	23.79
Coal (estimate)	3.5 million Tons	89250	5.11	8.23
Hydro	1000 GWh	3600	0.21	0.33
Solar PV (estimate)	100 MW-p (equivalent)	400	0.02	0.04
Biomass (estimate) (dry)	55 million Tons	660000	37.82	
	TOTAL →	1,744,950	100.00	100.00

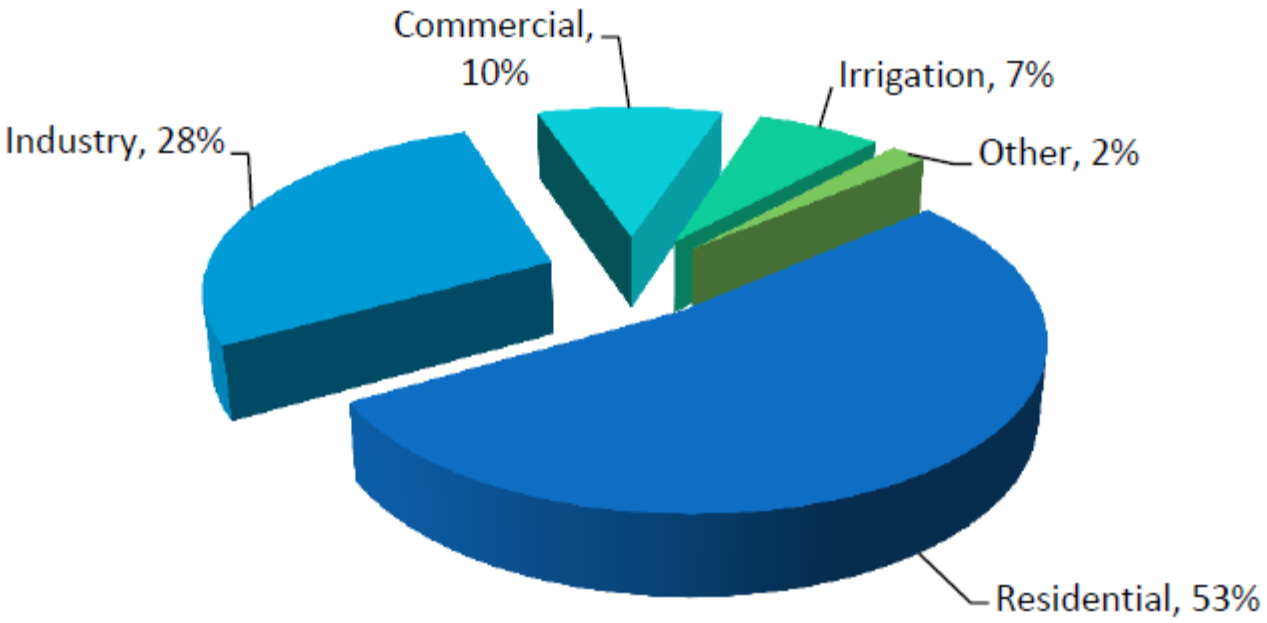
- Bangladesh is a low energy consuming country
- Per capita electricity consumption is about 250 kWh
- Since 2007 energy demand has outstripped supply
- GDP growth of 6% to 7% per year would have been higher if more electricity and gas could be supplied



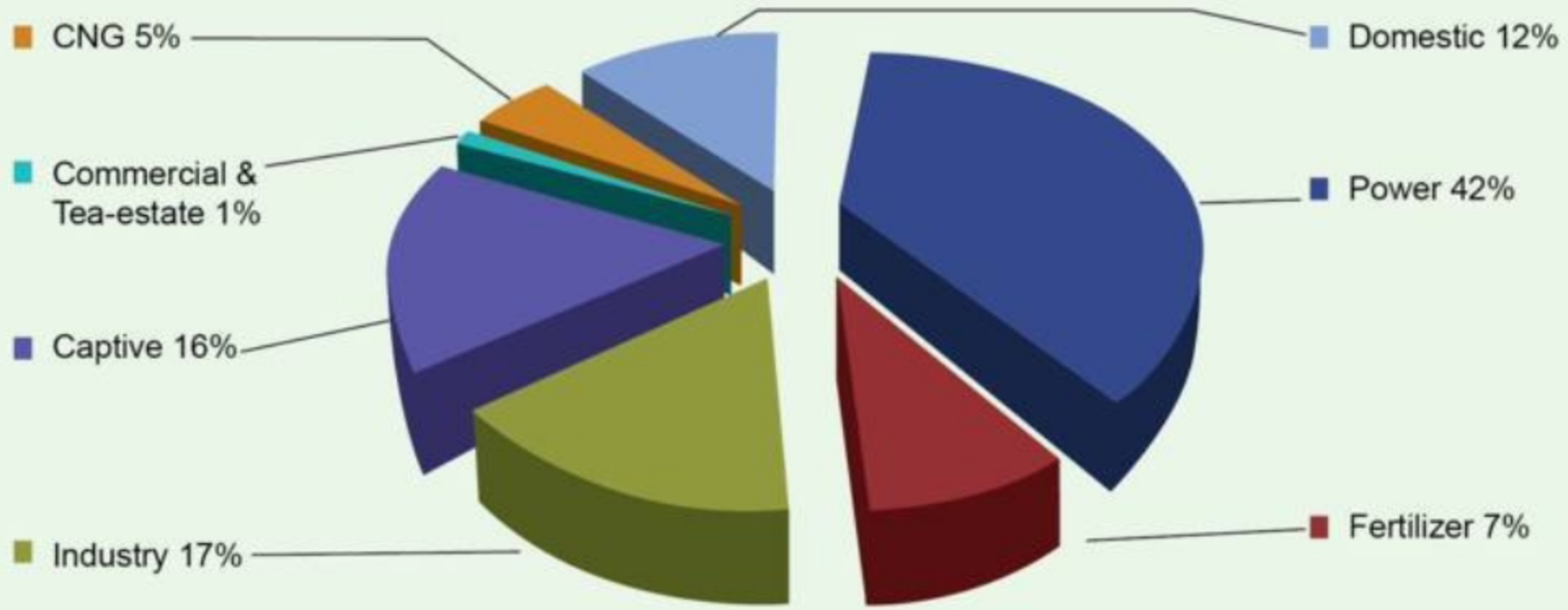
and urban electrification levels in "Big 5" in 2008.
ernational Energy Agency (accessed on March 2012).

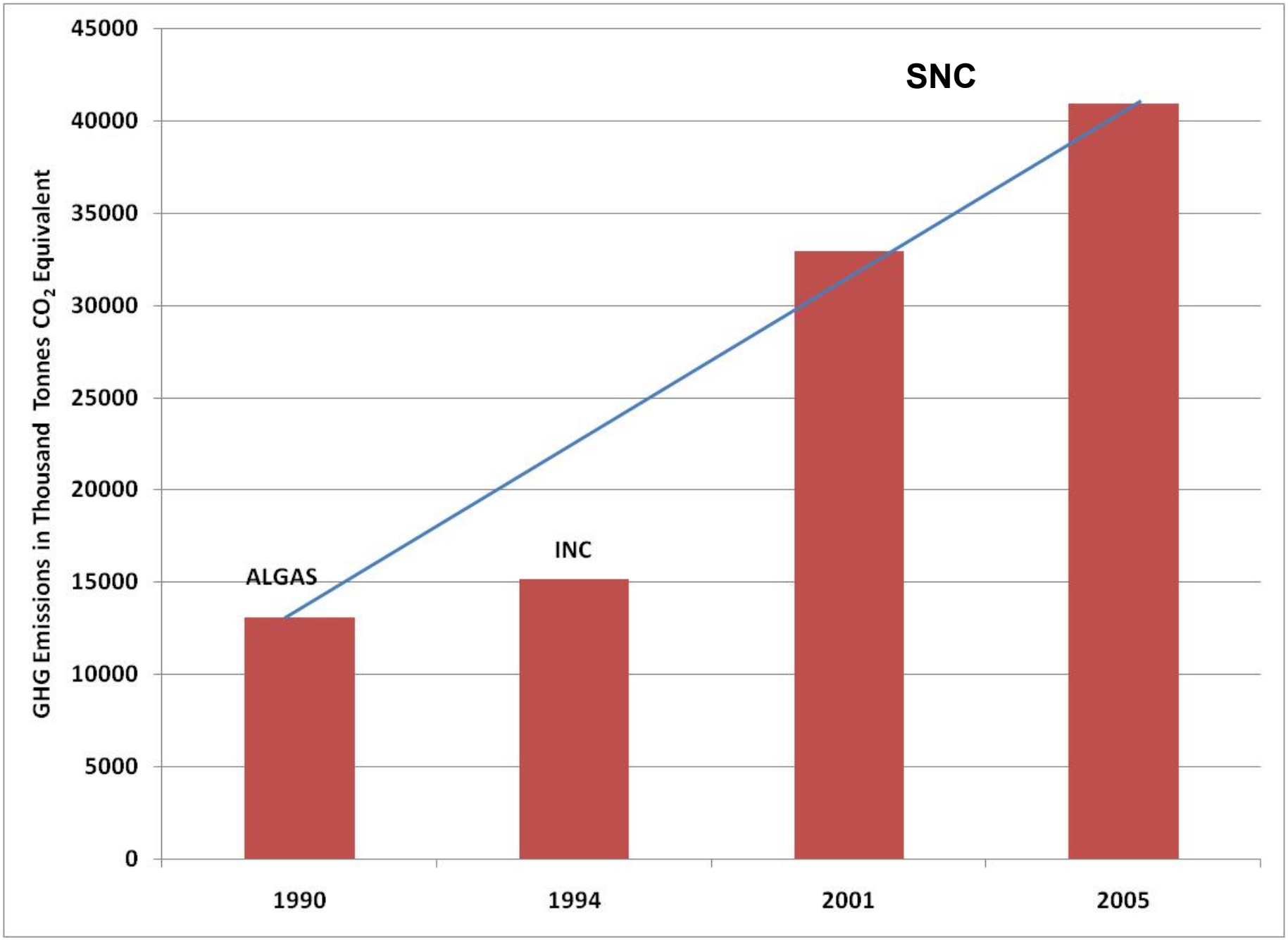
: Electricity consumption by customer type, FY12

Source: Utility company reports (REB, DPDC, BPDB)

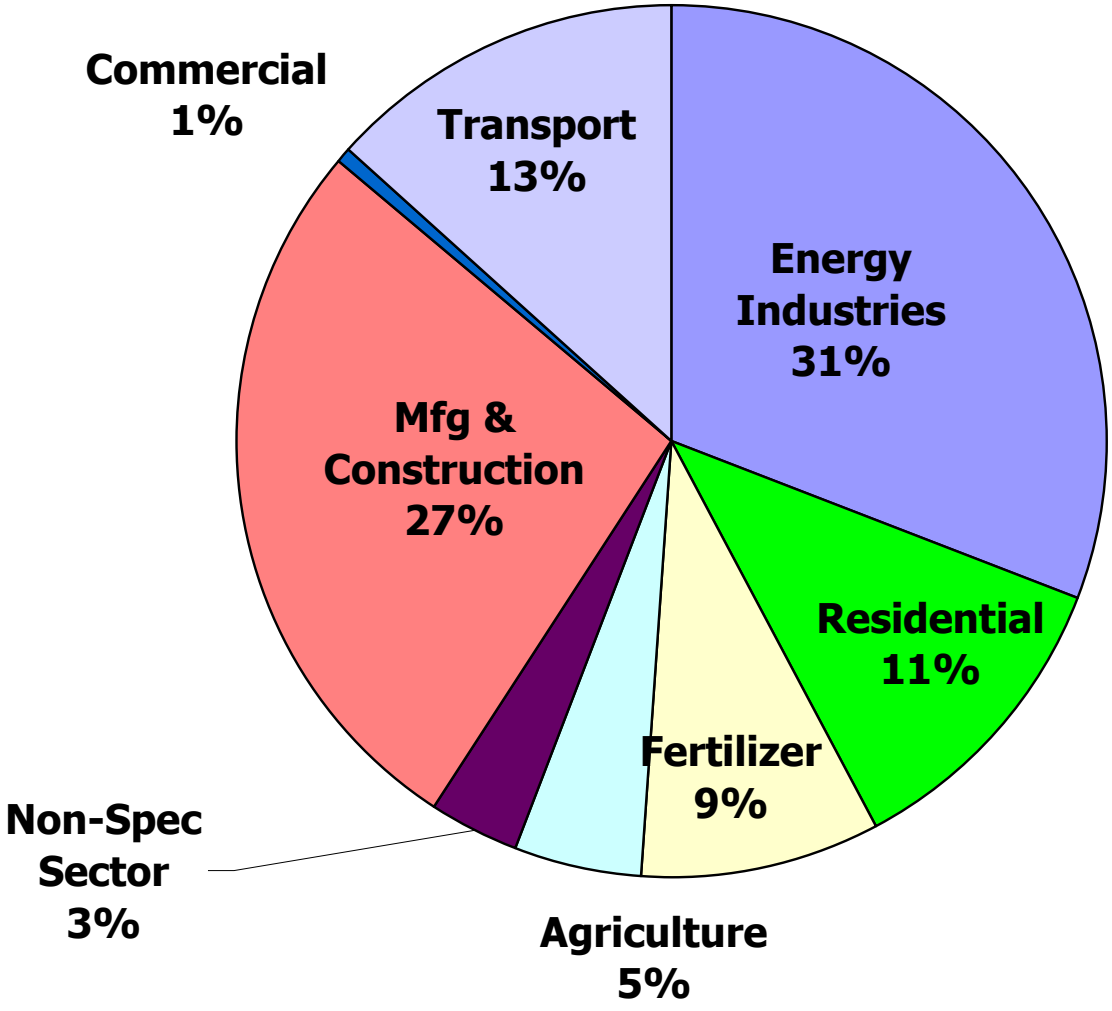


Sectorwise Gas Consumption (2011-2012)



