



ETSAP Annex IX Technical Conference
Energy Models Users' Group, Global and
Regional Energy Modelling

***Analysis of Power Supply Options for the
Interconnected Grid***

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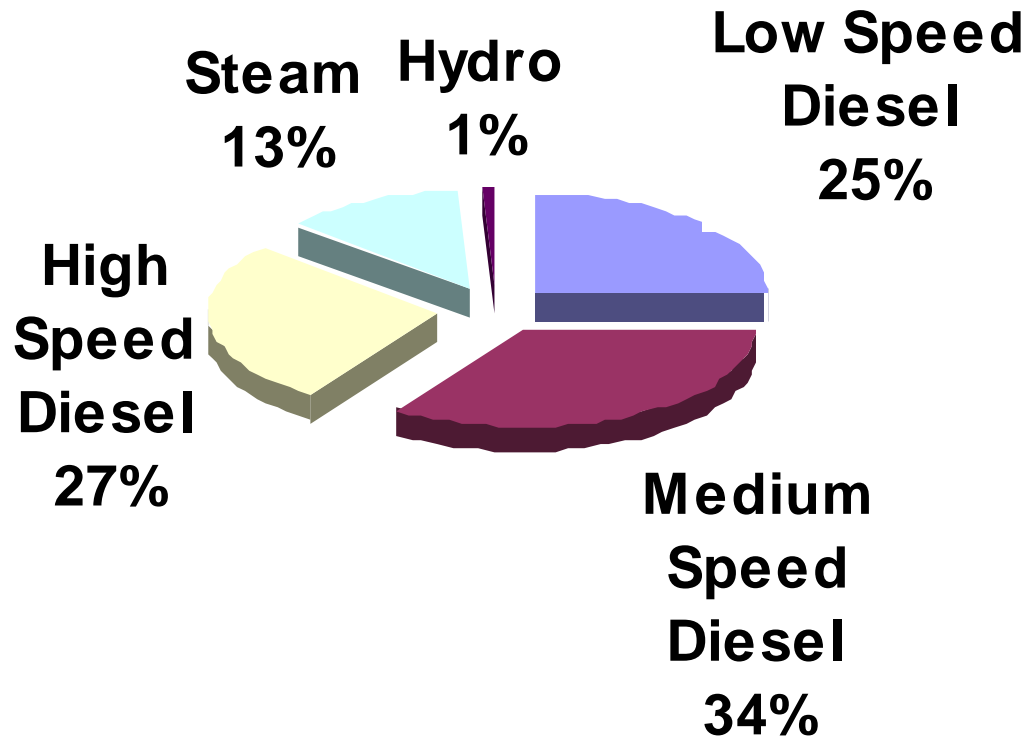
Country Profile of Energy Sector

- Territory: 181,035 sq. km
- Borders: THL-West, VN-East, LAO PDR-North, Gulf-south
- Population: 12 million
- GDP US\$ 280 per capita
- Lowest energy consumption : 45 kWh/capita
- Highest electricity price in the region
- High potential of hydroelectricity:
 - 10,000 MW in northern and 1,000 MW in Western
 - Long distance between sources and load center:
 - Difficult to developed

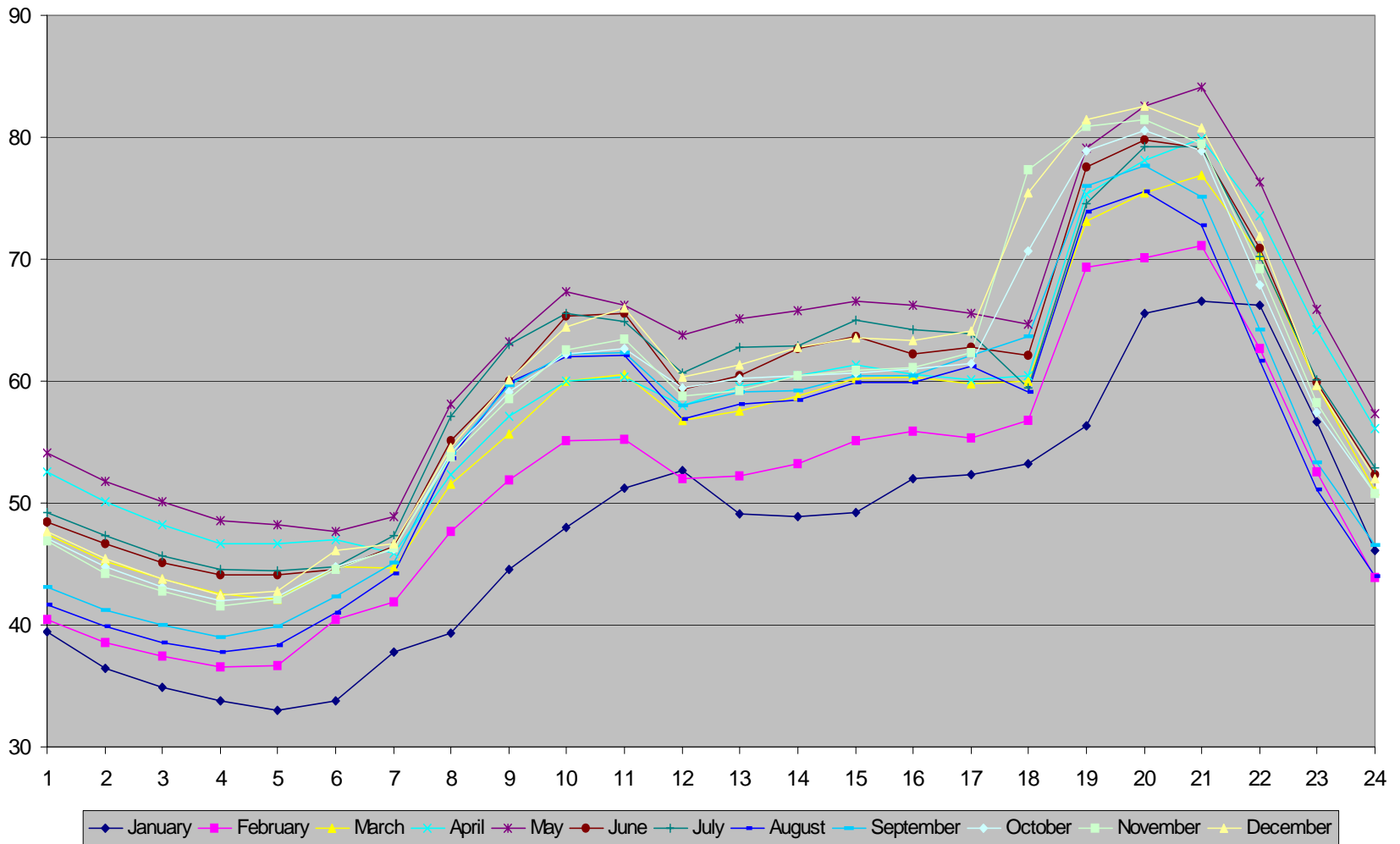
Country Profile of Power Sector (continued)

