Power Grids in Asia
Mode of operation and dynamics

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Outline

- Key issues and questions
- Four example countries
- Implications for CDM projects seeking to avoid electricity generation emissions in Asia

Key issues

Drawing on the *Baseline Recommendations* paper of Kartha, Lazarus and Bosi, Energy Policy 32, 2004:

- **Build, operating or combined margin: defining the marginal plant**
  - now
  - in the future
- **Baseline dynamics and crediting lifetimes**
  - will new construction change the marginal plant?
  - will this occur within the next 7 or 10 years?
- **Geographic aggregation, are plants dispatched**
  - by individual **state/province** only (sub-national)?
  - by multi-state/province **regions** (wider sub-national)?
  - across a **national** grid?
  - with **international** imports and exports?

Key questions

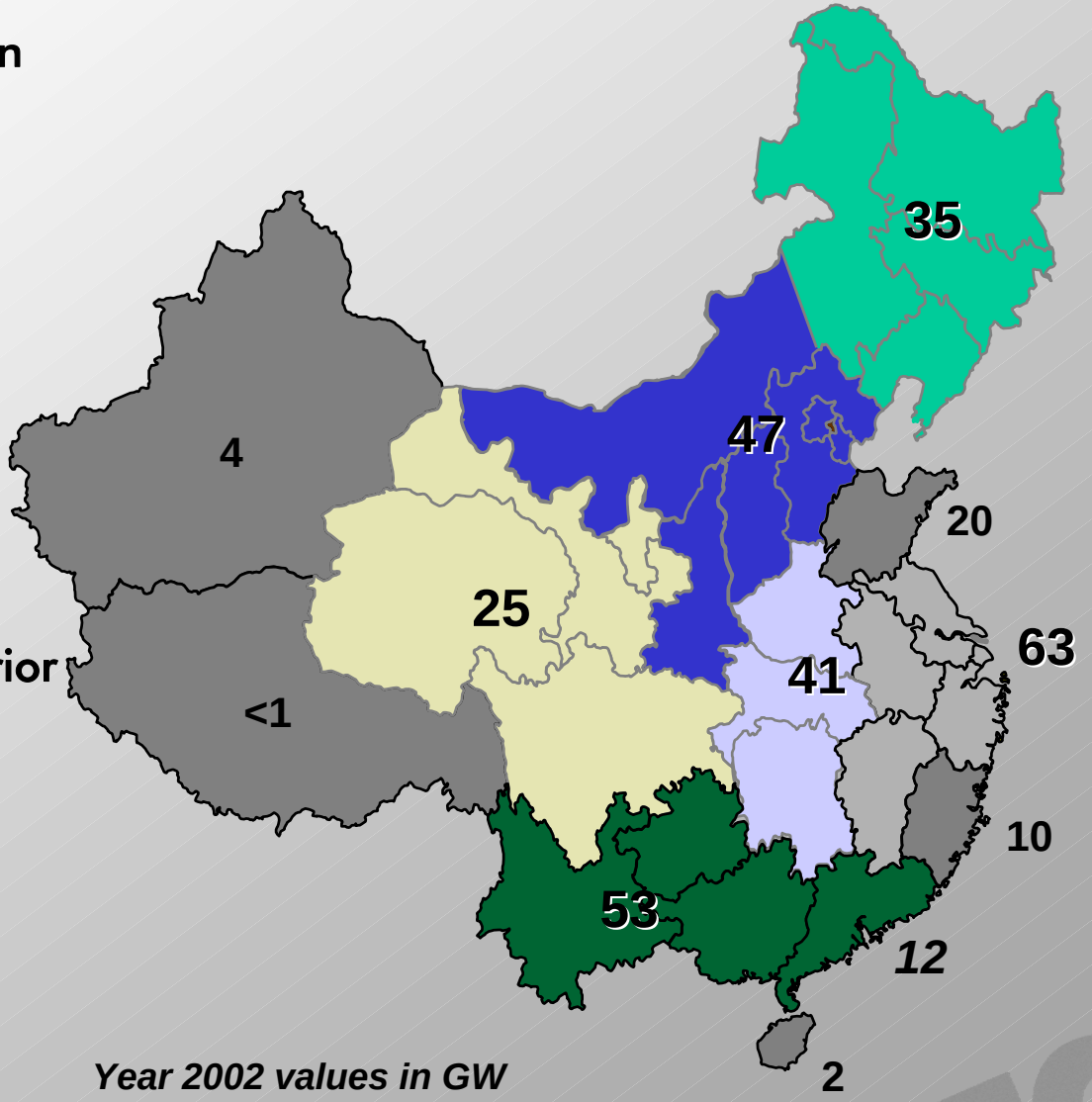
- Supply-demand balance
  - Is there adequate generation or a shortage?
  - If a shortage, is this met by off-grid generation?
- What is the current generation plant mix?
  - % of coal, gas-fired, hydro, nuclear, other
- What is the current generation fuel mix?
  - % of coal, gas-fired, hydro, nuclear, other
- What is the current dispatch method?
  - bid-based, economic least-cost or other
- Dynamics
  - What is the rate of growth and additions?
  - Will the additional plant change dispatch?
- How sensititive are future emissions to:
  - additional plant?
  - the dispatch method?