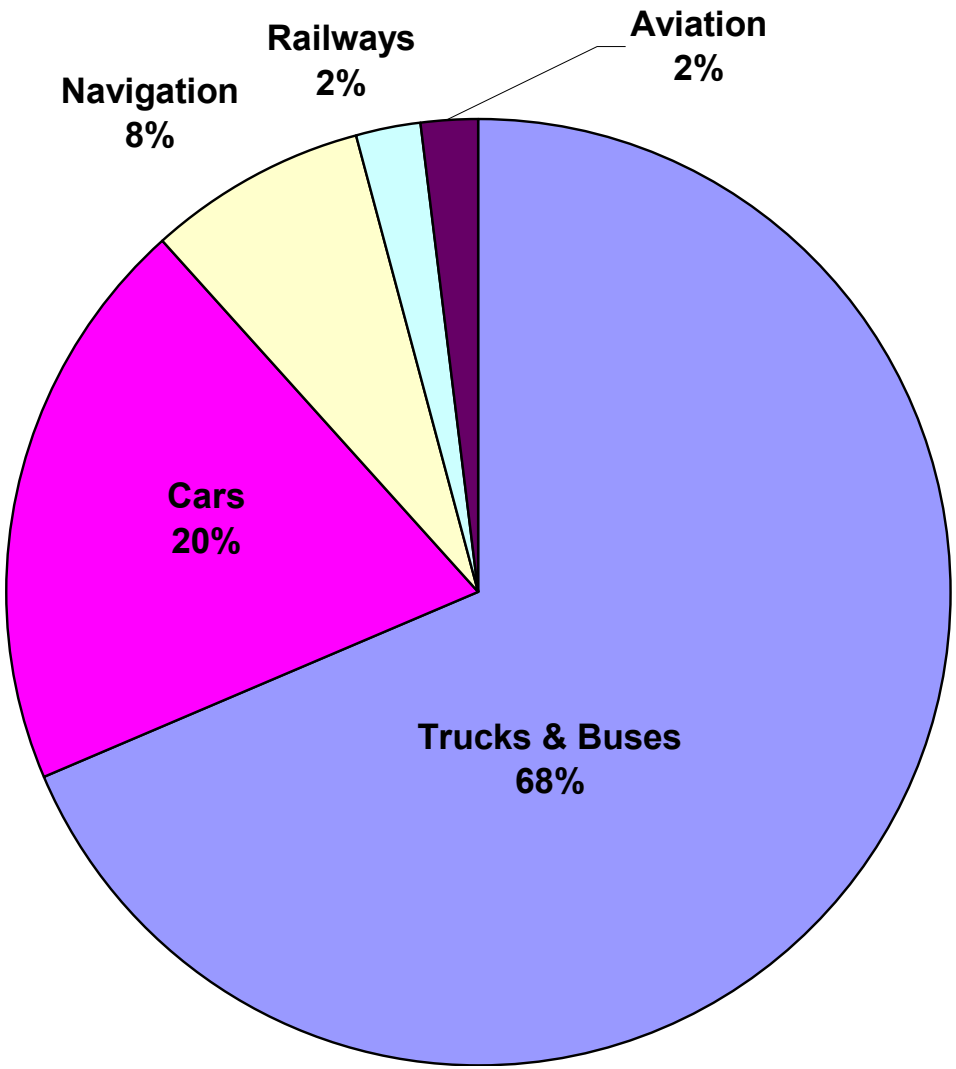

45000
40000
35000
30000
25000
20000
15000
10000
5000
0
GHG Emissions in Thousand Tonnes CO_2 Equivalent
SNC
INC
ALGAS
1990
1994
2001
2005