- Main Energy consumption: Wood
- Electrification rate:
 - Connect to the grid: 15%
 - Urban: 53.6%, Rural: 8.6%
 - Tariff: US¢ 9 – 25 per kWh
 - Rural generation and battery: 35%
 - Tariff: US¢ 40 – 80 per kWh
- Principal generation Fuel Oil (DO and HFO)
- Main consumption sector: Household

Installed electricity capacity in 2000, MW

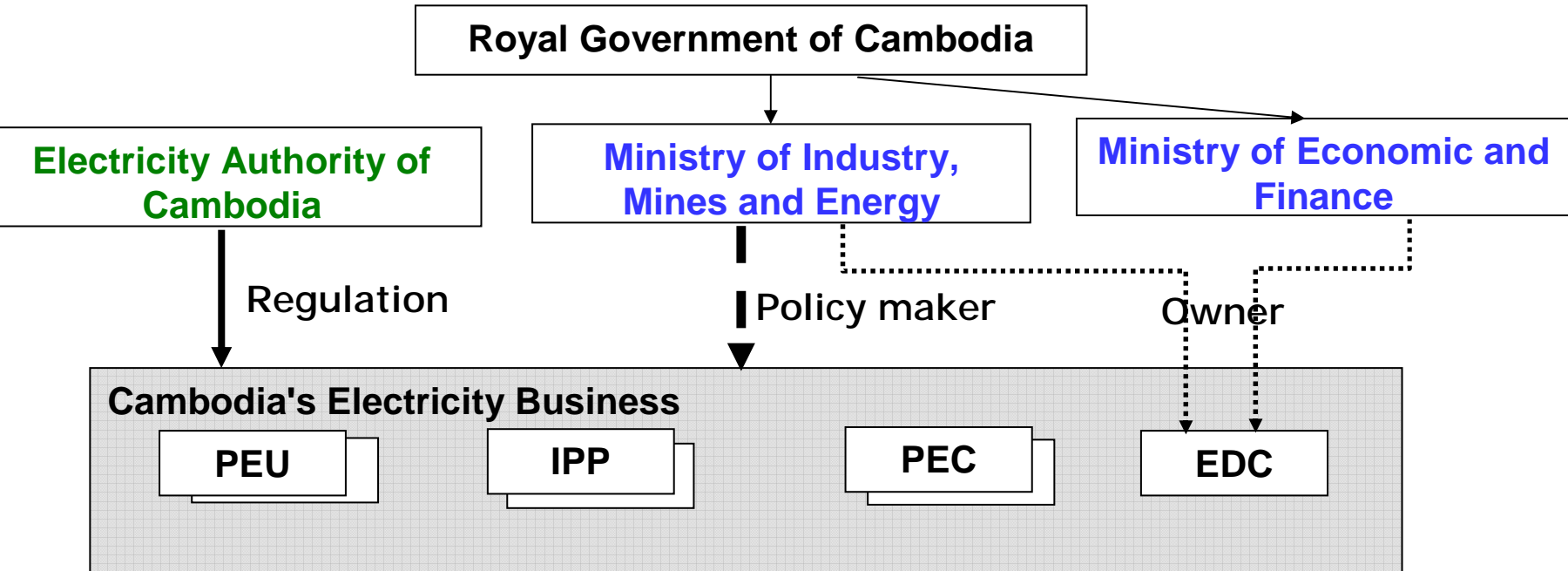


Average Daily Load Curve by Month



Source: EDC 2004

Current Structure of Electricity Sector



-➔ Ownership of EDC
- - - ➔ Policy; Planning; Development; Technical standard
- ➔ Tariff, license, Review the Planned Investments, finances and performance; Enforce the regulations, rules and standards

