CO_2 Baseline for Indian Power Grid: Concept, Draft Results, Lessons

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Objective

- Enable calculation of the baseline CO_2 emissions
- For projects displacing grid electricity:
  - Grid-connected renewable energy projects
  - Energy efficiency projects saving grid electricity, etc.

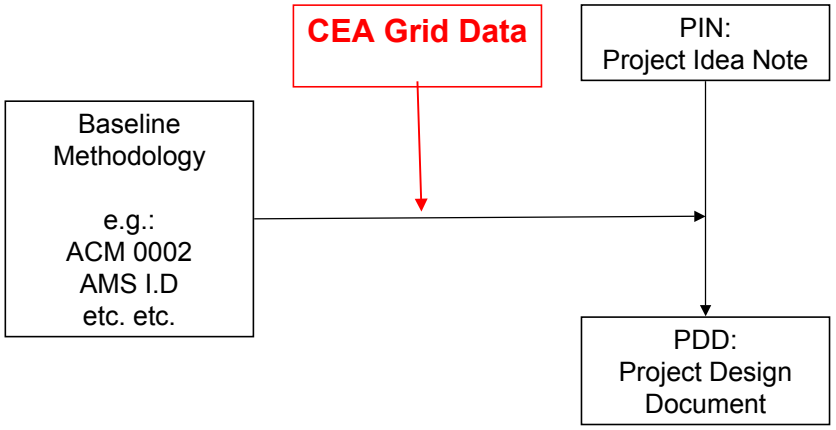
- Goal is to provide a tool for CDM project developers
- Not prescribe use of any specific values

Motivation

- Reduce transaction costs for CDM project developers
  - Enable more CDM investments
- Increase accuracy and consistency of ER calculations

➔ Data must be:
  - Accurate
  - Conservative

CEA Power Baseline Database: Context



Database Concept

- Provide the plant-level data required by CDM project developers:
  - Station-level net generation and CO2 emissions
  - Unit-level net generation and CO2 emissions
  - Import data
- Provide aggregate results for the five regional grids, consistent with ACM002 Version 06:
  - Operating margin (OM)
  - Build margin (BM)
  - Combined margin (CM)
  - Average emissions (AV)
- Document underlying assumptions
- Annual updating

Deliverables

- Database (MS Excel) with data at station / unit level:
  - Net generation (GWh)
  - CO2 emissions (absolute and per kWh)
- Users Guide:
  - Purpose of the database
  - Assumptions behind the CO2 calculations
  - Aggregate results by region
  - Examples for using the values for individual CDM projects

Status of Work

Completed steps:

- Data collection, FY 00/01 – FY 04/05
- Plausibility testing of data
- CO_2 calculations
- Confirmation of data and results by stations
- Draft version for stakeholder comments published on 04 October
  - See www.cea.nic.in

Next Steps:

- Nov. 06: Publish definitive Version 1.0
- Q1-07: Collect and process data for FY 2005-06
- Annual updates

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ACM0002 – Baseline Emission Factor: Combined Margin

- Assumption: CDM project displaces a mix of electricity in the grid:
  - Power from existing plants (Operating Margin, OM), and
  - Power from new plants whose addition to grid is delayed (Build Margin, BM)

➔ Baseline emission factor calculated as weighted average of OM and BM

$$EF_{CM} = w_{OM} \times EF_{OM} + w_{BM} \times EF_{BM}$$

EF_{BL} = Baseline emission factor = Combined Margin (t CO2/MWh)

$w_{OM} + w_{BM} = 1$ (default: $w_{OM} = w_{BM} = 0.5$)

Operating Margin

- Definition:
  - Weighted EF of all plants serving the system, excluding low operating-cost and must-run plants (= hydro + nuclear)
- Conditions:
  - Only applicable if share of low-cost / must-run plants is <50% (average of the five most recent years)
  - Imports and exports have to be considered
- Calculation:
  - Weighted average emissions of all thermal stations (t CO2 /MWh)
  - Inputs: Net generation and CO_2 emissions per station