Relative contributions to CO_2 emission 2005



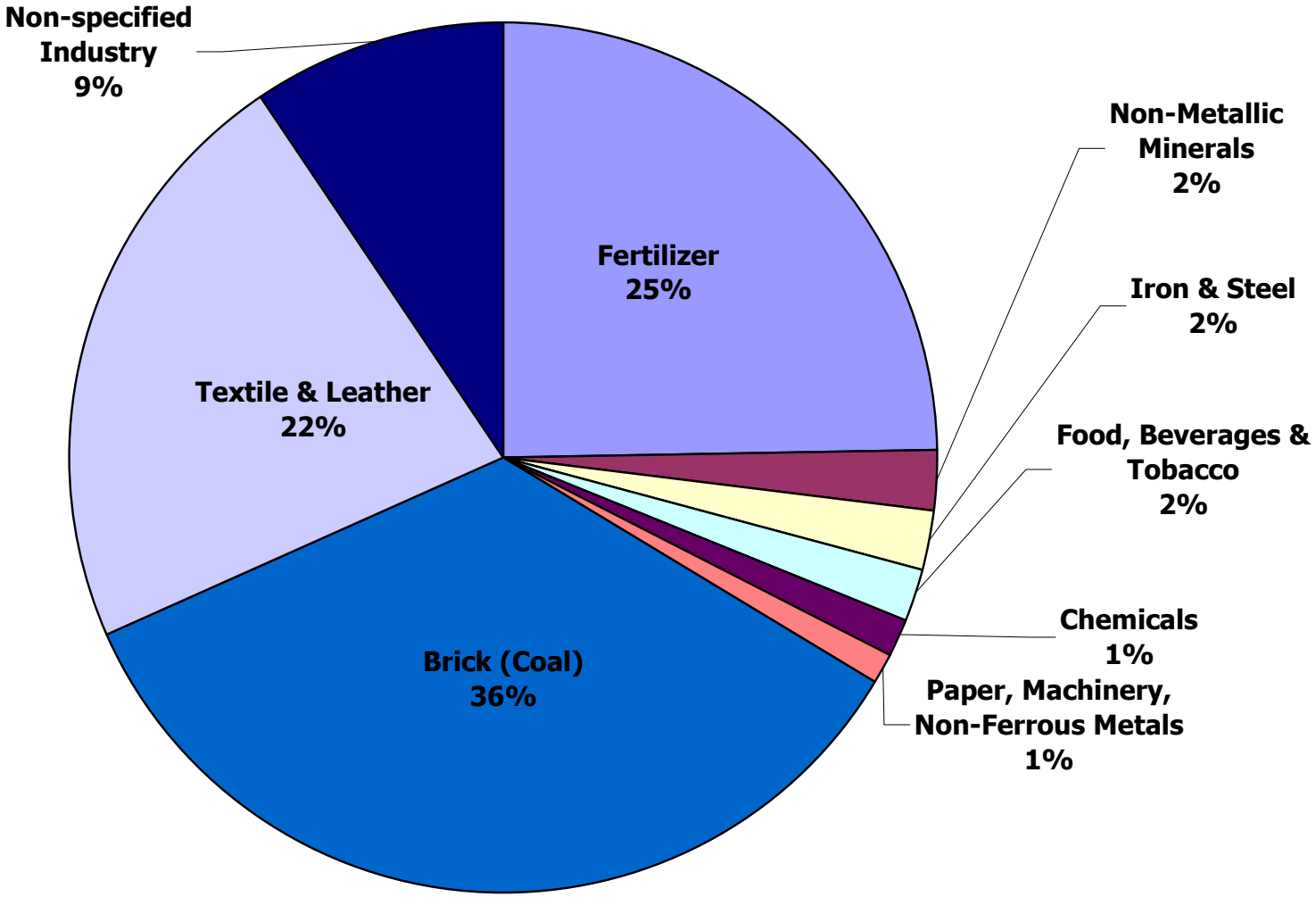
CO_2 from Transportation Sector

2005



CO_2 Emission by Manufacturing & Construction Sub-Sector

2005

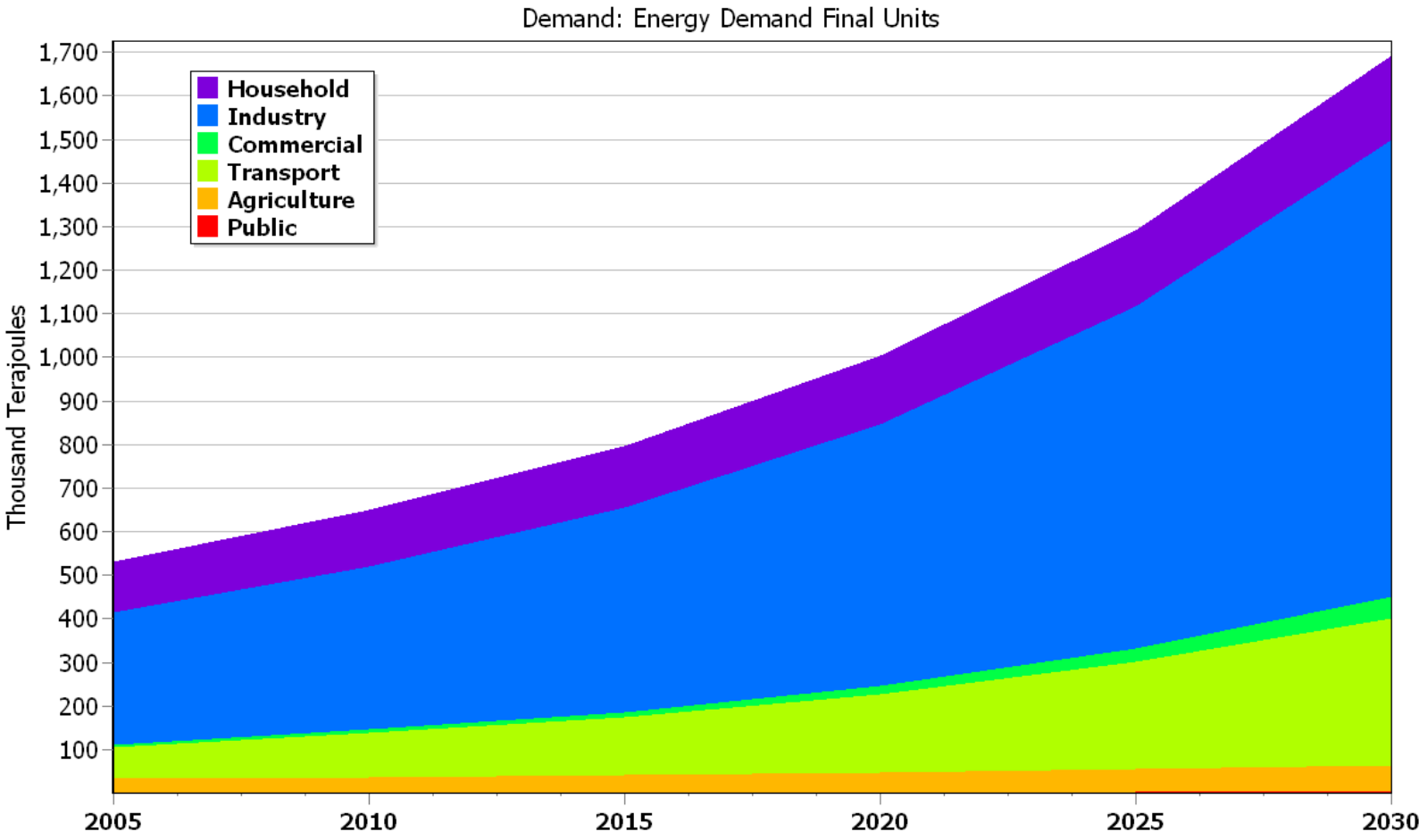


Major Assumptions for GHG Projection in LEAP

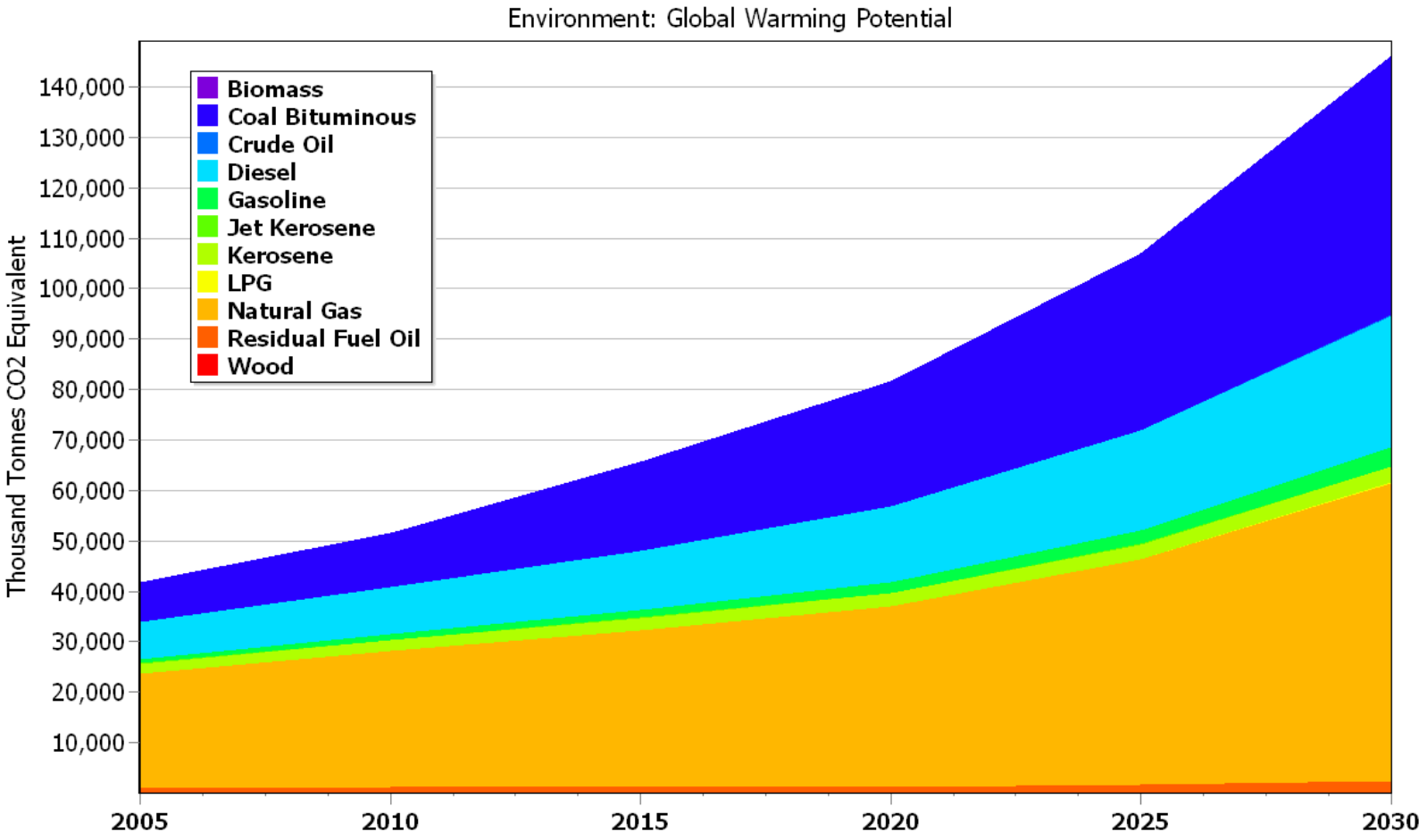
Item	Growth (%)	Comments
Population	1.75	Constant (not much slowing down expected)
Household	1.75	Constant (not much slowing down expected)
Income	5	Corresponds to GDP growth rate of 6.5% per year

Item	Value	Comments
Gas Reserves	12 + 25 Tcf	Daily production to reach a maximum of 4000 MMcfd by 2017
Coal Reserves	2000 MT	Production: 1 MT/yr up to 2015; to reach 10 MT/yr in 2030
Imports	500 MMcfd	LNG from 2012; Coal from 2015; All fuel shortfall met by imports
Electricity (2030)		
New Coal	10000 MW	40% efficiency sub-critical boiler power plants starting at 2015
Gas Based	6000 MW	CCGT for intermediate and baseload; GT for peak load
Others	4000 MW	2000 MW Nuclear and 5% of Total to be solar + wind + hydro by 2030

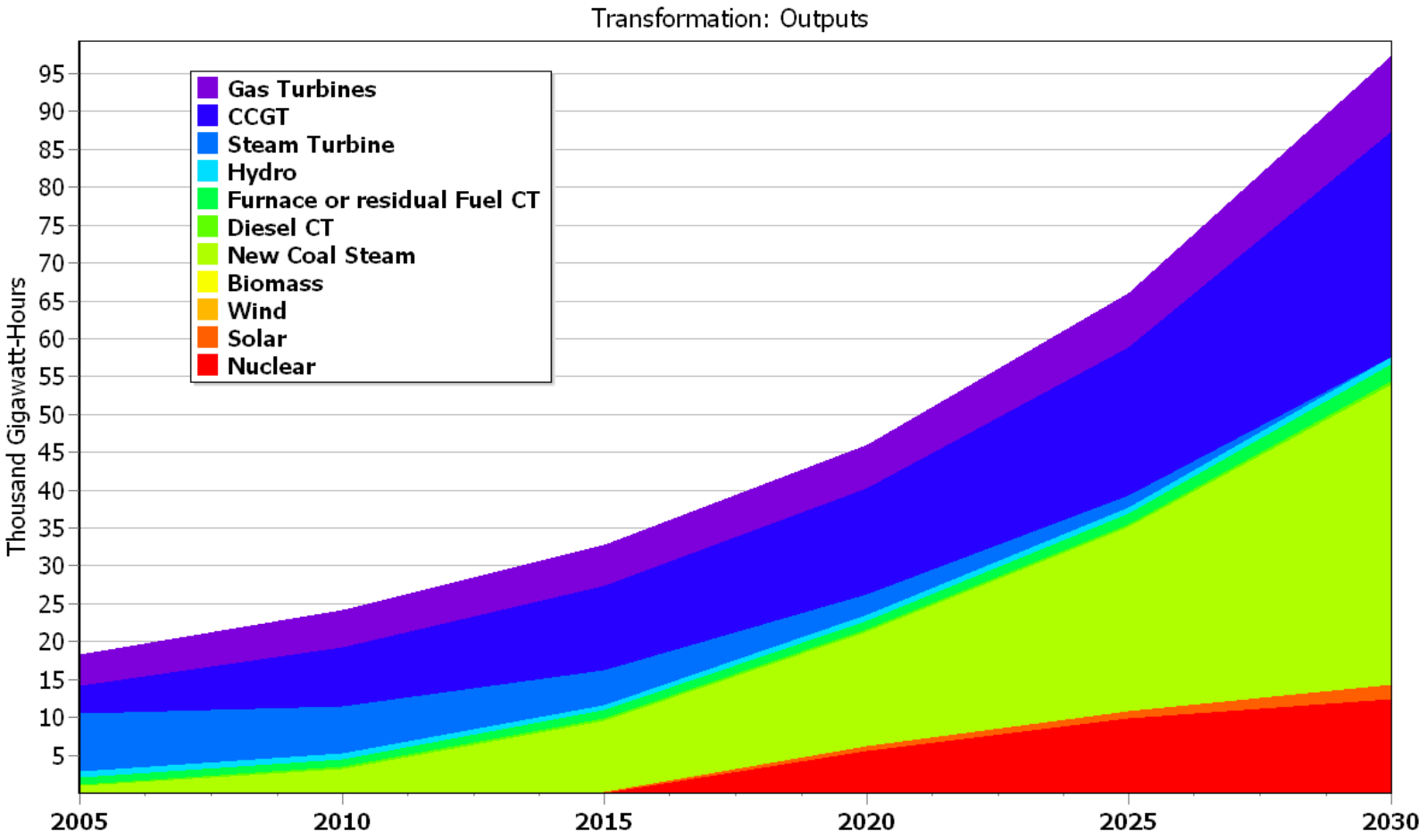
Energy projection of the demand sectors for the period 2005 to 2030



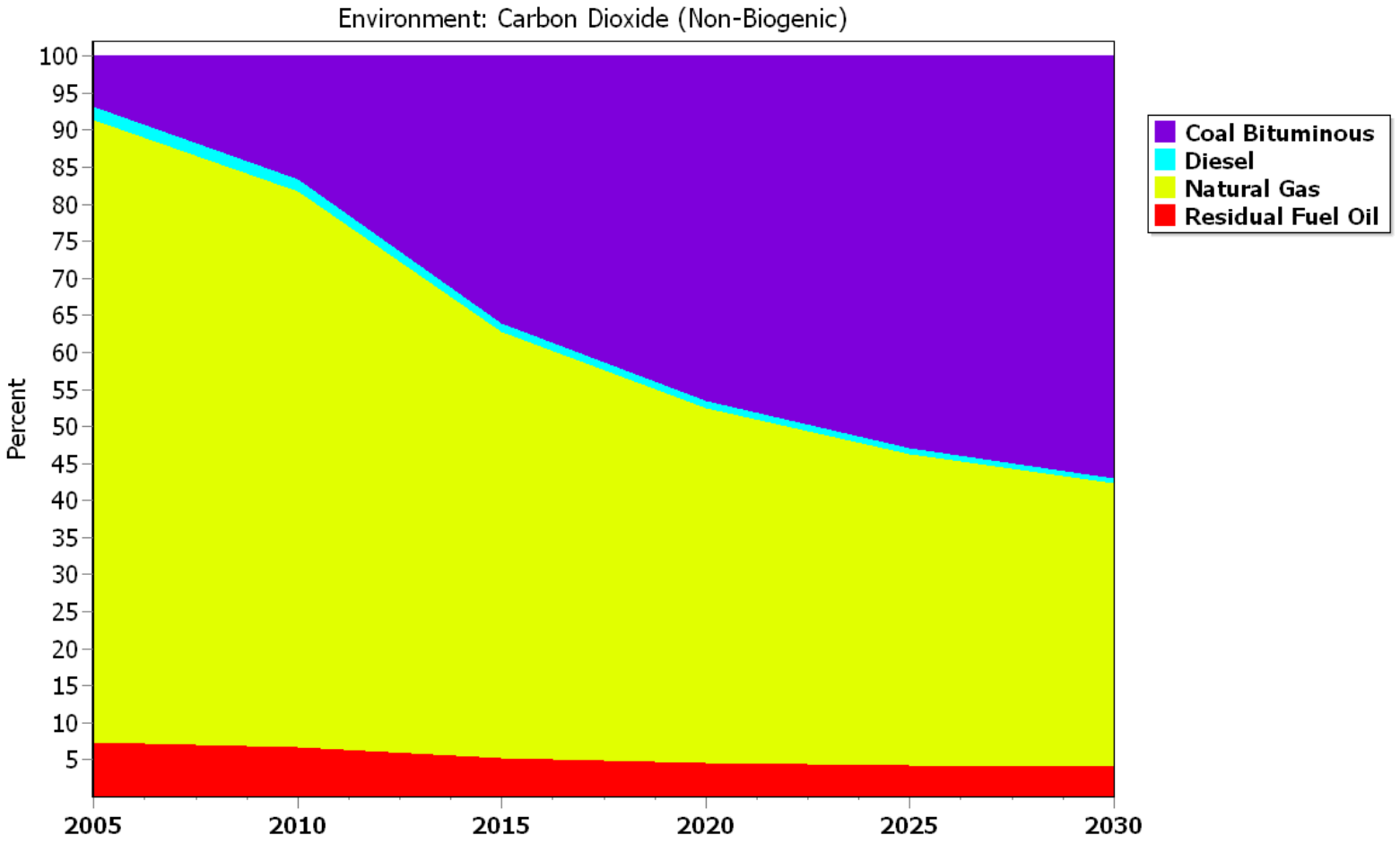
GHG emissions projection by fuel type for the period 2005 to 2030



Electricity generation plan by technology type



CO_2 emissions from power plants grouped according to type of fuels



Mitigation Sectors Considered

- Primary Energy (mainly power)
- Transport – rail and water
- Energy Intensive Industries – Public and Private
- Residential, Commercial and Agricultural sectors
- Cross-sectoral options (boiler, CHP, DSM)
- Renewables

On-going Government efforts on Energy Efficiency and Renewables

- Sustainable and Renewable Energy Development Authority (SREDA) for Energy Efficiency and Renewable Energy promotion to be created soon
- Energy Conservation Act (ECA) to be passed soon
- Building code being updated to include EE
- Strengthening of BSTI for labeling and testing of appliances (BSTI already working on CFLs)
- Strong support for Solar PV at highest level (PM)
- Directives to all gas and power utilities to promote conservation and energy efficiency