Power Sector Policy

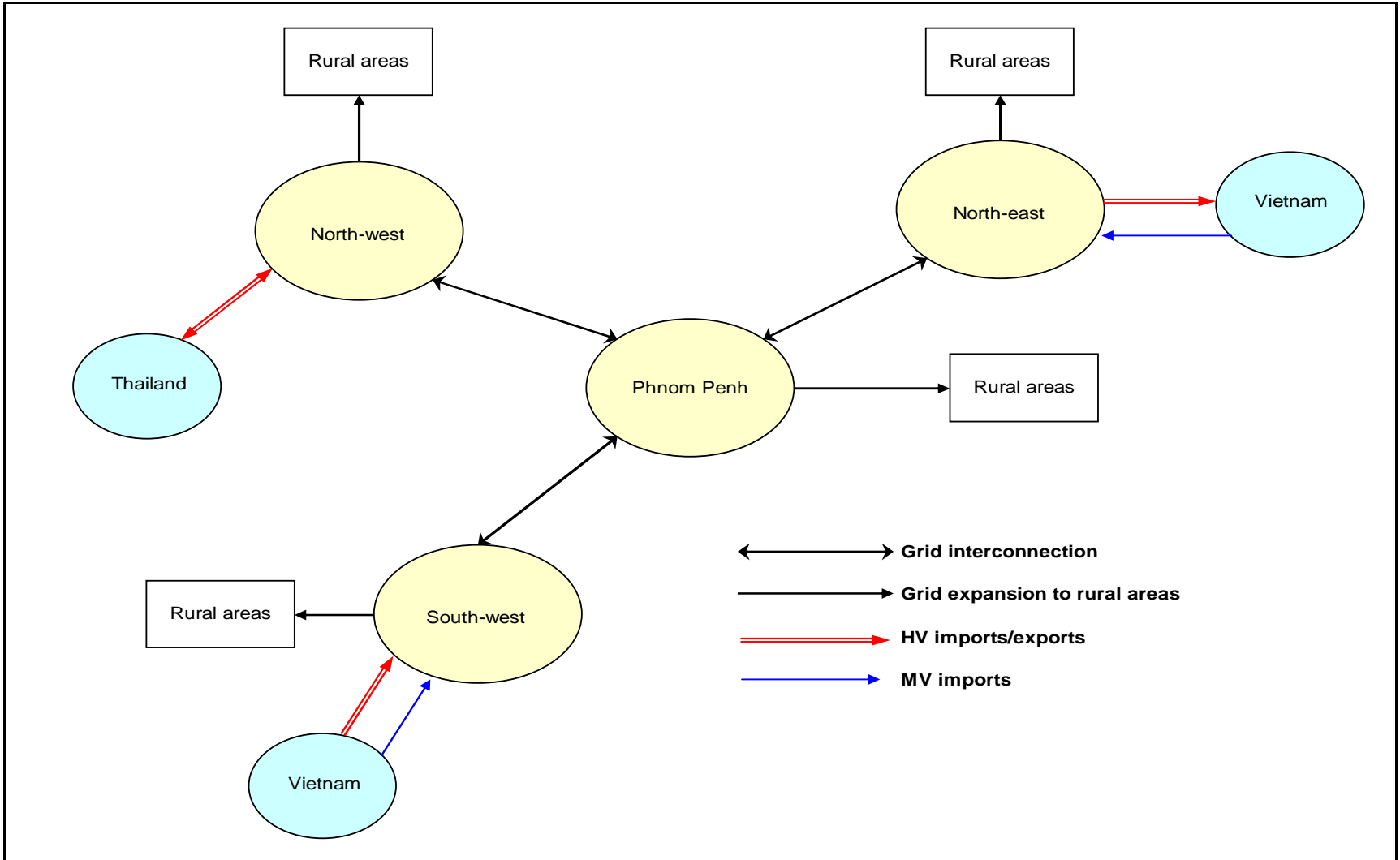
- To provide an adequate supply of energy throughout Cambodia at reasonable and affordable price,
- To ensure a reliable and secured electricity supply at reasonable prices, which facilitates the investments in Cambodia and developments of the national economy,
- To encourage exploration and environmentally and socially acceptable development of energy resources needed for supply to all sectors of Cambodia economy,
- To encourage the efficient use of energy and to minimize the detrimental environmental effects resulted from energy supply and consumption.

Cambodian Power Development Plan (2004-2008)