Example Asian countries

Country	Installed capacity	GW	Growth	
			Doubling	% pa
China	2nd largest	~ 380	7y	10%
India	=6th (with Germany)	~ 112	11y	6%
Thailand	Mid-sized	~ 25	10y	7%
Vietnam	Small	~10	8y	9%

China

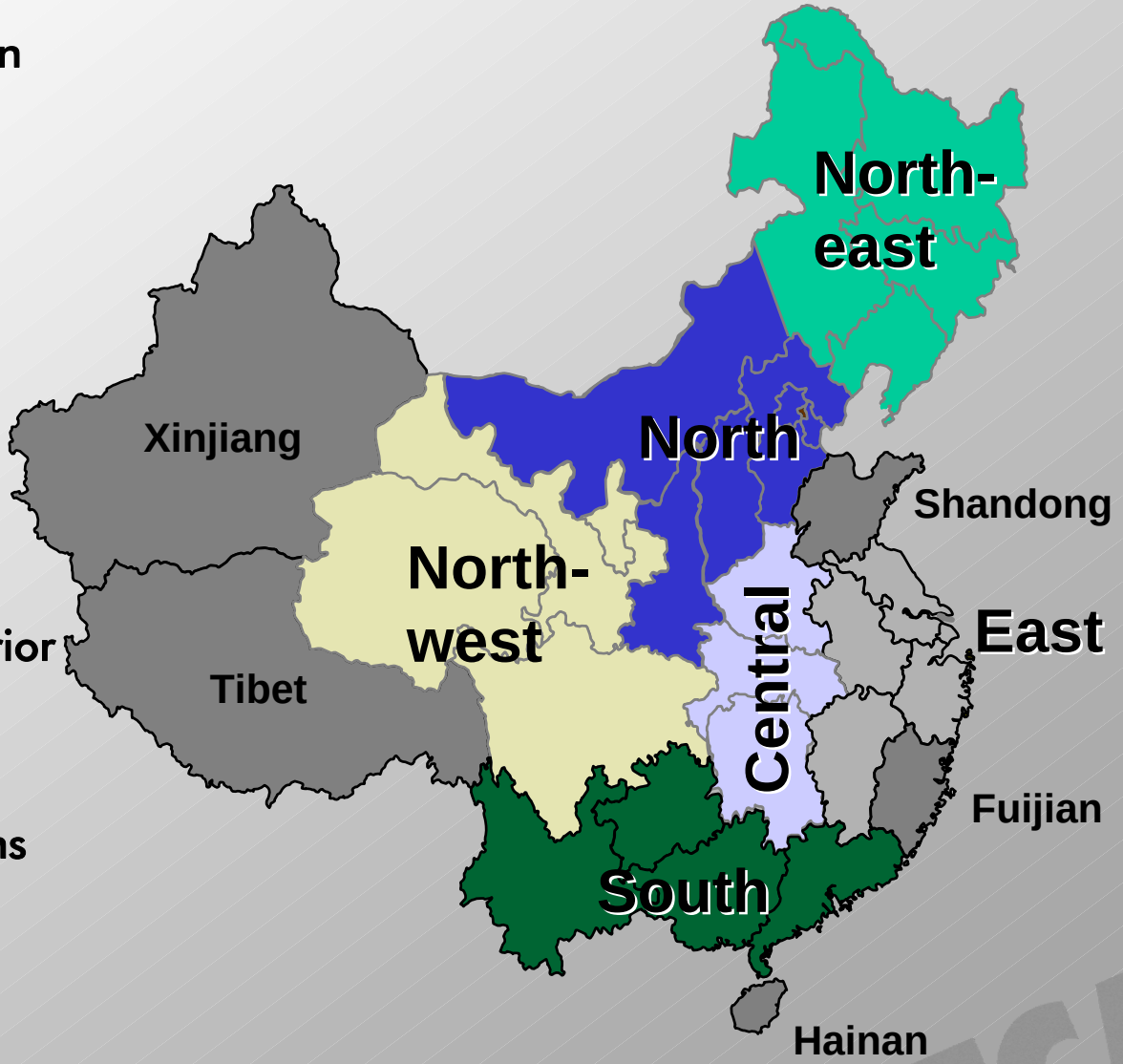
- Huge system 300+ GW in 2002, ~380 GW in 2004
- 2nd largest in the world
- High developing country growth rates especially in the coastal south and east
- Large income and development disparities between coastal and interior provinces