MITIGATIONS OPTIONS – I

Transport Sector

- Modal shift from (i) road to railway and (ii) road to waterway

Agriculture Sector

- Solar PV irrigation pumps

Residential Sector

- Metering residential gas supply and Improved gas stoves
- Solar PV lanterns to replace kerosene lamps

Industry Sector (both public and private sector industries)

- New Urea fertilizer plants
- Sugar mills (cogeneration plant efficiency improvement)
- Steel re-rolling mills efficiency improvement
- Brick making – Higher efficiency kilns
- Industrial cogeneration for captive generators
- Boiler efficiency improvement

MITIGATIONS OPTIONS – II

Commercial Sector

- Solar reflective glass for façades and windows
- Use of hollow bricks as partition walls

Energy Sector (Electricity)

- CCGT to replace old Steam Turbine (ST) plants
- Electricity distribution loss reduction
- Supercritical boilers for coal fired power plants

Cross Sectoral Options

- Efficient fans
- Efficient lighting (T8 replaced by T5 fluorescent tube-lights)

Biomass Options

- Efficiency improvement of parboiling
- Biogas plants

Rail Transport

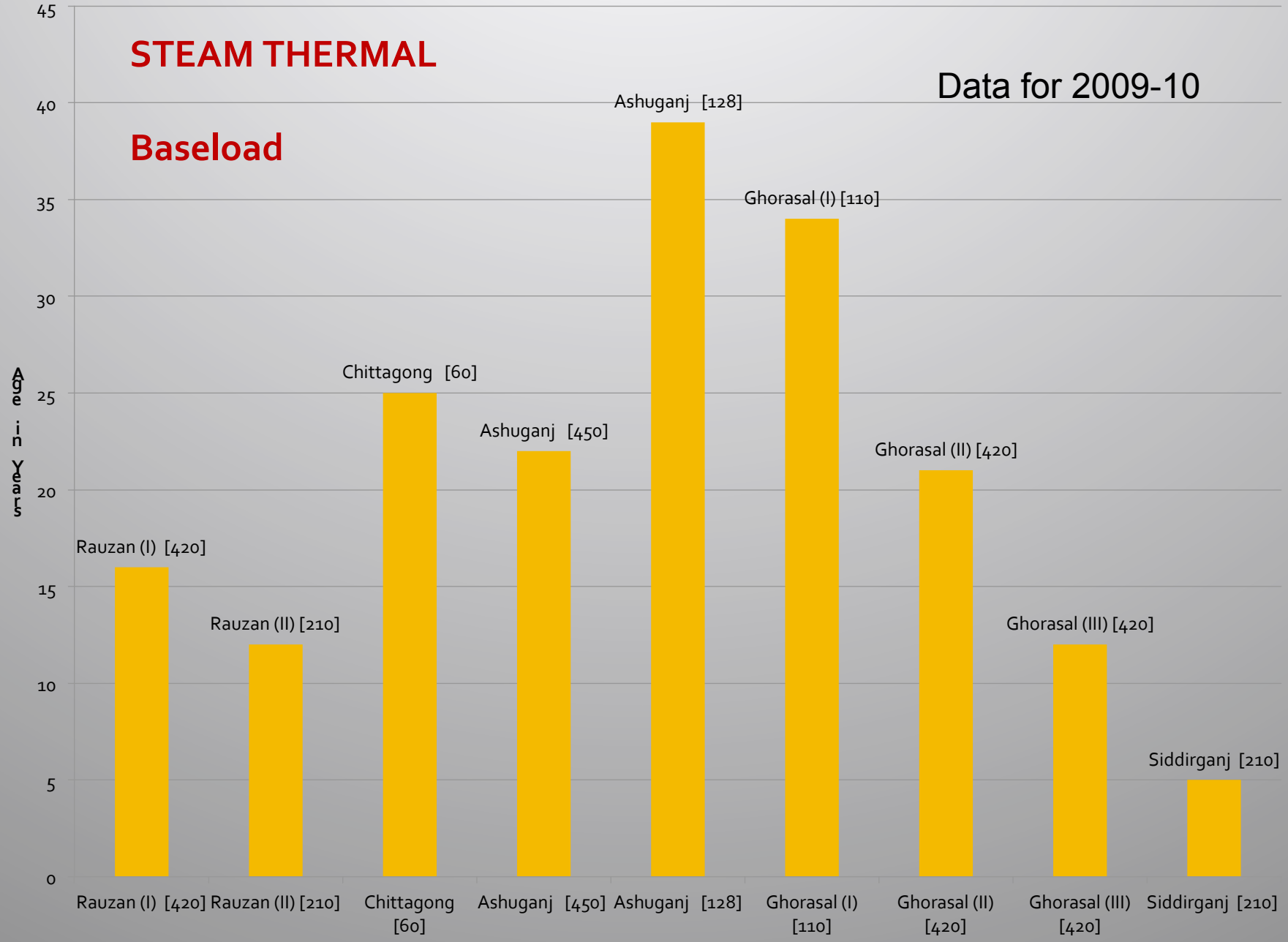
- A passenger-kilometer is 2-3 times more efficient than buses
- A freight-kilometer is 5-6 times more efficient than trucks
- Modal shift by expanding and upgrading service

- **Government has provided strong support for railway**
- **Budget allocation has been significantly increased**
- **US$ 1 billion deal with India is mainly for improving and expanding railway network and services**

Water Transport

- Most efficient mode of transport in terms of energy use; more than even railway
- Passenger-kilometer is **3-4** times and freight-kilometer is **8-10** times more efficient
- Expand and upgrade service for modal shift
- Maintain waterways and ensure security

- **Government Plans: Water bus route around Dhaka City**
- **More water bus routes are being considered**
- **Dredging of waterways program has been expanded**


STEAM THERMAL
Baseload
Data for 2009-10
Age in Years
45
40
35
30
25
20
15
10
5
0
Rauzan (I) [420]
Rauzan (II) [210]
Chittagong [60]
Ashuganj [450]
Ashuganj [128]
Ghorasal (I) [110]
Ghorasal (II) [420]
Ghorasal (III) [420]
Siddirganj [210]
Rauzan (I) [420]
Rauzan (II) [210]
Chittagong [60]
Ashuganj [450]
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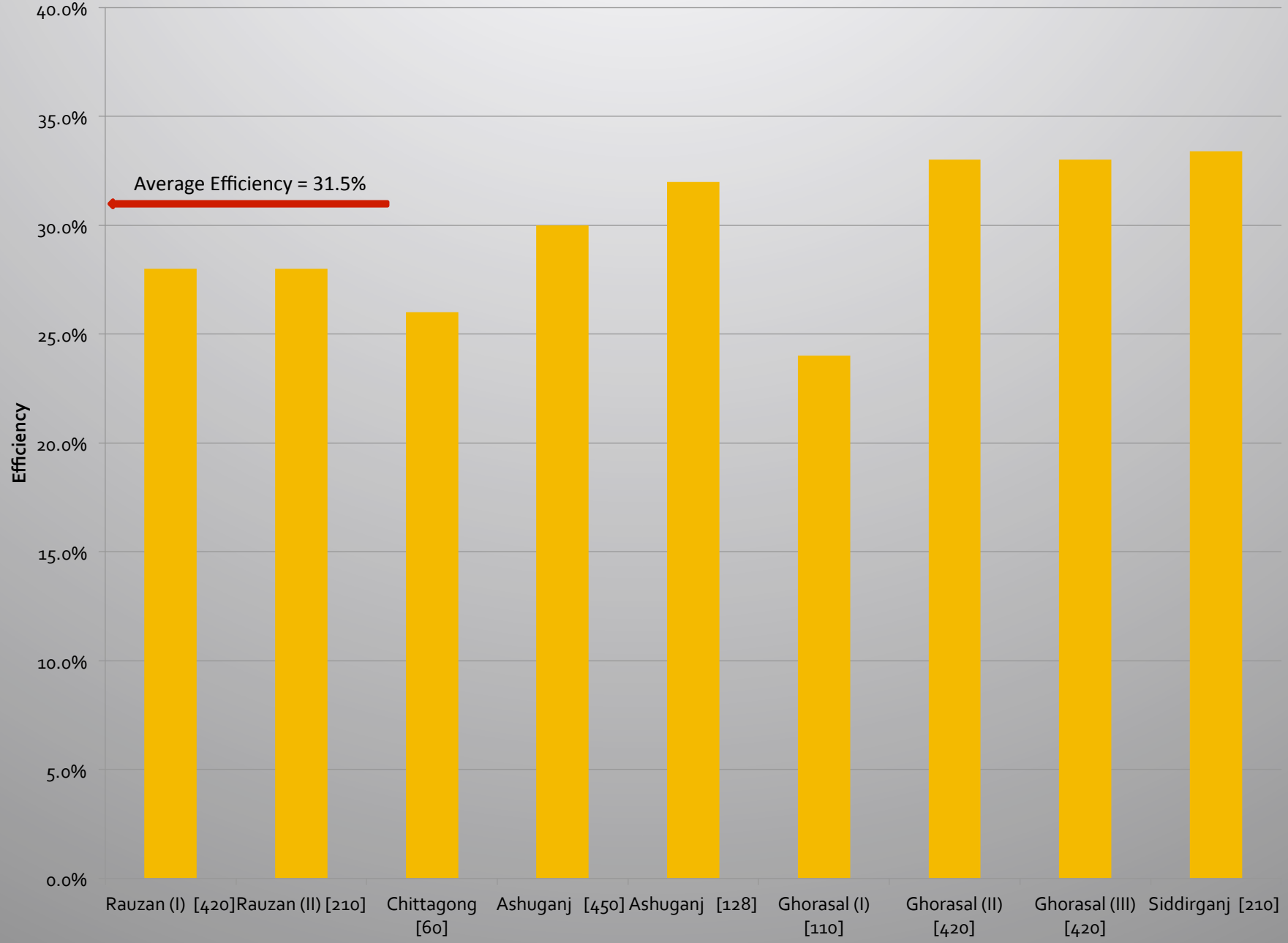
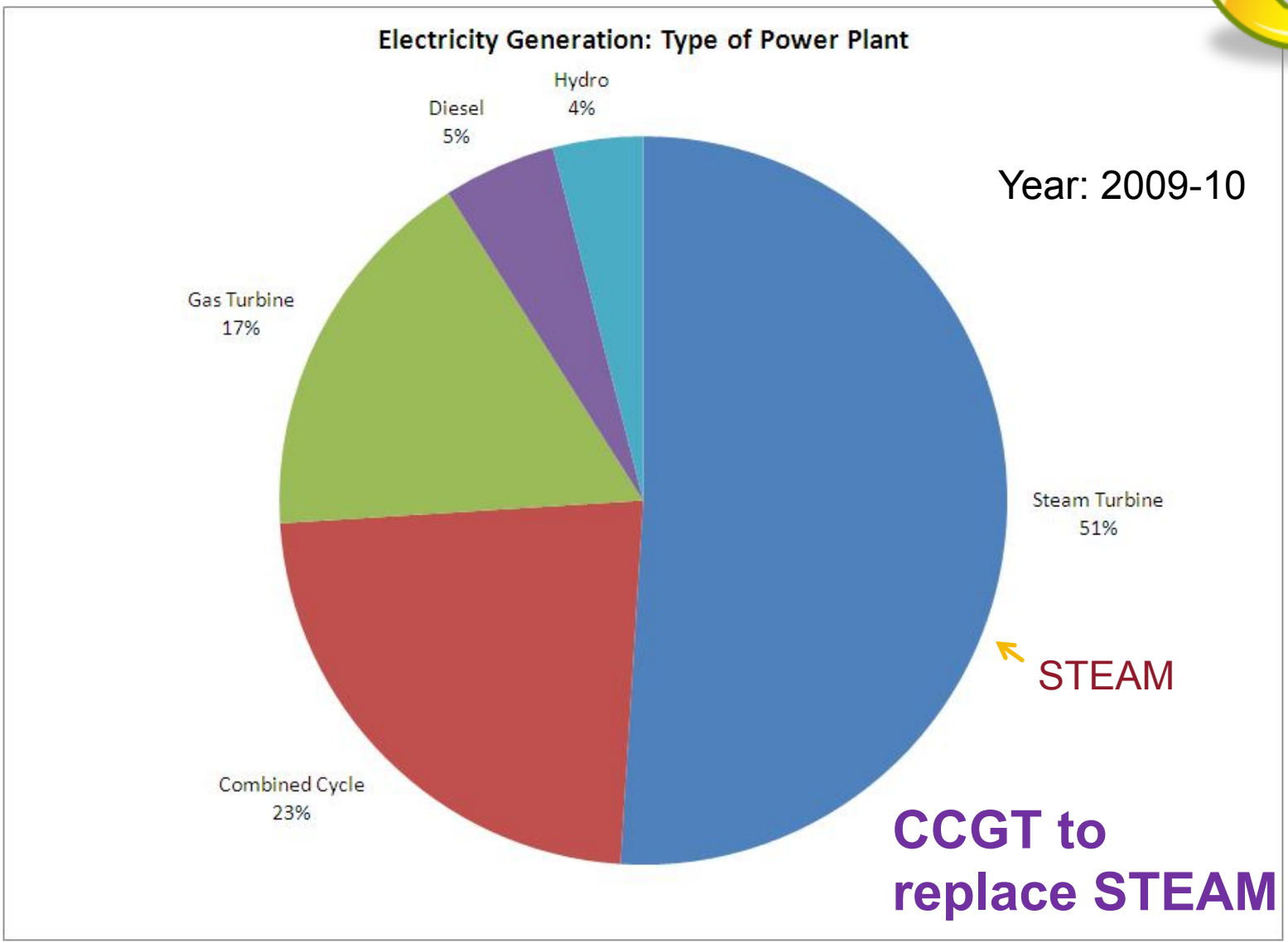
Ghorasal (I) [110]
Ghorasal (II) [420]
Ghorasal (III) [420]
Siddirganj [210]