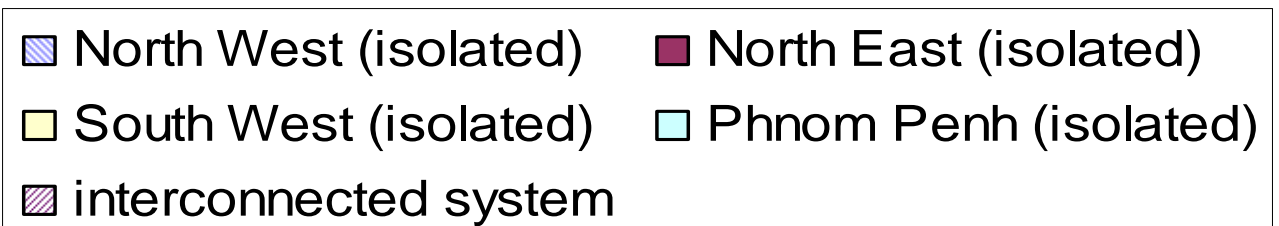
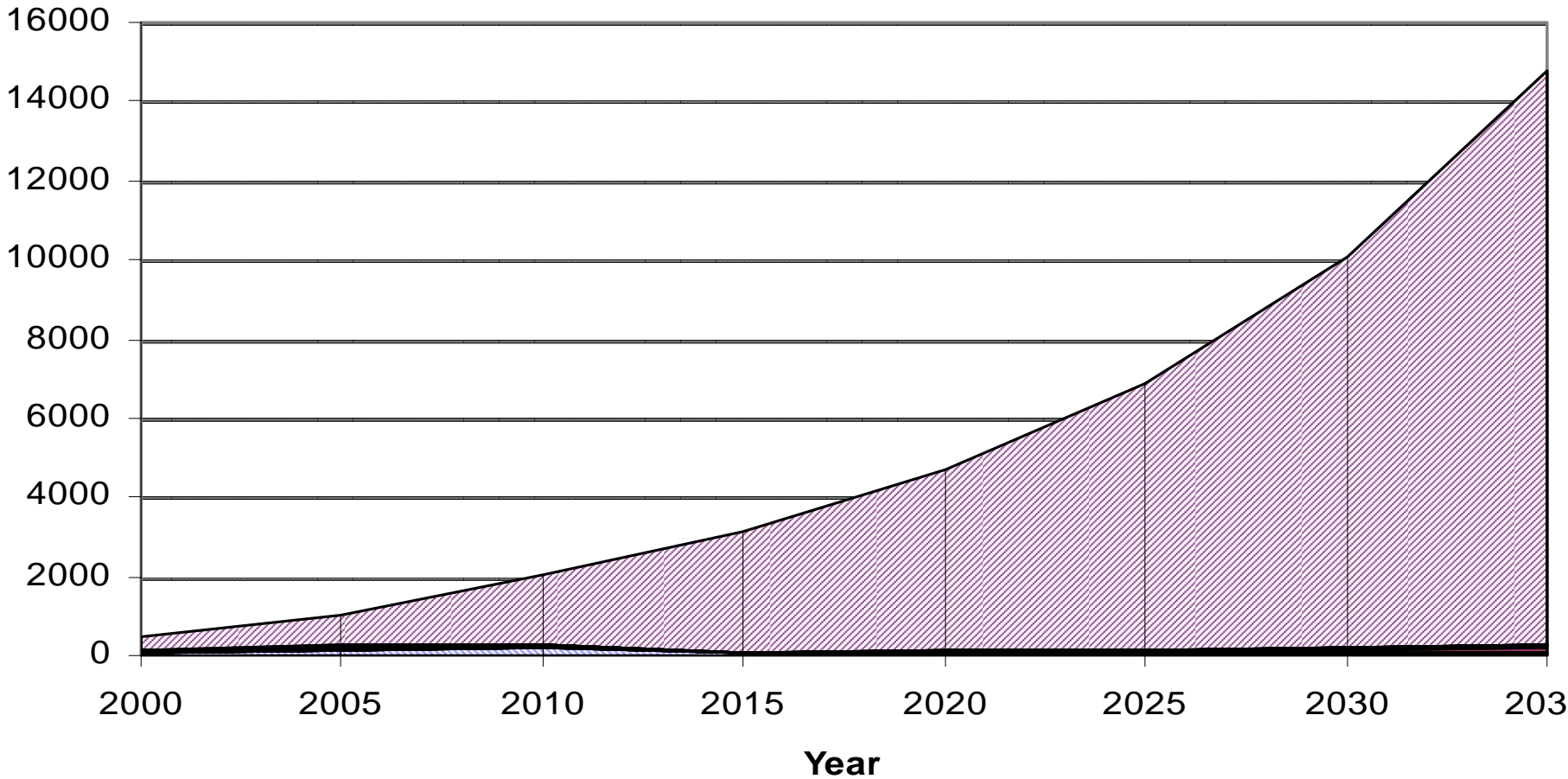
Promoting Private sector Participation in these development is needed

- 2004: Commissioning 10 MW HFO in Siem Reap (Japanese Grant Aid).
- 2005: Develop an IPP-KEP of 32 MW
- Import from Thailand for North-Western Grid
- 2006: Expect to add 10 MW HFO (Japanese Grant Aid).
- 2007: Import from Vietnam 80 MW for the first step from Thailand 20 MW
- 2008: Commissioning of Kirirom III 13 MW Hydropower Plant