Year 2002 values in GW

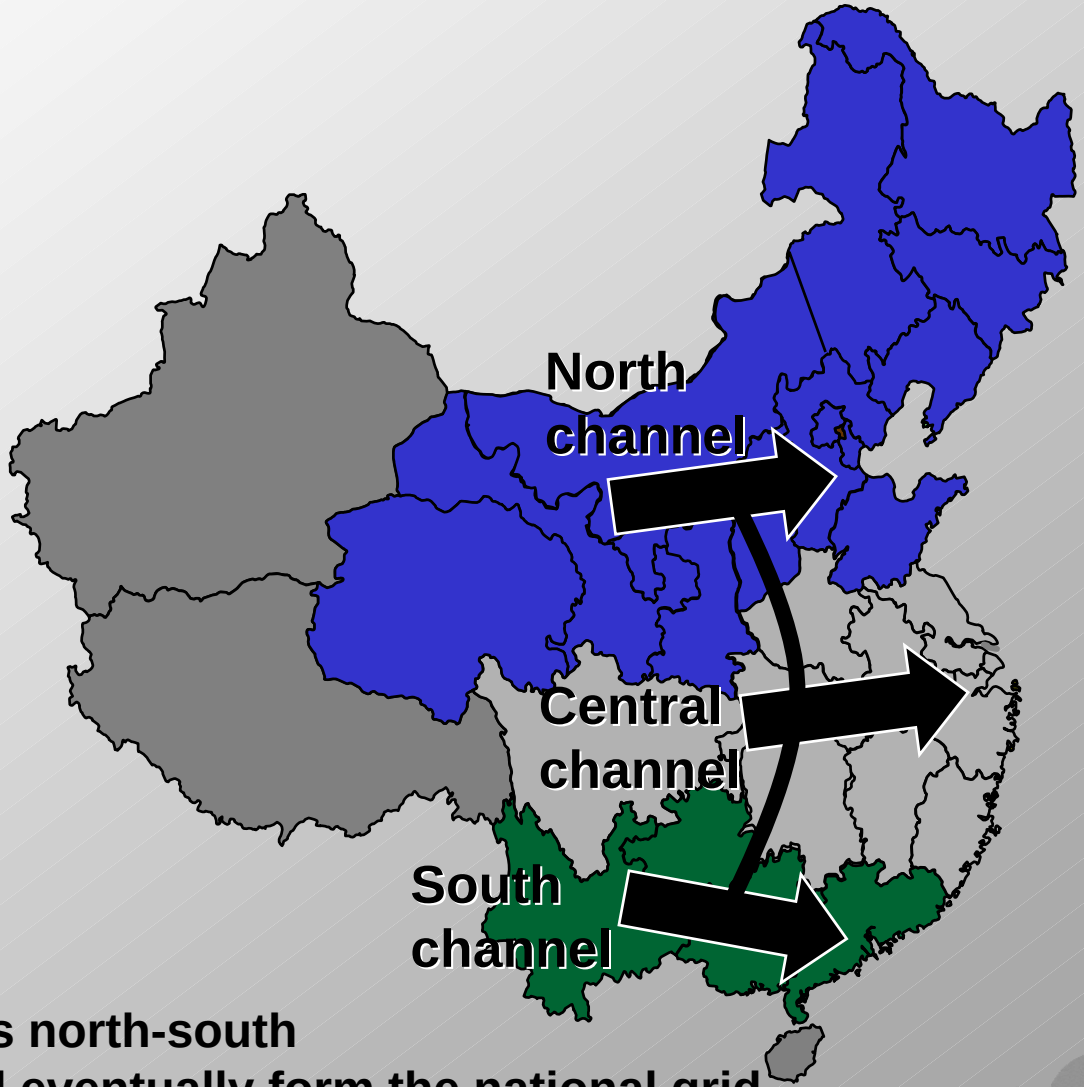
China

- Huge system 300+ GW in 2002, ~380 GW in 2004
- 2nd largest in the world
- High developing country growth rates especially in the coastal south and east
- Large income and development disparities between coastal and interior provinces
- Regional grids, with weak interconnections between provinces and largely non-existent interconnections between grids