Build Margin

- Definition: Weighted average emissions of:
  a) The five power plants that have been built most recently, OR
  b) Most recent capacity additions comprising 20% of generation in grid
  - Which ever gives higher generation (in India: Option b)
- Calculation:
  - Capacity additions are analyzed at unit level
  - Input 1: Commissioning date and gross generation of all units
  - Input 2: Net generation and CO_2 emissions of most recent units

Approach for Calculation of CO_2 Emissions

$CO2 = \text{fuel consumed} \times GCV \times EF_{Fuel} \times \text{oxidation factor}$

Data sources:

- Fuel consumption and GCV from stations
- Fuel emission factor - coal: Fixed at 90.7 g/ MJ GCV
  - Default value from India's Initial National Communication to UNFCCC
  - Converted to GCV basis
- Emission factors of other fuels: Standard values (IPCC)
- Oxidation factors: Standard values (IPCC)
  - For coal: 0.98 (value confirmed by own sample)

Annual Data Collected From Each Station

- Station Level:
  - Gross generation (GWh /yr)
  - Net generation (GWh /yr)
  - Fuel consumption (t or m3), including auxiliary / secondary fuels
  - Gross calorific value of each fuel
- Unit Level:
  - Gross generation (not available for hydro stations)
  - Net generation and fuel consumption generally not available at unit level

Station Level Assumptions : (Only where data is missing)

- Net generation: Derived from gross data using CEA normative values for auxiliary consumption

Coal Stations	%	8.0
Gas Stations	%	3.0
Diesel + Naphta stations	%	3.5
Nuclear	%	10.5
Hydro	%	0.5

Station Level Assumptions: (Only where data is missing) (2)

- Fuel consumption: CEA normative station heat rates
  - Coal: not required
  - Gas: 2043
  - Naptha: 2117
- Fuel oil consumption (CEA standard values):
  - Coal stations: 2 ml /kWh
  - Lignite stations: 3 ml /kWh
- GCV: CEA values where available, otherwise IPCC data
  - GCV available for almost all coal stations

Unit Level Assumptions

- Assumptions only required for units in build margin
- Emission factor of unit was assumed equal to station where:
  - All units of the station fall in the build margin, or
  - All units of the station have the same capacity
- This applies for >80% of all thermal units in build margin
- For remaining units, differentiated net heat rates where assumed:
  - Gross heat rate = Design heat rate plus 5%
  - Design heat rates differentiated by fuel type and unit capacity
  - Auxiliary consumption = CEA standard values
- For hydro units, generation derived from station total, pro rata capacity

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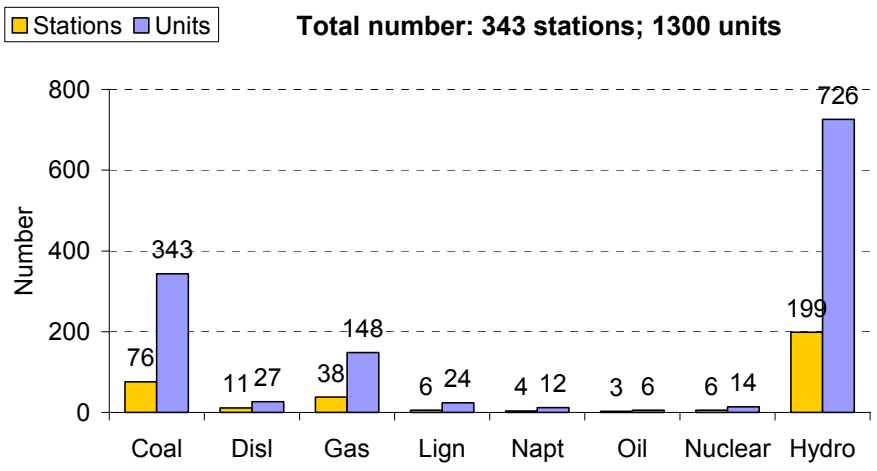
Coverage

The database covers all grid-connected power stations in the country, except:

- Captive stations
  - About 10% of nation-wide generation
- Non-conventional renewable sources (hydro <5 MW, biomass, wind, ...)
  - About 6,000 MW (5% of installed capacity)
- Small decentralized gensets
- Island States: Andaman, Nicobar, Lakshadweep

Coverage: Stations and Units (Version 04 Oct 2006)



Definitions

- AV: Average CO_2 emissions per MWh of all stations
- OM: Operating margin
  - Average emissions of all thermal stations
- BM: Build margin
  - Average emissions of the most recently added units covering 20% of total net generation
- CM: Combined margin
  - Weighted average of OM and BM,
  - Default weights are 50 : 50
  - Other weights may used under specific circumstances

Results: Margins 2004/05 (t CO2/MWh) incl. imports (Version 04 Oct 2006)

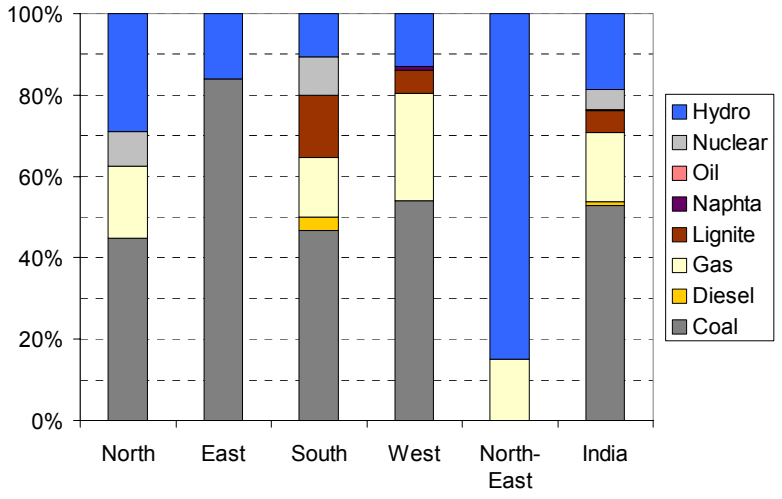
	Average	OM	BM	CM
North	0.72	0.98	0.53	0.75
East	1.05	1.18	0.90	1.04
South	0.78	1.00	0.71	0.85
West	0.92	1.01	0.77	0.89
North-East	0.46	0.81	0.10	0.45
India	0.84	1.02	0.70	0.86

Role of Imports between regions and from abroad (Version 04 Oct 2006)

	CM excl. Imports	CM incl. Imports
North	0.75	0.75
East	1.05	1.04
South	0.85	0.85
West	0.89	0.89
North-East	0.38	0.45
India	0.86	0.86

Build Margin 2004/05: (Version 04 Oct 2006)

Generation of most recent units covering 20% of total gen.



Sensitivity

- Station data with relatively high uncertainty:
  - Fuel consumption data
  - Fuel GCVs
- Sensitive assumptions:
  - Carbon emission factor for coal (g CO2 /MJ)
- Less sensitive assumptions e.g.:
  - Heat rates of gas- naphta-, oil- and diesel stations where missing
  - Heat rates of units in build margin, where not assumed equal to station
- Overall, results are robust

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Lessons - Methodological

- Quality of station-level data is decisive
  - Input for aggregate grid emission factors
  - Needs careful review and plausibility testing
- Fuel consumption not available at unit level
  - Need conservative assumptions for calculation of Build Margin
- GCV more common (and accurate) than NCV
  - Need to convert NCV-based emission factors to GCV basis
- Division into regional grids deserves closer analysis
  - When do transmission constraints cease to be "significant"?

Lessons - Operational

- Need to archive outdated database versions
  - "Housekeeping obligations" for agency compiling the data
- Implications of annual updating to be explored
  - Applying actual-year grid data for CER issuance:
    Will project owners have to wait for most recent grid emission factor?
- In India, baseline emission factor no longer the "weakest link" in CER calculations
  - Uncertainty of grid data now much smaller than the inherent uncertainty of the combined margin approach
  - Hence little environmental benefit in further refining the data (except annual updates)

Thank you!

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Download of CEA database: www.cea.nic.in