40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Efficiency
Average Efficiency = 31.5%
Rauzan (I) [420]
Rauzan (II) [210]
Chittagong [60]
Ashuganj [450]
Ashuganj [128]
Ghorasal (I) [110]
Ghorasal (II) [420]
Ghorasal (III) [420]
Siddirganj [210]

Electricity Generation



ELECTRICITY SUPPLY

- CCGT to replace steam thermal plants
- Supercritical boiler (coal)
- T&D infrastructure up-grading and rehabilitation

Feasibility Studies with the Aim of Developing a Bilateral Offset Credit Mechanism FY2011

Studies for Project Development and Organization

Newly-constructed CCGT Power Generation Project in the People's Republic of Bangladesh

New Energy and Industrial Technology Development Organization (NEDO)
Mitsubishi Research Institute, Inc.

Newly-constructed CCGT Power Generation Project in the People's Republic of Bangladesh

1.Background & Objective

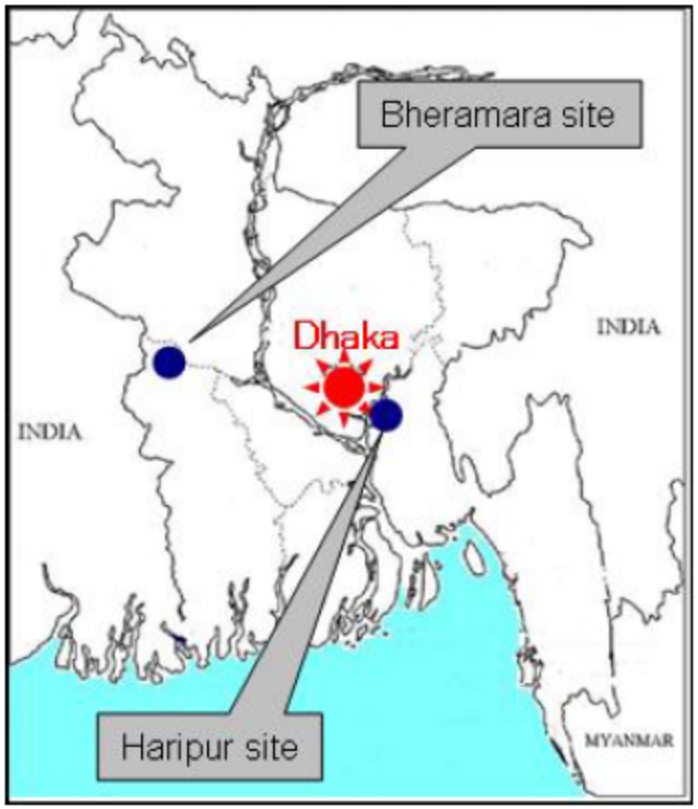
- Introduction of CCGT is significantly important for Bangladesh's power resources development plan for maximizing effective use of existing natural gas.
- Accumulation of operational experience and know-how through its early introduction is indispensable for the stable power supply in Bangladesh.

2.Estimation of Emission Reductions

- There is a wide range of difference in emission factor depending on the calculation method (AM0029, ACM0013, J-MRV0004, Standardized Baseline) from 0.542～0.762 kg-CO2/ MWh .
- Difference in the amount of emission reduction is 542,163～1,232,794t-CO2/year. Ripple effect of this project would be about 8.3-18.8 million t-CO2.
- For the purpose of verification of additionality, average power generation cost in the host country and that of the project are compared. And, when power sources are listed in the order of higher emission factor, those of which emission factors are lower than Ya% (ex.80%) will be deemed as additional.

3.Economic Evaluation

- FIRR: 11.41% (High-EF), 9.40% (Low -EF) , 7.85% (No credit)
- The economic effects include reduction of O&M cost and supplying about 17~39% of EPC cost.



Conceptual Specification (CCGT)

Capacity	421,600 kW
Type	1 on 1
Gas Condition	49,115kJ/kg (LHV)
Gross Efficiency	57.3% (LHV)

Captive Power Generation

- Because of electricity shortage and unreliable power supply, gas utility started allowing captive power generation about 15 years back
- 1400+ MW is now in Captive Generation
- 25% of the gas for power is consumed by this sub-sector
- Plant efficiencies vary from 28% to 42% (average = 35%)
- Waste heat is mostly not utilized
- Ideal opportunity for **cogeneration**

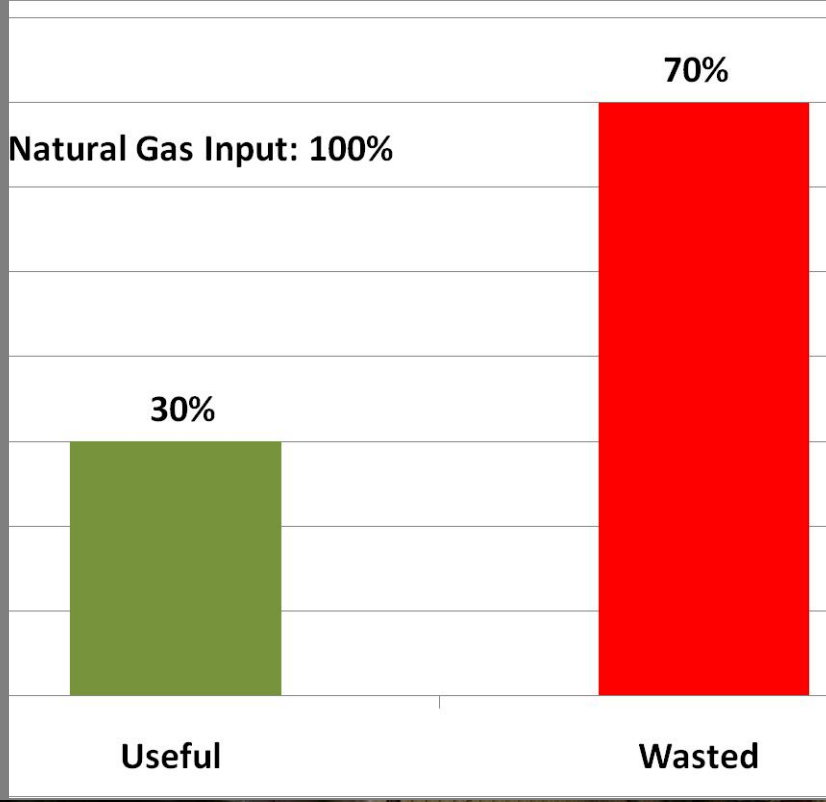
COGENERATION

A waste-heat boiler can recover a good portion of the wasted heat to produce steam

This will replace the existing boiler thus saving the natural gas used to make steam

If the industry does not require steam, then absorption refrigeration can be used for air-conditioning or making ice

Otherwise, the steam can be sold to neighboring industries



Industries

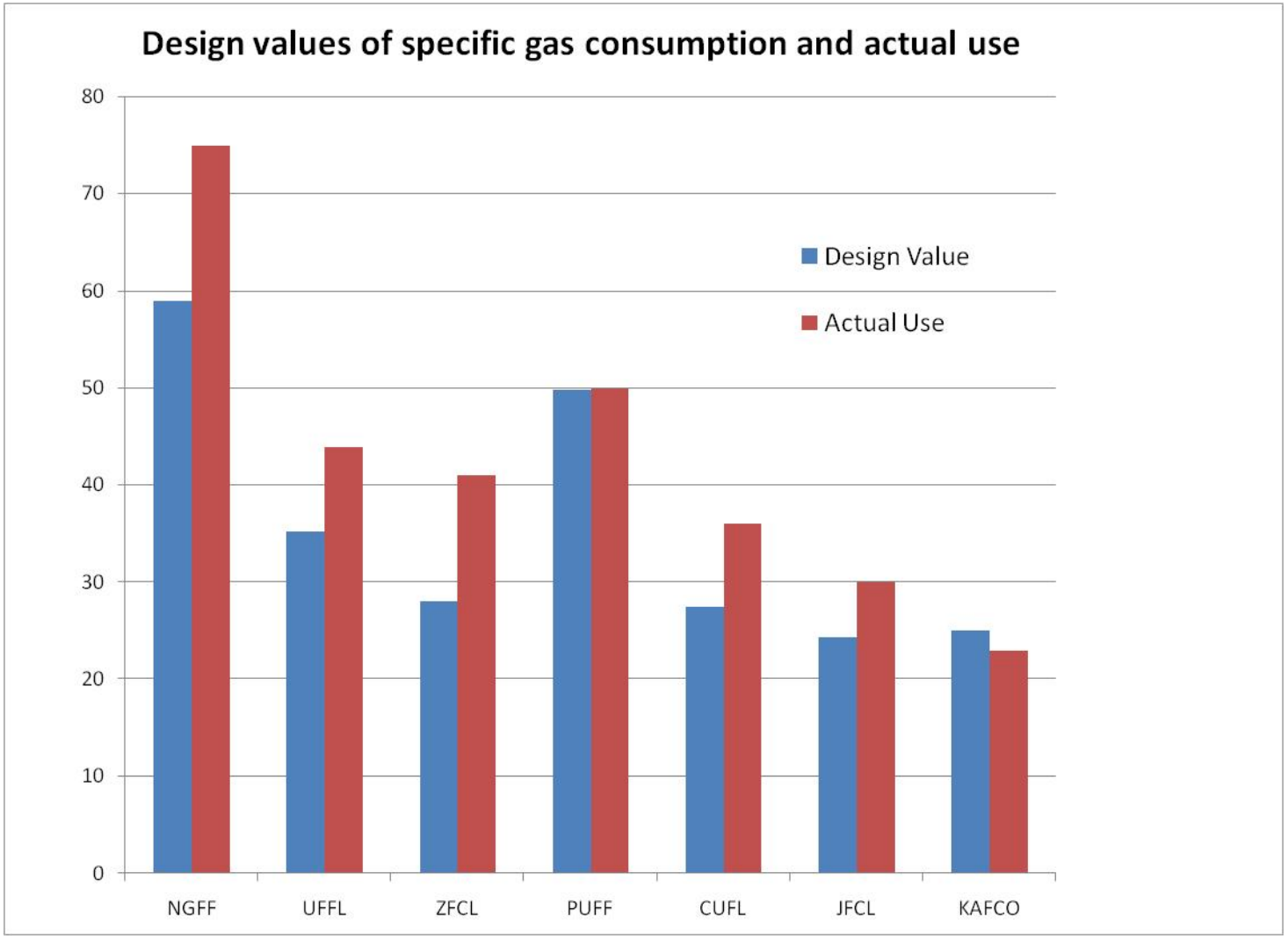
Public

- Urea fertilizer plants (GoB)
- Sugar Cogeneration (BSFIC-ADB CDM project)

Private

- Brick Kilns (CASE Project, World Bank, UNDP, GTZ)
- Steel Mills (TITAS Gas)

Urea Fertilizer: Four plants (NGFF, PUFF, UFFL, ZFCL) consume for 1 ton of urea more than 40 Mcf of natural gas, compared to 23 Mcf and 30 Mcf by KAFCO and JFCL respectively



Mills are so old that simply building new mills can double the energy efficiency

Cogeneration in Sugar Mills

- There are 15 medium sized sugar mills owned by BSFIC
- Most of these mills are more than **40 years** old, and use very low pressure boilers for electricity generation
- State-of-the-art bagasse boilers are **82 bar**, whereas some boilers under BSFIC are **11 bar; best are 42 bar**
- Each mill can export surplus electricity between **3-4 MW** to the grid. A **feed-in tariff** appropriate for renewable energy is needed to promote this option

Private Industries: Brick Kilns

- 5000+ Fixed Chimney Kilns (FCK) and Zigzag Kilns consume more than 3 million Tons of coal - Highly polluting and energy inefficient
- FCK/Zigzag Kiln – Very crude furnace; dugout area in open field
- Smalltime entrepreneurs run the industry

- **Government has undertaken several measures to improve the present situation both in terms of energy consumption and environmental pollution**
- **GEF project in 2005-2008; UNDP, WB and GTZ have facilitated**
- **World Bank pilot project for improvement of FCK**
- **CDM project using Hybrid Hoffman Kiln have been registered**
- **World Bank CASE project is ongoing to improve situation**

Fixed Chimney Kiln (FCK)

VSBK: 40-50% more efficient than FCK

HOFFMAN KILN – Coal Fired: 25-35% more efficient than FCK

Earthen Techno
亀井製陶株式会社

Company guide
Press release
Delivery results
Non-fired eco bricks
Manufacturing process
Materials
Handling products

Although they are non-fired, they are very safe, high quality and low price.