China

- West-to-East power transmission project in 10th Five-year Plan
- 3 major power transmission 'channels'
- Major 500kV AC and some DC investments

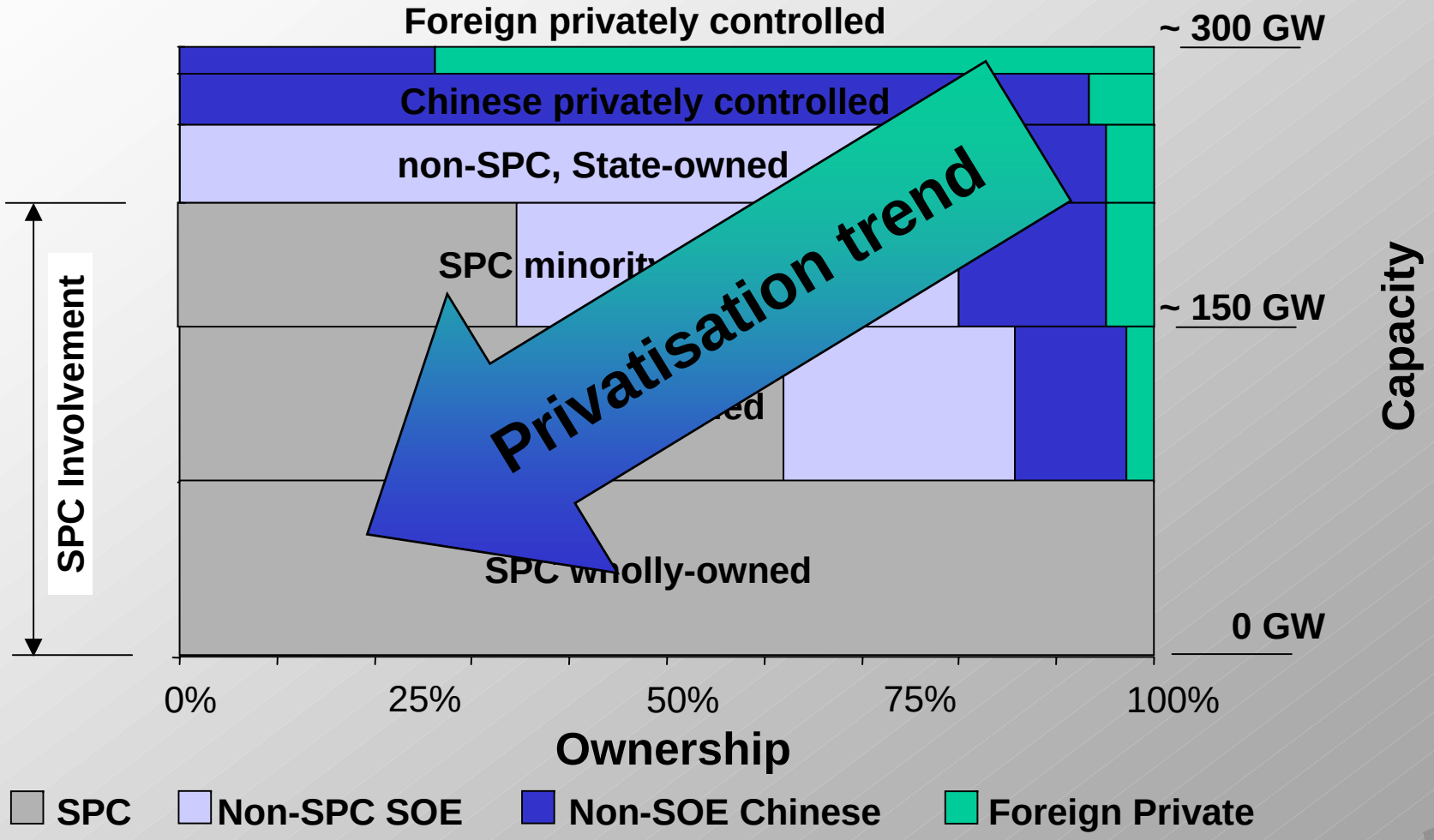


The 3 'channels' plus north-south interconnections will eventually form the national grid