Representation of electricity system



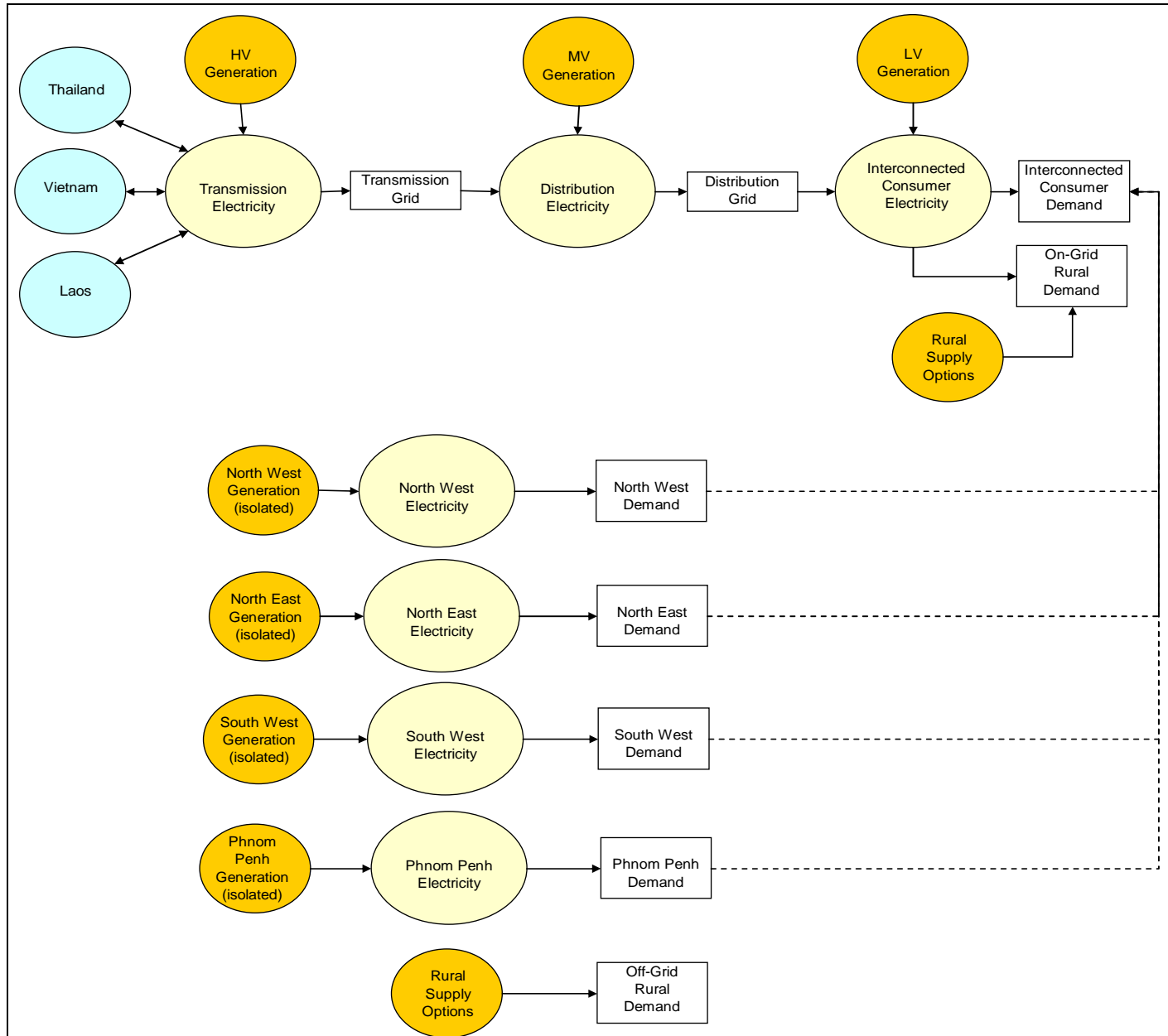
Electricity Demand Forecast - GWh



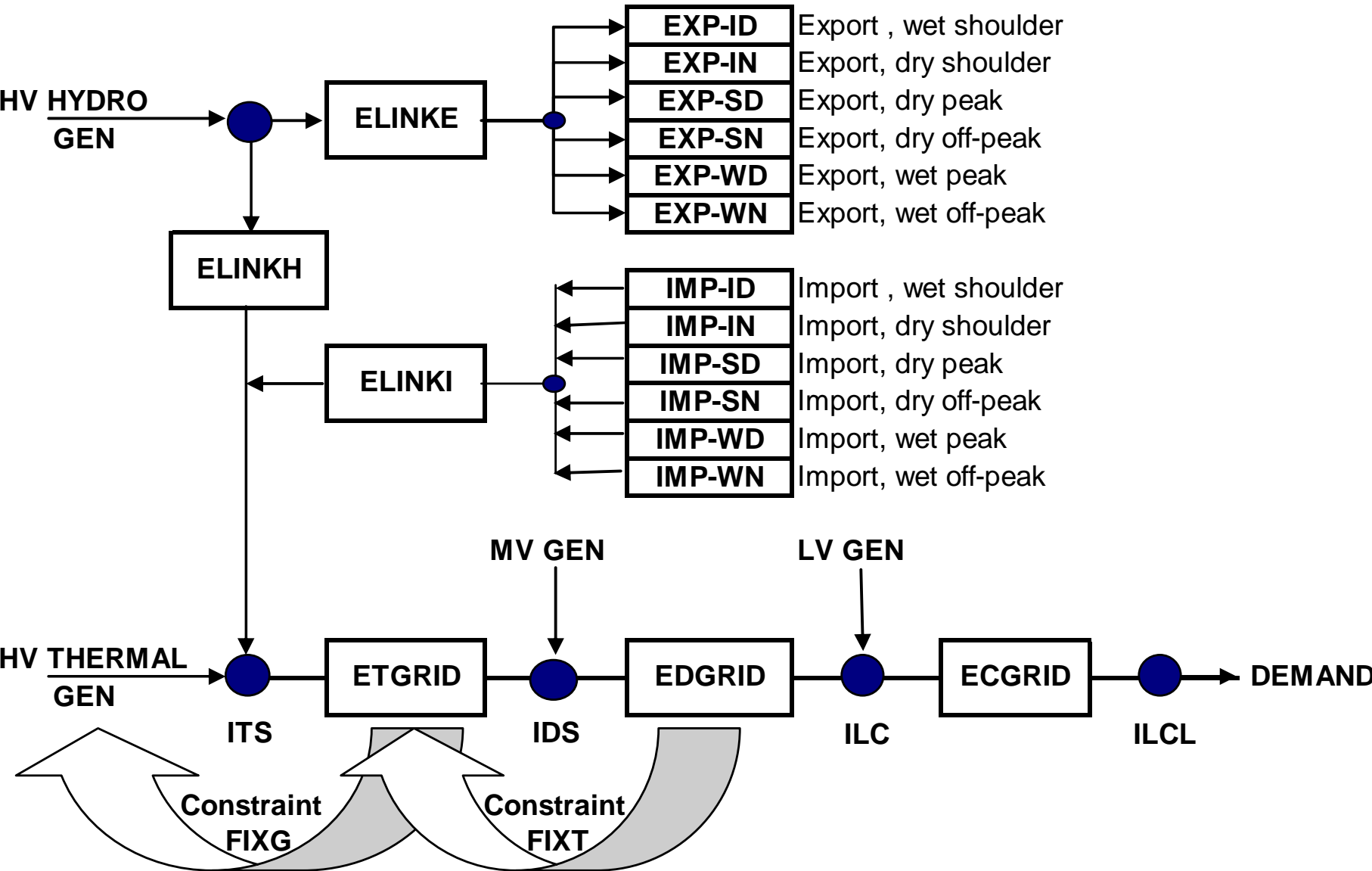
Seasonal and Diurnal Time Definitions

Time Slice	Description	Season		Time	
		From	To	From	To
I-D	Partial peak - Wet	May	October	08:00	18:00
				22:00	00:00
I-N	Partial peak - Dry	November	April	08:00	18:00
				22:00	00:00
S-D	Peak - Dry	November	April	18:00	22:00
S-N	Off peak - Dry	November	April	00:00	08:00
W-D	Peak - Wet	May	October	18:00	22:00
W-N	Off peak - Wet	May	October	00:00	08:00