Sewer sludge, burned ash, coal ash, ceramics abolished soil [Kira], molten slag, glass waste and many other unused resources are utilized, and are regenerated to form a revolutionary brick style block, without baking, using our special slodificaton technology (Patent process).

We feel it is important to create materials of soft disposition, that feel like ceramics, which gives warmth and serenity to the cityscape.

Feature

Scrap Steel Mills + Re-rolling Mills

- Energy component more than 25% of product cost
- Crude Operation and Inefficient Induction Furnaces
- Plant shuts down during peak hours (6 – 11 pm). Furnaces undergo cyclic cooling and heating
- Load shedding causes significant losses. Scrap melting and ingot re-rolling not synchronized
- Re-rolling: Bad insulation; no heat recovery and inefficient burners
- SEC varies from 25 to 75 m^3/ton for modern to traditional re-rolling mills

Demand Side Management

- Metering of domestic gas connections
- Efficient lighting and fans
- Improved gas cookstoves
- Efficient building: Solar Reflective Glass

Solar Reflective Glass

- Huge tendency to build commercial building with glass façades
- Even though all commercial building are air-conditioned not enough regard being paid to lessen air-conditioning load
- Several measures exist to lessen cooling load in commercial buildings
- One is the use of Solar Reflective Glass

Source: EE Roadmap report

6. Commercial and Industrial FL Re-lamping Program

Consuming sector, sub-sector, industry:

All sectors where fluorescent lamps are used especially commercial and manufacturing:

- Garment Industry and Knitting Industry
- Commercial establishments and offices; Signboards and advertisements
- Hospitals and residential hotels, Apartment Complexes and Households

Current situation (business-as-usual) regarding equipment, process, or end-use:

Fluorescent lamps (FL) are widely used in Bangladesh especially in offices and manufacturing industries such as the garments and knitting factories. The most common lighting device is the 4-ft magnetic ballast T8 Fluorescent Lamp. The T8 Lamp is an improvement over the T12 lamp, but still inefficient. The latest in this line of FL products is the T5, which also comes with integrated electronic ballast (which saves over magnetic ballast). Even though users can install electronic ballast in T8 configuration, the standard practice is to use magnetic ballast. The power rating of the T8 is 36 watts, but along with the magnetic ballast, the total consumption is 45 watts. To assess the current situation, a survey was conducted of different types of users. The results of that survey finding is presented below for three major categories:

Source: EE Roadmap report

8. Ceiling Fan Replacement Program

Consuming sector, sub-sector, industry:

Garment industry, Educational institution, Commercial establishment, Office, Hotel, Hospital, Shop, Apartment Complex and household

Current situation (business-as-usual) regarding equipment, process, or end-use:

Most ceiling fans in current use are induction type motors with poor quality mild steel (MS) sheet core, MS motor body, MS sheet blades and low-cost, poor-quality motor winding. These result in poor flux density, lower magnetic field, higher power consumption (in wattage) and unnecessary thermal losses that heat up the operating environment. There are more than 70 different brands and types of ceiling fans available locally; many are locally produced but some are imported brands. Only a few of them are found to be energy saving type. A good quality ceiling fan uses silicon sheet core, aluminum body, and aluminum blades. A 56-inch blade ceiling fan having MS sheet core, MS body, MS blade and economy winding consumes 100 to 130 W of power, and has higher thermal loss due to heat generation in the body compared to an efficient model.

A survey was conducted in a garments factory in order to estimate the number of fans used, and the potential for energy savings from a replacement program.

Traditional Cook Stove burning attended

Improved Cook Stove with Auto-igniter

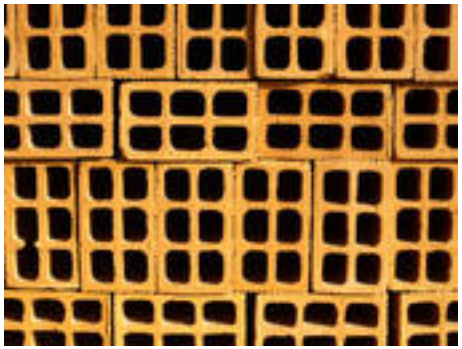
Cookstoves (old and new type)

Solar Reflective Glass could have been used

Solar Irrigation

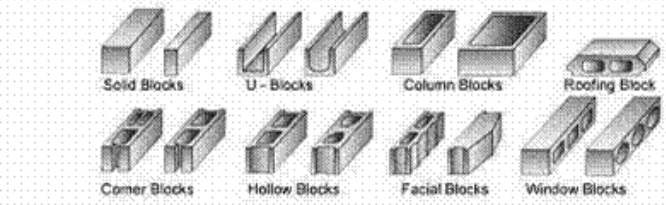
Metering Domestic Gas Connection

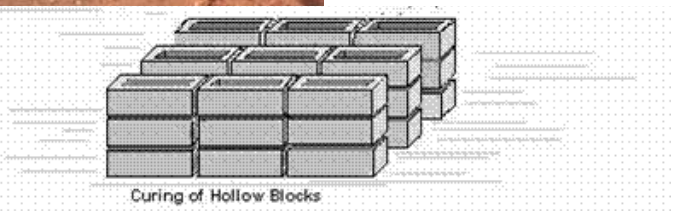
Solid bricks and alternatives



Hollow bricks -
less clay, less coal

Hollow bricks





Cement Blocks

BOILERS

- According to the Chief Inspector of Boilers (CIB) there are more than 5000 registered boilers in Bangladesh
- Based on preliminary assessment, the CIB believes many boilers are operating in the region of **70% efficiency**
- The boilers that are in the most neglected condition are in the Textile Dyeing Sector. Also, many of the Garments sector boilers are not in a good shape
- The most prospective size range for intervention in boiler efficiency improvement is the 1-5 t/h.
  More than 50% of the boilers are in this size
- **Boiler efficiency should be above 85%**

MOTORS

- Efficient motors
- Specialized motors
- Efficient drives
- Intelligent Motor Controllers
- Preventing rewinding of motors

Agricultural: PV Irrigation

- There are more than 0.5 million irrigation pumps of all types in Bangladesh (40% electric; 60 diesel)
- Seasonal demand of 1500 MW from January to April. Solar irrigation can alleviate the problem significantly as well as save fossil fuel
- REB project to install 100+ solar PV pumps . More efforts are underway (> 100 MW)
- Government is very keen on this idea, and is actively looking for bilateral and multilateral funding

Renewables: Present Achievements

- Up to February,2014 more than **2,000,000** Solar Home Systems have been installed by IDCOL through its 23 partners in the remote areas of Bangladesh
- Grameen Shakti alone has installed about 65% of the total
- About 25,000 domestic sized biogas plants have been installed (Based on data from Grameen Shakti)
- Recently the office of Prime Minister, Head office of Bangladesh Bank and Head office of DGFI have been fully covered by Solar Power Systems

Renewables: Ongoing Projects

- IDCOL is financing a project to install about 40,000 Biogas plants ; poultry farms are all installing large units for power
- It is also financing to set up a solar submersible pump of 250,000 Liter/day with a head of 35 m at Sapahar, Naogaon. A total of 64 solar PV modules with 175 Wp capacity each will be installed to provide the required power to run the pump
- Solar Micro grid is also an ongoing project of IDCOL
- IDCOL is also extending help to private SME organizations (for example Paragon Poultry Ltd., Gazipur, a 400-kW rice husk gasification based power generation at Thakurgaon)

(Source: IDCOL website)

Renewables: Biomass efficiency improvement

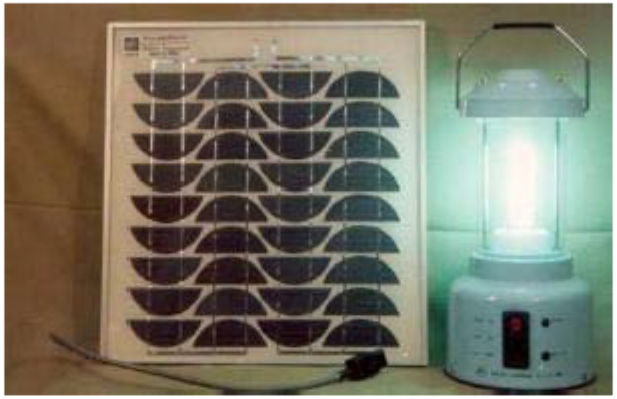
- Improved Cook Stoves(ICS) and Improved Rice Parboiling Systems are two excellent options
- These can reduce biomass utilization by up to 50%, and also reduce environmental pollution
- Up to February, 2014, more than 500,000 ICS installed. Grameen Shakti alone has installed more than 200,000 ICS. **POA CDM project registered**
- There are 50,000 Rice Parboiling System in BD (Data from GIZ)
- Biomass thus saved can be utilized in biomass gasification plants (ongoing GIZ project)

Solar Lanterns

- More than 300,000 tons of kerosene used annually for lighting purpose
- Solar PV lanterns are high quality replacement for kerosene lamps (KUPI)

RE Practices in Bangladesh - Solar PV Technologies

Solar Lantern Programme for Rural Poor Households in Bangladesh (UNDP supported)



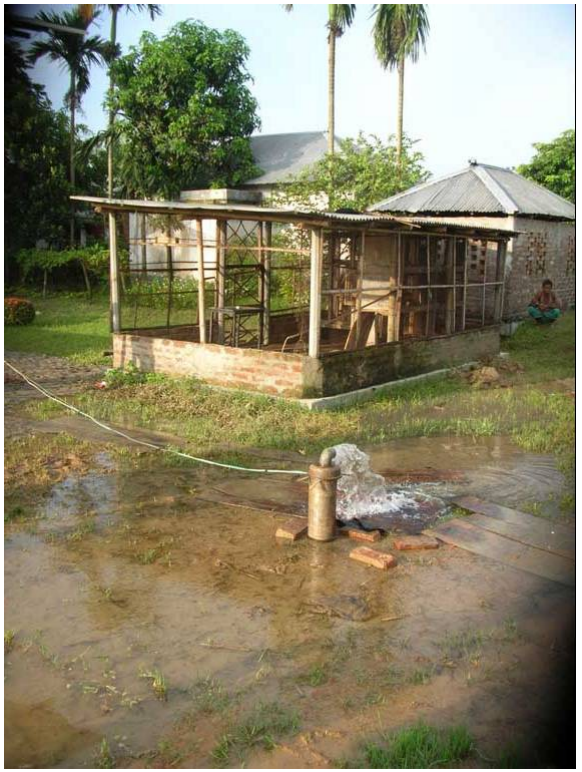
DNA has given approval for a PIN for a Solar PV Lantern CDM project

Biogas Digester

Biogas can Replace LPG

Solar Irrigation

	Diesel-Pump	Solar-Pump
Price:	US$ 1000	US$ 6000
Diesel:	US$ 1000/yr	US$ 100/yr
Life:	10 years	20 years