China

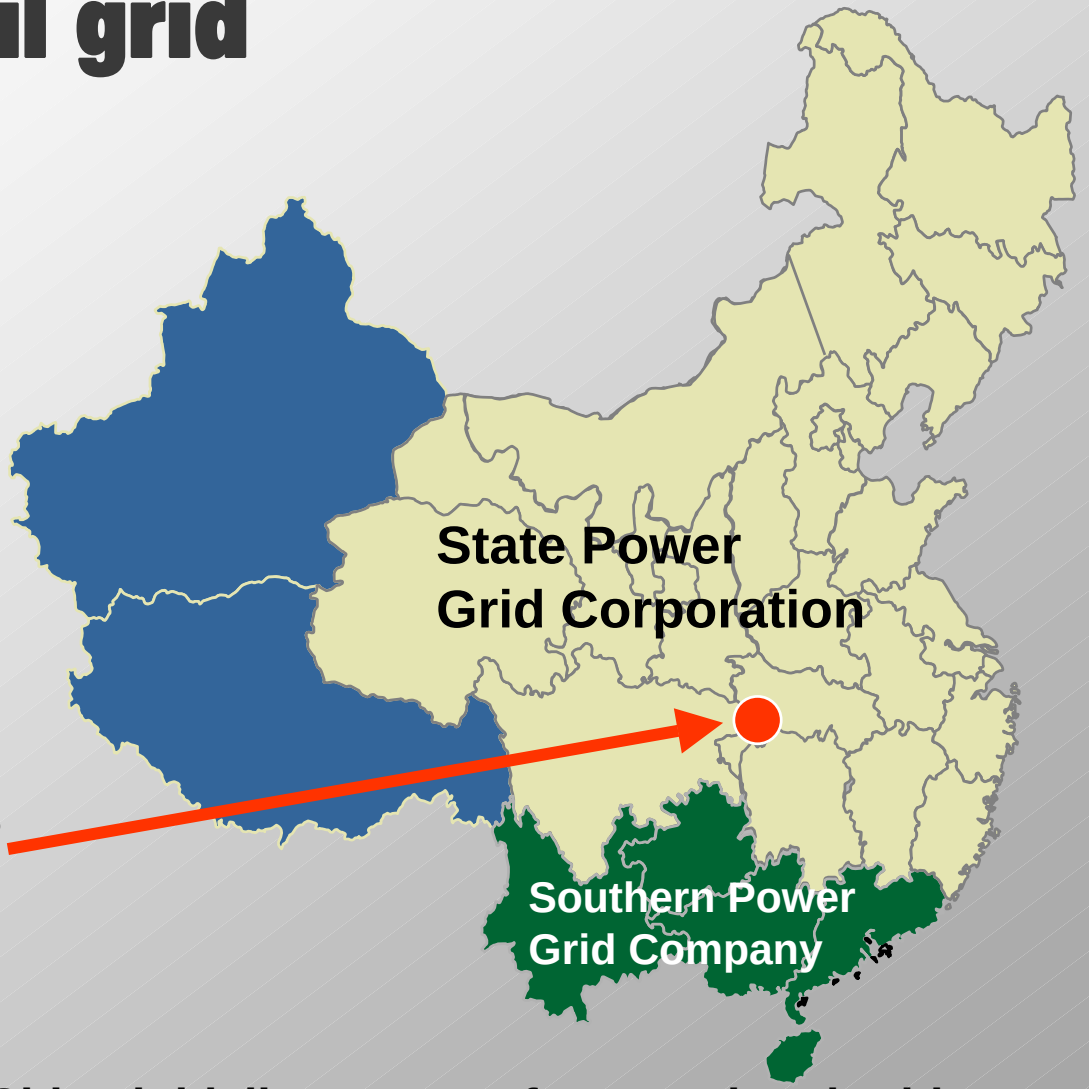
- Still predominantly state-owned, but trend is towards privatisation
- State-power generation assets divested into 5 gencos
- two large grid companies formed
- regional grids being tied together
- western resources (gas and hydro) being developed and 'forced' in to eastern provinces
- dispatch still involves 'sharing'
- generation shortage in some areas (eg: Guangdong)
- CDM unlikely to change hydro dispatch, gas will be must-run, so the 'marginal' plant is likely to be coal for the foreseeable future