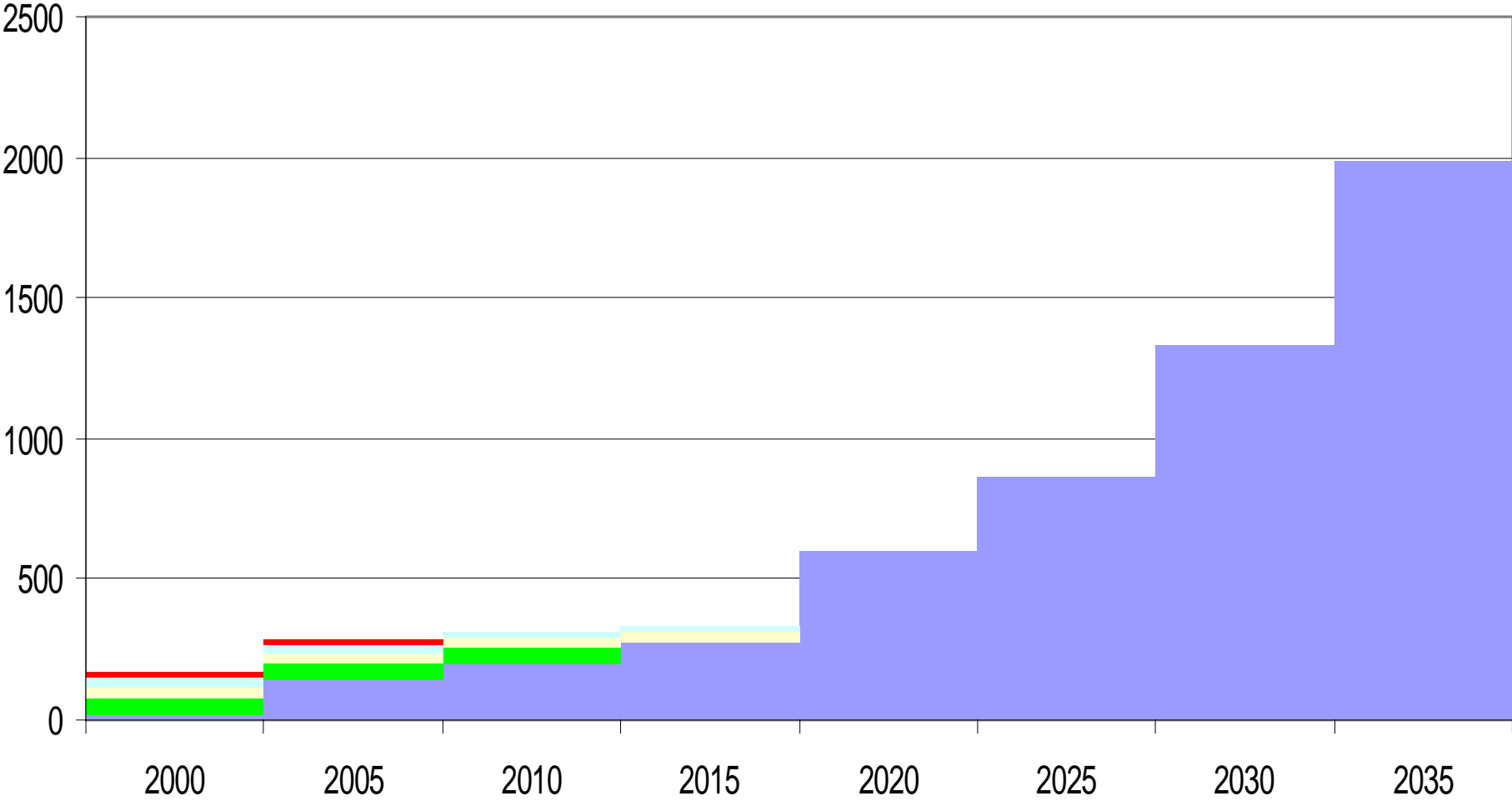
MARKAL Representation of the Electricity System