Improved Biomass Cookstove

Improved Cook Stoves (ICS) can easily achieve a thermal efficiency of 20%

If the saved biomass is Non Renewable Biomass, CDM can be used to promote ICS

← ICS →

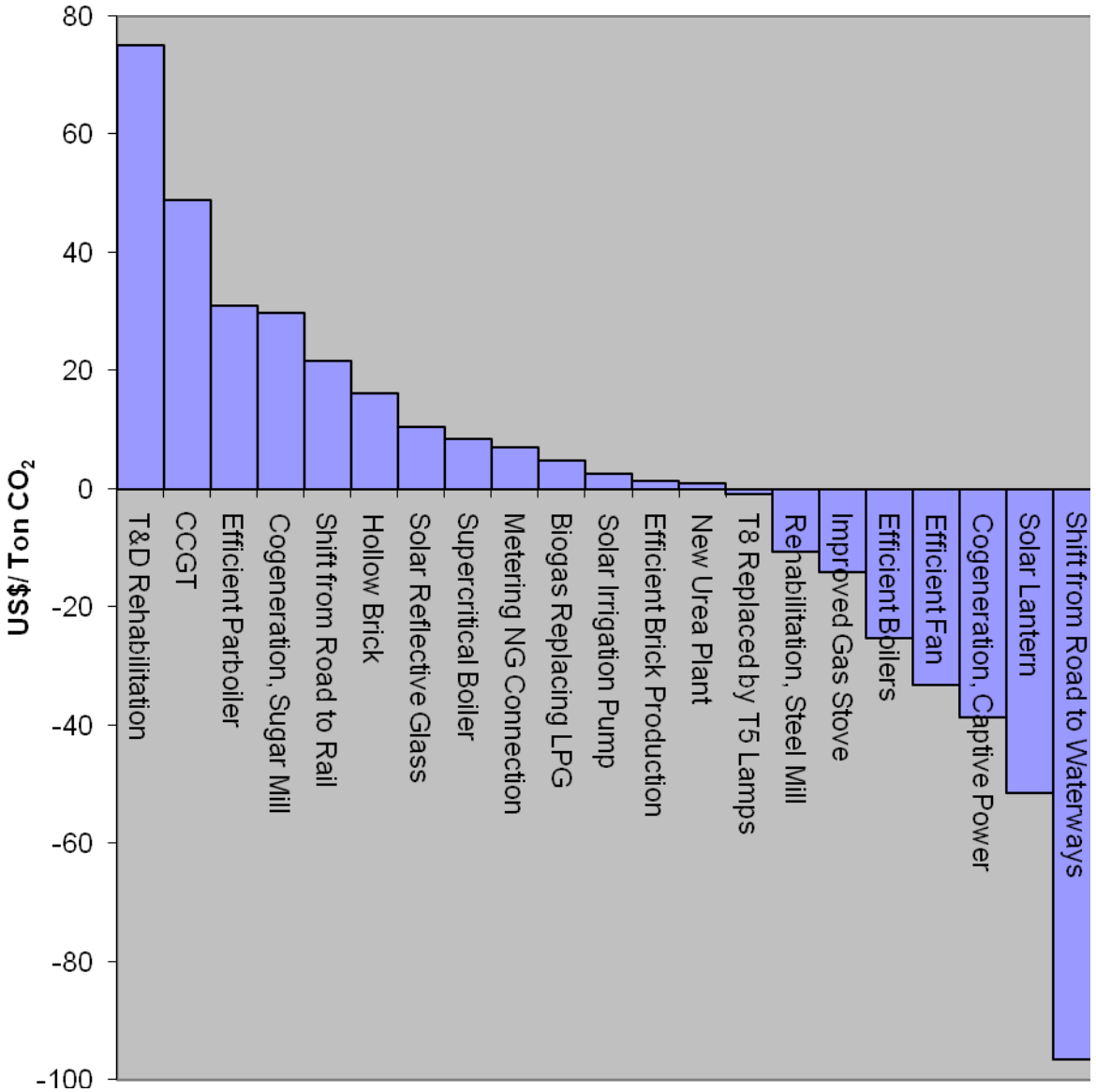
Village Restaurant

Efficient use of Biomass

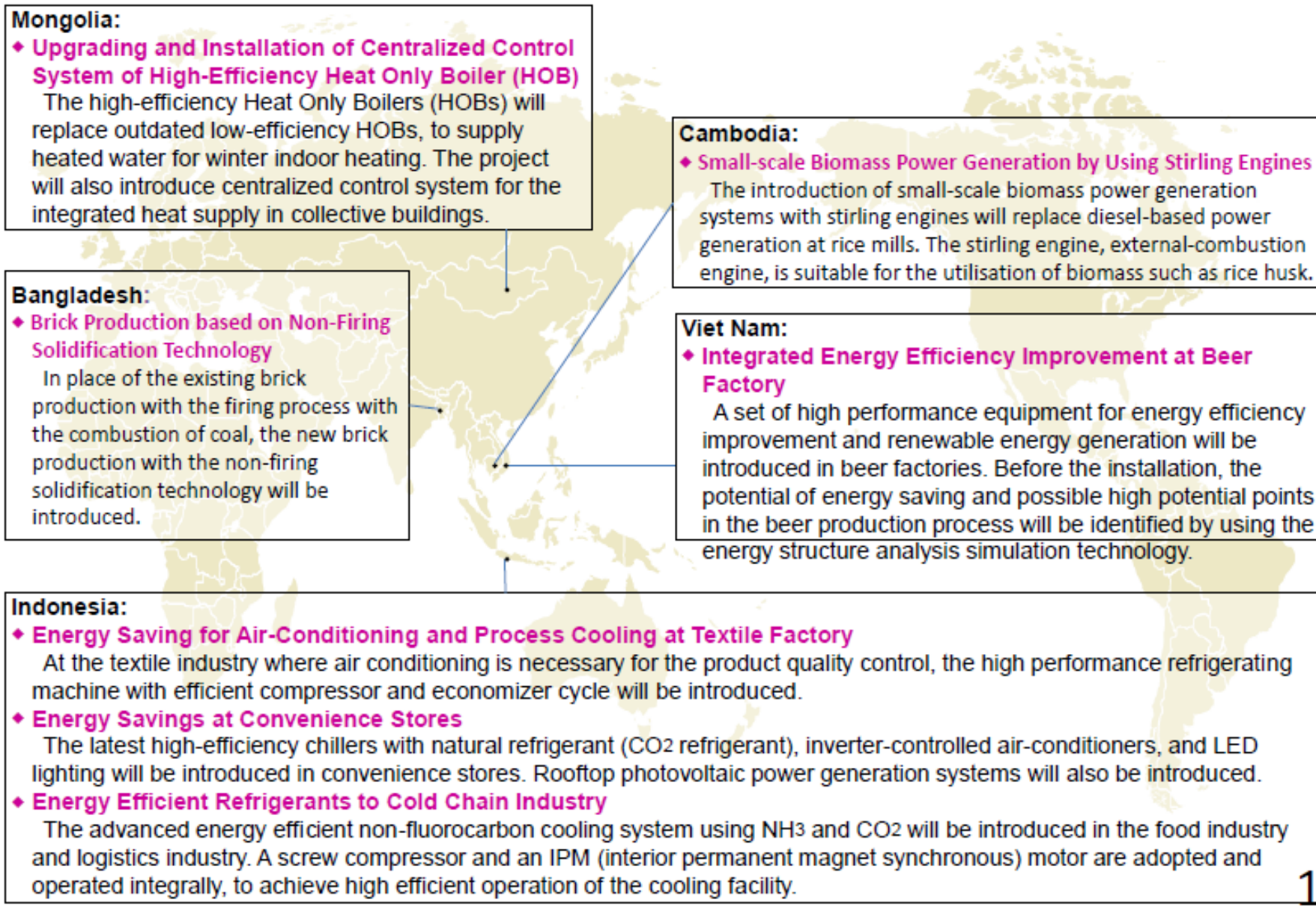
Efficiency improvement of paddy PARBOILERS

GIZ Project

Cost Effectiveness ($/ton)



JCM Model Projects in 2013 by MOEJ



Mongolia:

- **Upgrading and Installation of Centralized Control System of High-Efficiency Heat Only Boiler (HOB)**

  The high-efficiency Heat Only Boilers (HOBs) will replace outdated low-efficiency HOBs, to supply heated water for winter indoor heating. The project will also introduce centralized control system for the integrated heat supply in collective buildings.

Cambodia:

- **Small-scale Biomass Power Generation by Using Stirling Engines**

  The introduction of small-scale biomass power generation systems with stirling engines will replace diesel-based power generation at rice mills. The stirling engine, external-combustion engine, is suitable for the utilisation of biomass such as rice husk.

Bangladesh:

- **Brick Production based on Non-Firing Solidification Technology**

  In place of the existing brick production with the firing process with the combustion of coal, the new brick production with the non-firing solidification technology will be introduced.

Viet Nam:

- **Integrated Energy Efficiency Improvement at Beer Factory**

  A set of high performance equipment for energy efficiency improvement and renewable energy generation will be introduced in beer factories. Before the installation, the potential of energy saving and possible high potential points in the beer production process will be identified by using the energy structure analysis simulation technology.

Indonesia:

- **Energy Saving for Air-Conditioning and Process Cooling at Textile Factory**

  At the textile industry where air conditioning is necessary for the product quality control, the high performance refrigerating machine with efficient compressor and economizer cycle will be introduced.

- **Energy Savings at Convenience Stores**

  The latest high-efficiency chillers with natural refrigerant (CO_2 refrigerant), inverter-controlled air-conditioners, and LED lighting will be introduced in convenience stores. Rooftop photovoltaic power generation systems will also be introduced.

- **Energy Efficient Refrigerants to Cold Chain Industry**

  The advanced energy efficient non-fluorocarbon cooling system using NH_3 and CO_2 will be introduced in the food industry and logistics industry. A screw compressor and an IPM (interior permanent magnet synchronous) motor are adopted and operated integrally, to achieve high efficient operation of the cooling facility.

三菱証券

Project Design Document

for

A.T. Biopower
Rice Husk Power Project

July 2003

Mitsubishi Securities

Clean Energy Finance Committee

equipment, and storage facilities. The rest will be used as buffer zones and green space.