Context: generation ownership in China's electricity sector



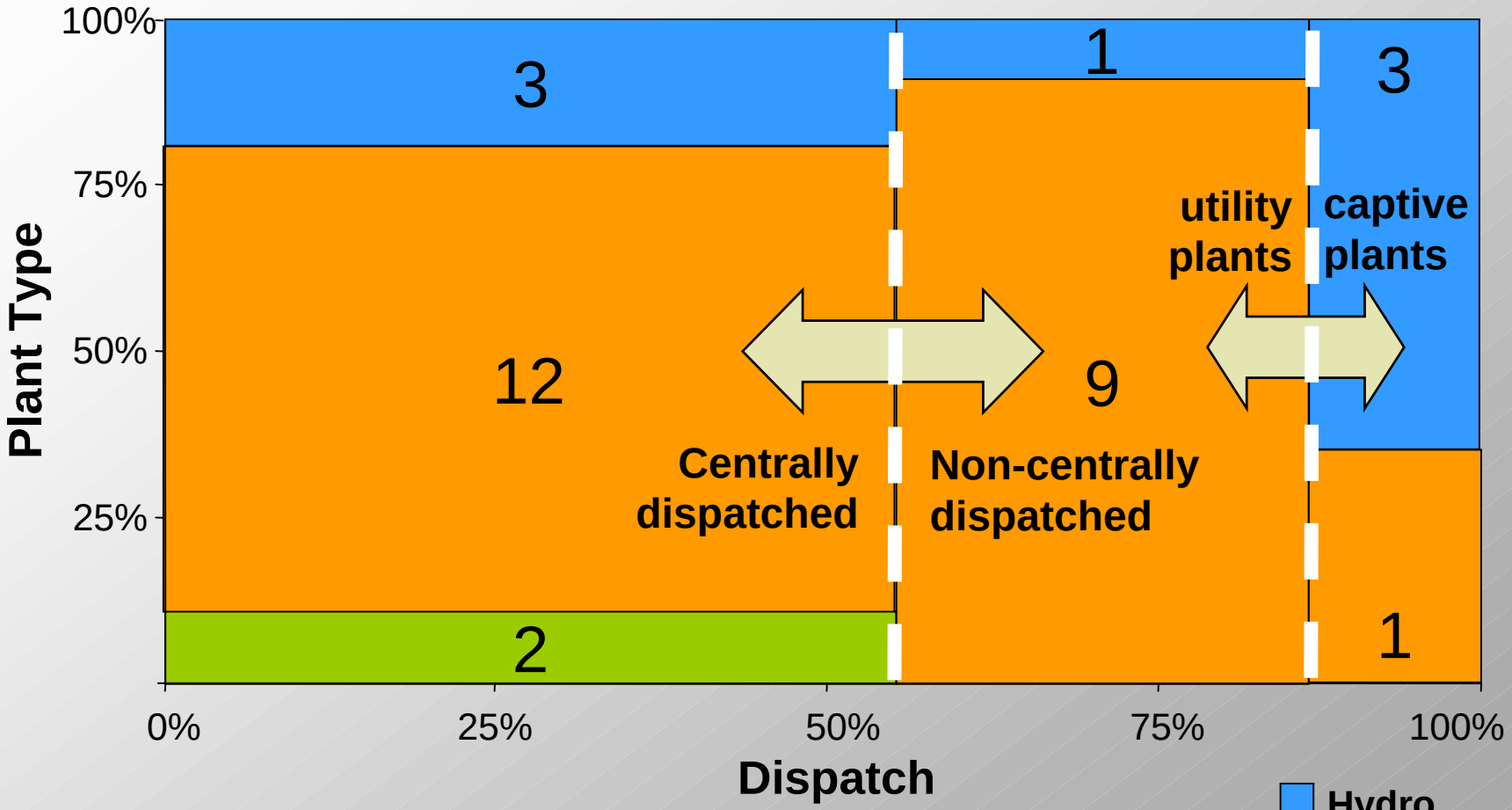
China: national grid

- Generation already separated from transmission
- State Power's generation assets allocated to five companies, transmission assets to two companies
- State Power to be a transco and system operator
- The 18 200 MW Three Gorges project will play a major role at the heart of the China's future national grid



Guangdong and south China initially separate from 'national grid'