MARKAL Modelling of Electricity Trade

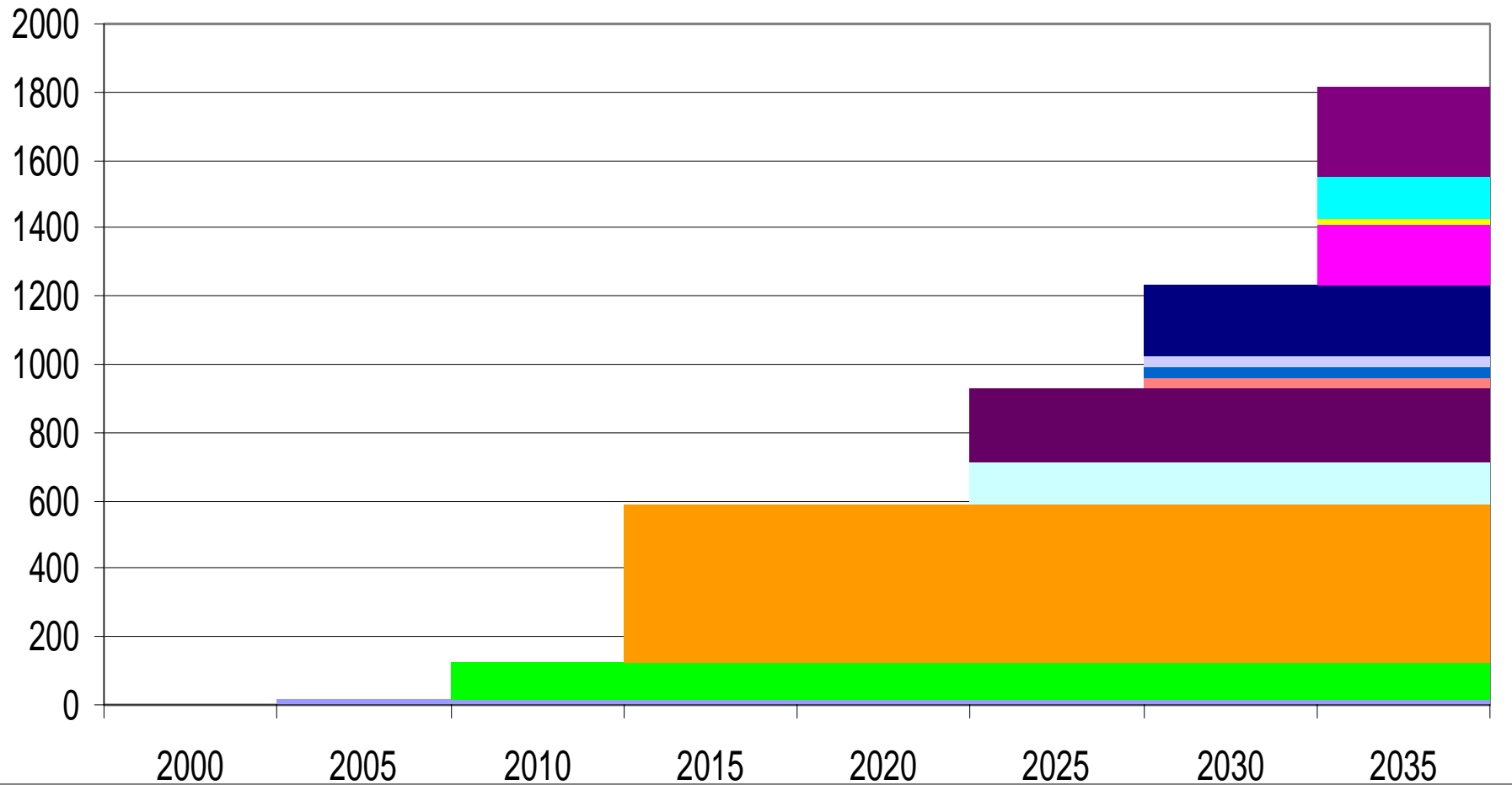


Thermal Installed Capacity (MW) - Case - BASE - Base data - Crude 40\$/bbl - No trade



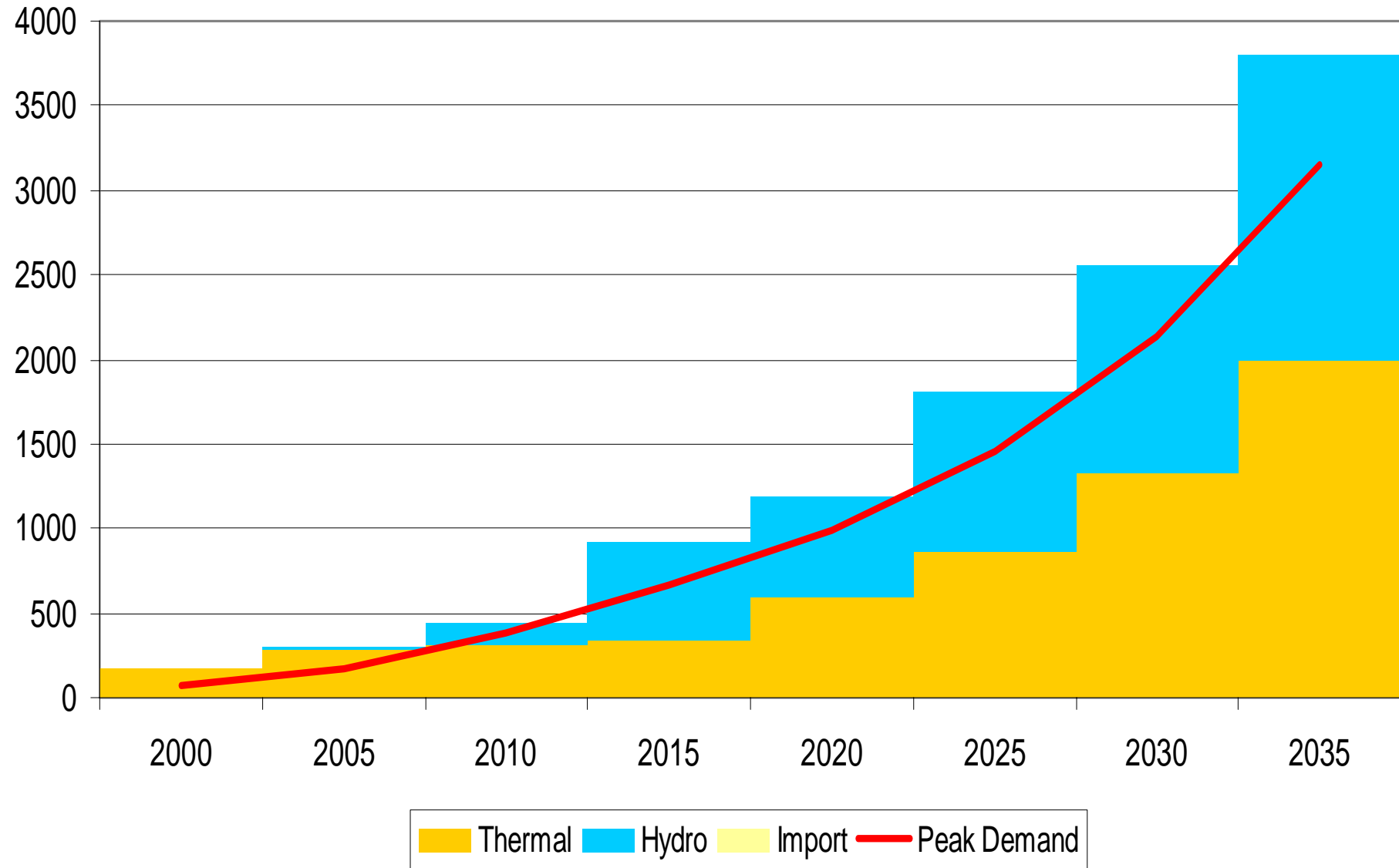
- Middle speed diesel (fuel oil)
- Private diesel
- Low speed diesel (Fuel oil)
- Middle speed diesel (diesel)
- Oil steam (Phnom Penh)
- New oil steam (Sihanoukville)
- OCGT (diesel) HV
- High speed diesel
- OCGT (diesel) MV
- CCGT (gas)
- CCGT (Dsl)
- OCGT (gas) HV
- OCGT (gas) MV