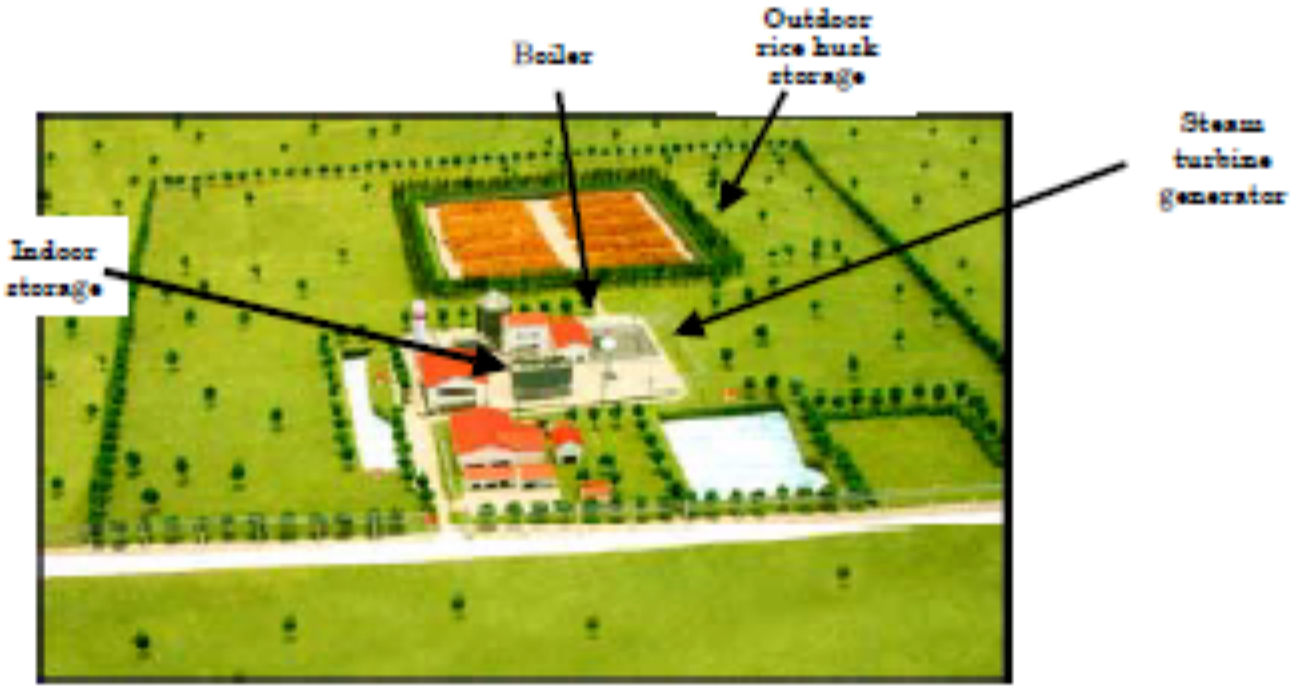
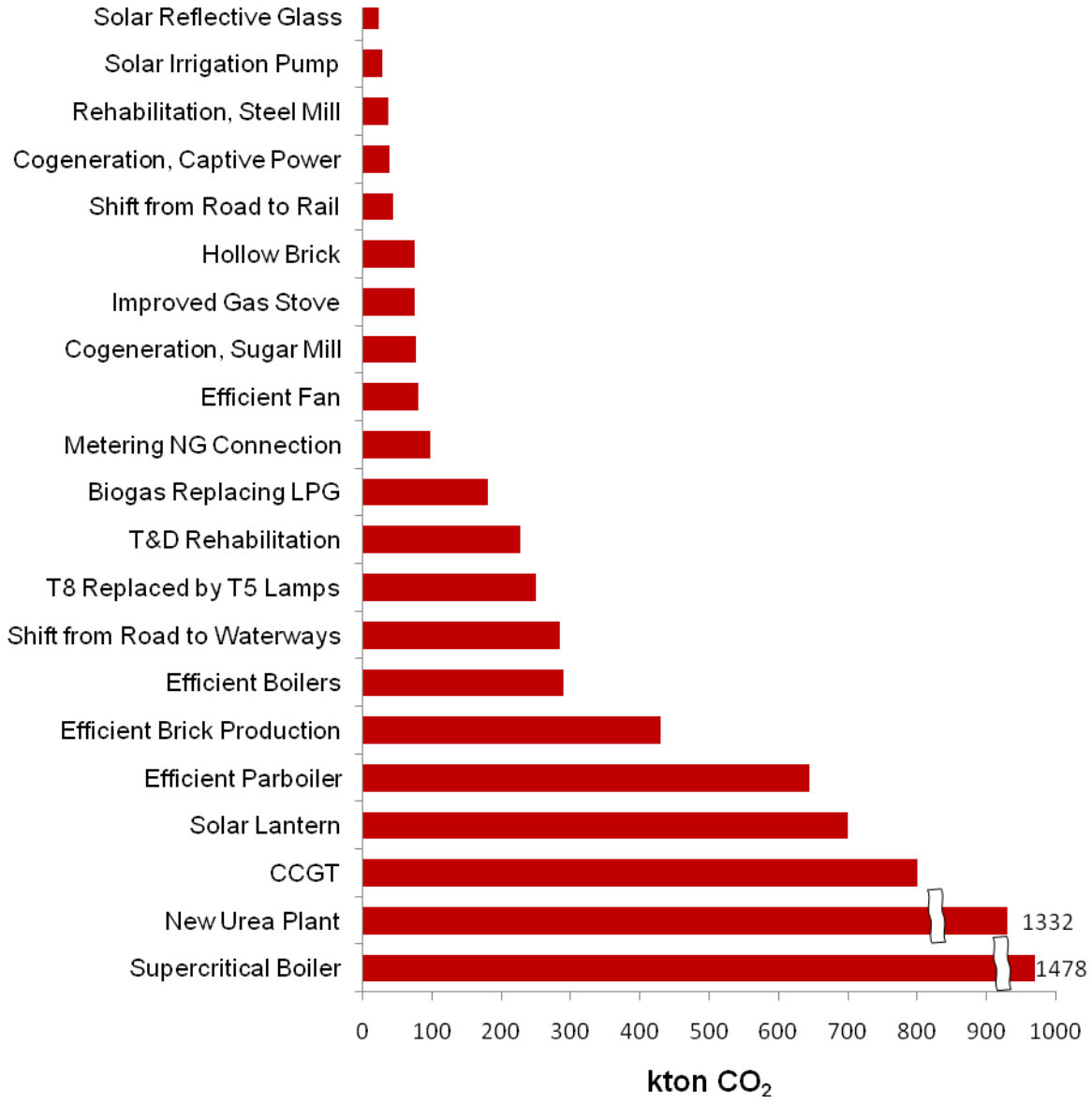
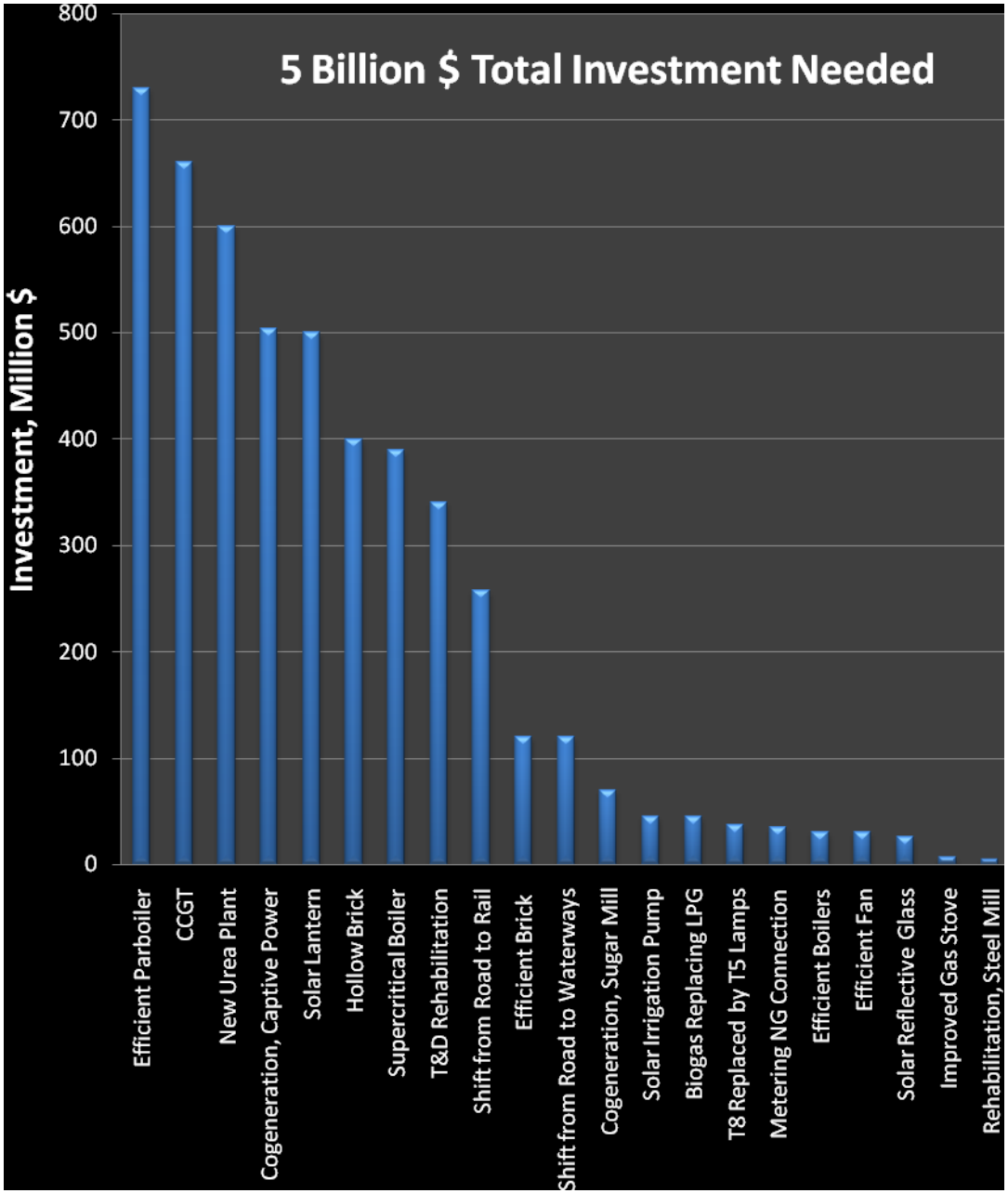


Image of Pichit Plant Site



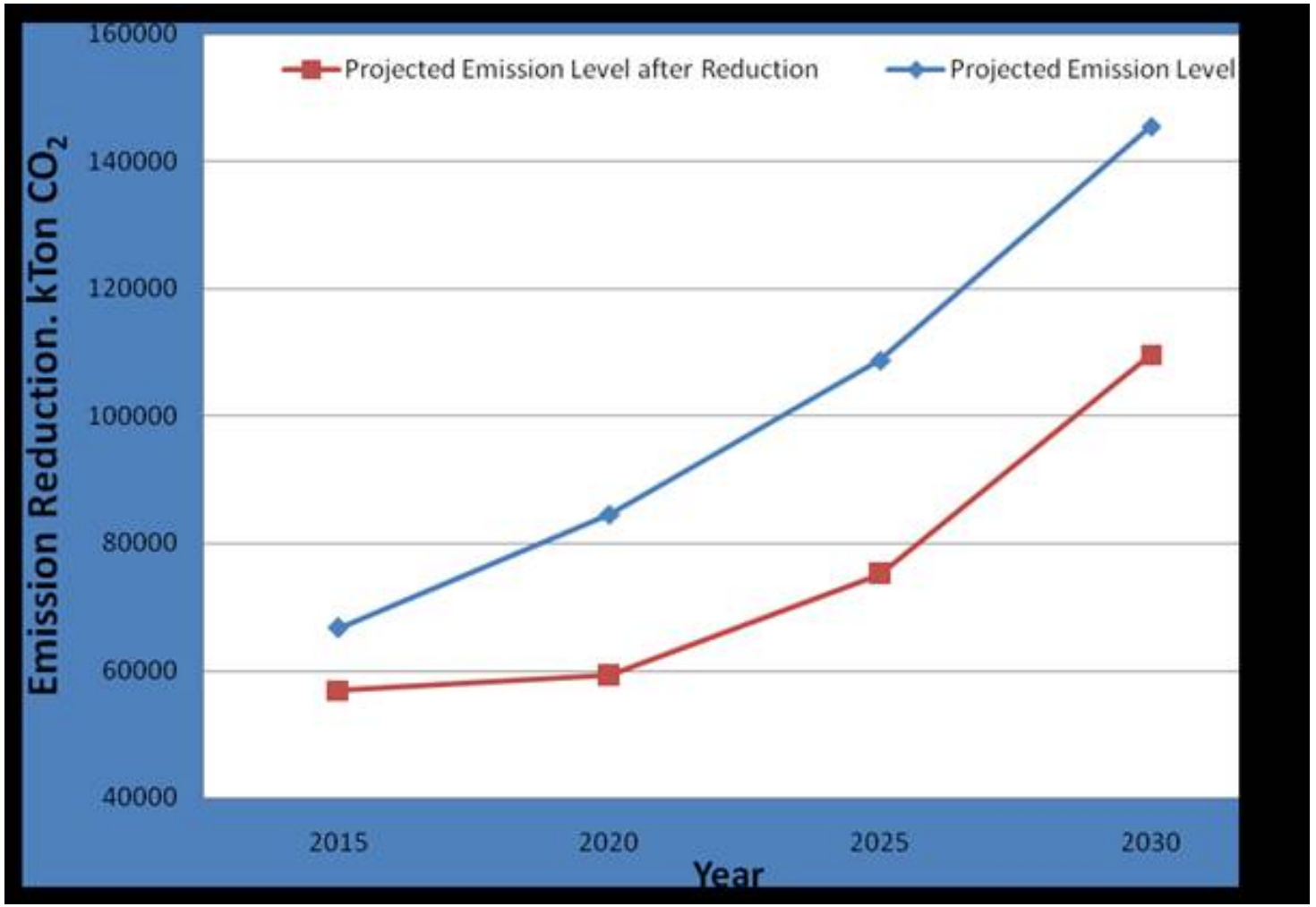
GHG Reduction Potential of Mitigation Options

Selected abatement measure	US$/ Tonne CO_2	Unit type	Emission reduction Tonne CO_2/Unit	Unit penetration by 2030	Emission reduction kilo Tonne CO_2/year
T8 Replaced by T5 Lamps	-0.89	lamp	0.05	5000000	250
Efficient Boilers	-25.23	boiler	96.80	3000	290
Shift from Road to Rail	21.55	train	592.53	75	44
Efficient Fan	-33.29	fan	0.08	1000000	80
Solar Irrigation Pump	2.53	pump	2.76	10000	28
Hollow Brick	16.18	0.5 Million bricks	73.99	500 Million bricks	74
Rehabilitation, Steel Mill	-10.74	7500 ton of Steel	371.47	750000 ton of steel	37
Solar Reflective Glass	10.47	1000 ft^3 space	0.30	75000	23
T&D Rehabilitation	75.00	20 MW	1515.15	3000 MW	227
Biogas Replacing LPG	-18.37	1 plant for 20 persons	1.80	100000	180
Efficient Brick Production	1.41	15 million bricks	2686.57	2.4 billion bricks	430
CCGT	48.89	200 MW	266588.67	600 MW	800
Cogeneration, Sugar Mill	29.83	mill	7747.67	10	77
Improved Gas Stove	-14.19	household	0.22	337500	74
Shift from Road to Waterways	-96.60	cargo vessel	1426.33	200	285
New Urea Plant	0.95	urea plant	1332114.67	1	1332
Cogeneration, Captive Power	-38.59	plant	31.42	1200	38
Supercritical Boiler	8.51	650 MW	492822	1950 MW	1478
Metering NG Connection	7.08	household	0.29	337500	98
Solar Lantern	-51.57	household	0.14	5000000	700
Parboiler-Generator	30.95	1 MW	1290.67	500	645



Investment Requirement for Mitigation Options

GHG Emissions from the Baseline and Mitigation Scenarios



Thank You