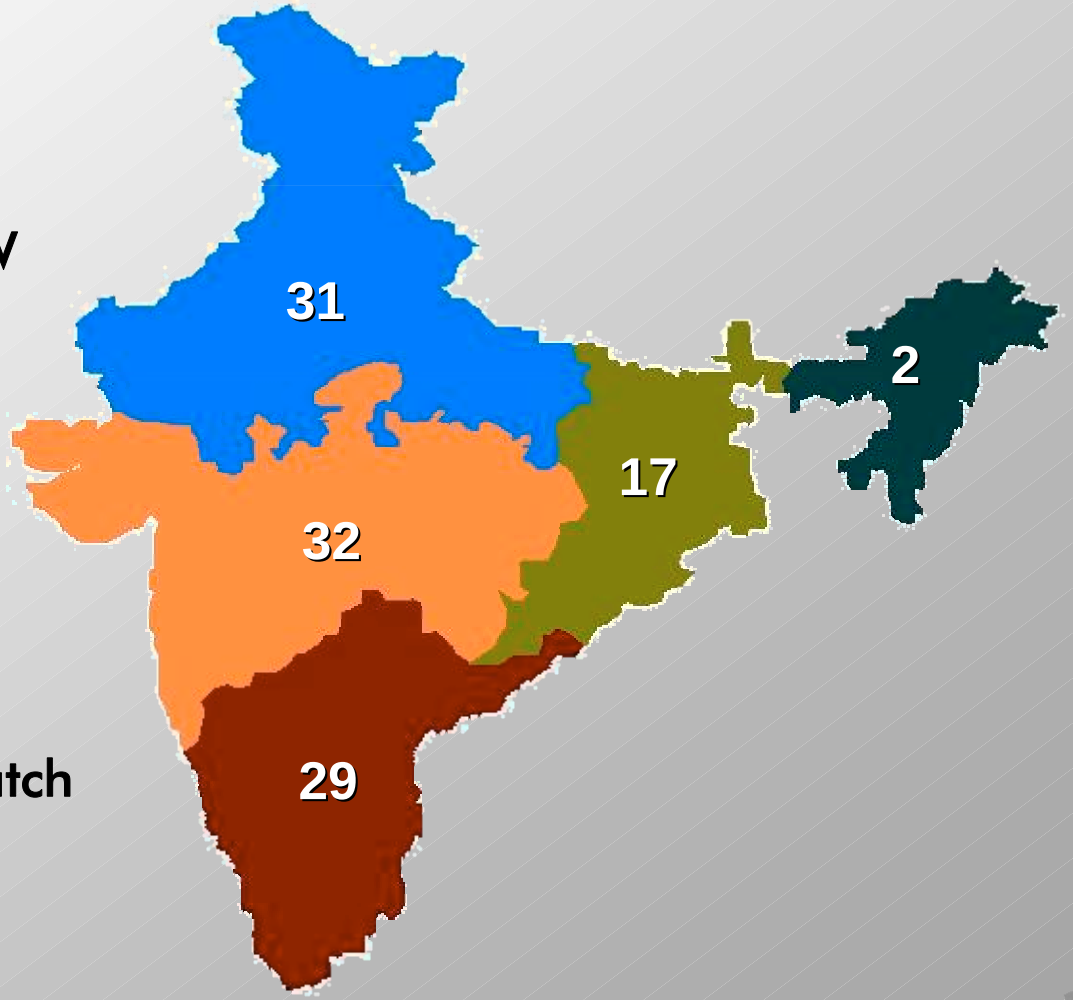
China: special case of Guangdong



A large proportion of on-grid capacity in Guangdong is not centrally dispatched

India

- Very large system 112 GW
- Thermal dominated
- High developing country growth rates
- 5 regional grids, improved and improving interconnections and dispatch co-ordination within and between regions



Year 2002 values in GW

India

- Mix of central and state-level ownership
- Capacity is still predominantly (90%) government-owned, but there is a trend to privatisation, some states further down the path than others
- 5 regional grids, 4 regional dispatch centres
- dispatch previously state-by-state by telephone negotiation, little discipline, poor frequency control
- now much more co-ordinated, new availability-based generation tariff, Power Trading Corporation managing trades between excess and shortage states and catalysing new projects
- still generation shortages in some areas
- interconnections being improved, moving towards integrated national power market
- gas *MAY* play an increasingly large role
- marginal plant will be thermal, but gas or coal?

Thailand

- Mid-size system ~25 GW
- Thermal dominated, with a majority of gas
- High developing country growth rates
- National grid, with some constraints

Thailand

- Mix of state-ownership (EGAT still has 60%) and private
- One large base-load coal plant (~10%), but capacity (70%) and energy (~60%) is dominated by gas-fired combined cycle plant
- In dispatch EGAT decrements its plants to meet IPP contractual commitments
- Base load coal and hydro will always be dispatched
- It is safe to say that any CDM project would be avoiding gas-fired CCGT emissions

Vietnam

- Majority state-owned (EVN) but private IPPs coming in (eg: Phu My gas-fired CCGT)
- Hydro-thermal system, with gas-fired CCGT to dominate the thermal side
- EVN are also planning a nuclear plant
- Assuming that gas-fired IPPs will be must-run, coal could be the marginal plant, but likely to need simulation to determine role of hydro

Economics: China

	Coal	Gas	
CapEx	500	600	*US$/kW*
Annualised	83	100	*US$/kW/y*
Unitised	1.12	1.33	*USc/kWh*
Fuel cost	2.28	4.17	*USc/kWh*
Total	**3.40**	**5.50**	*USc/kWh*
	+O&M	+O&M	

Cost of capital 10% over 10y (ie: 15% RoE if 70% debt @8%)
85% plant load factor
Coal @$65/tce, coal -> elec sent out 35%
Gas @$5.50/mmBtu, gas -> elec sent out 50%

Economics: India

	Coal	Gas	
CapEx	850	600	*US$/kW*
Annualised	142	100	*US$/kW/y*
Unitised	1.90	1.34	*USc/kWh*
Fuel cost	2.10	2.31	*USc/kWh*
Total	**4.00**	**3.65**	*USc/kWh*
	+O&M	+O&M	

Cost of capital 10% over 10y (ie: 15% RoE if 70% debt @8%)
85% plant load factor
Coal @$60/tce (~$2/GJ), coal -> elec sent out 35%
Gas @$3/mmBtu (subsidised), gas -> elec sent out 50%

Economics: India (2)

	Coal	Gas	
CapEx	850	600	*US$/kW*
Annualised	142	100	*US$/kW/y*
Unitised	1.90	1.34	*USc/kWh*
Fuel cost	2.10	3.80	*USc/kWh*
Total	**4.00**	**5.14**	*USc/kWh*
	+O&M	+O&M	

Cost of capital 10% over 10y (ie: 15% RoE if 70% debt @8%)
85% plant load factor
Coal @$60/tce (~$2/GJ), coal -> elec sent out 35%
Gas @$3/mmBtu (subsidised), gas -> elec sent out 50%

Carbon economics

	China	India	India	
Gas	5.50	3.65	5.14	
Coal	3.40	4.00	4.00	
Cost Δ	2.10	-0.35	1.14	*USc/kWh*
Emission Δ	0.45	0.45	0.45	*kg/kWh*
Unit cost	**~47**	**-8**	**25**	*US$/t CO_2*

Dynamics

- Transmission projects can significantly change plant dispatch where they inter-connect
  - states or provinces to sub-national regional grids (examples: China, India)
  - sub-national grids to a national grid (examples: China, India)
  - countries into international regional grids (examples: India with Nepal and Bhutan, Thailand and Vietnam with Laos)
- Power trading between previously connected but poorly co-oprdinated grids can significantly change plant dispatch
  - example: India
- A move from traditional to market-based models has the potential to change plant dispatch significantly
  - partial example: power trading in India

Dynamics

Changes in: Country	Geographic aggregation	Dispatch method	Plant mix	Marginal plant
China	Yes	Tentatively	Somewhat	Probably not
India	Rapidly	Yes	Yes	Quite likely
Thailand	[Imports]	Maybe	Yes	No
Vietnam	[Imports]	Not likely	Somewhat	Possibly

Conclusion

- **China:**
  - Huge potential market and CDM projects could avoid coal emissions, but geographic aggregation and market developments *may* affect this
- **India:**
  - Theoretically large potential market but with several dynamic changes, CDM projects are likely to be avoiding gas-fired CCGT emissions
- **Thailand:**
  - CDM projects will be avoiding gas-fired CCGT emissions, therefore will need to be relatively low incremental c/kWh projects
- **Vietnam:**
  - A relatively small market, but rapidly growing. Stable plant mix and non-imminent market reforms suggest minimal dynamic changes

Key questions

- What price does the CDM project need to sell the electricity at to get dispatched?
  - What does this imply about the plant being displaced in the dispatch schedule?
  - What does this imply about the plant being deferred as a result of the CDM project?
  - Will market reforms change this picture within the crediting life of CDM projects?

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