Hydro Installed Capacity (MW) - Case - BASE - Base data - Crude 40\$/bbl - No trade



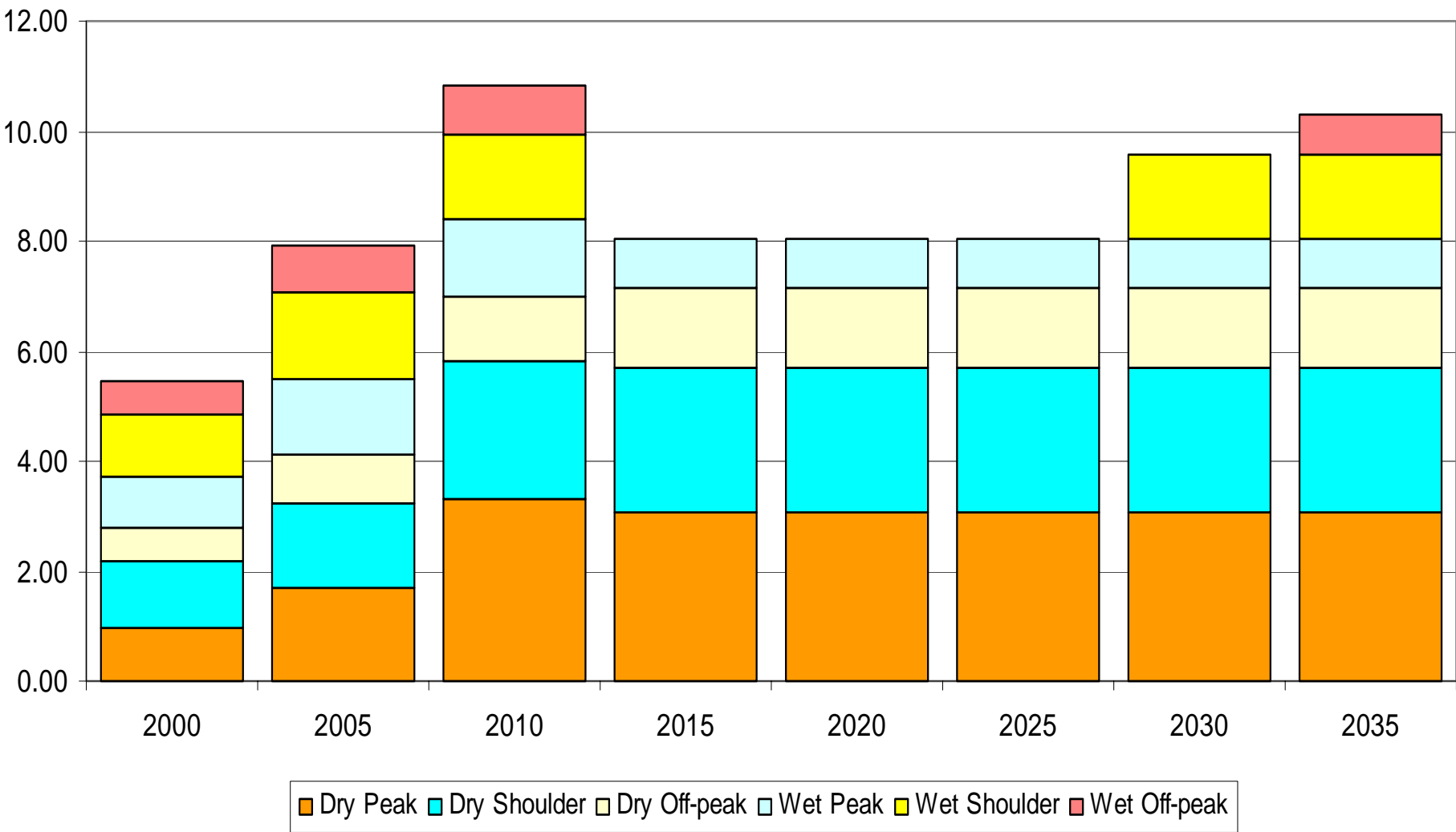
- Kirirom hydro
 - Lower Sre Pok 2 hydro
 - Lower Sesan 2 hydro
 - Stung Cheay Areng hydro
- Stung Atay hydro
 - Battambang 1 hydro
 - Kamchay hydro
 - Stung Metoeuk hydro
- Sambor hydro (storage)
 - Battambang 2 hydro
 - Battambang 3 hydro
 - Stung Tatay
- Lower Russey Chrum hydro
 - Upper Russey Chrum hydro
 - Middle Russey Chrum hydro
 - Sambor hydro (run of river)

Capacity Balance (MW) - Case - BASE - Base data - Crude 40\$/bbl - No trade



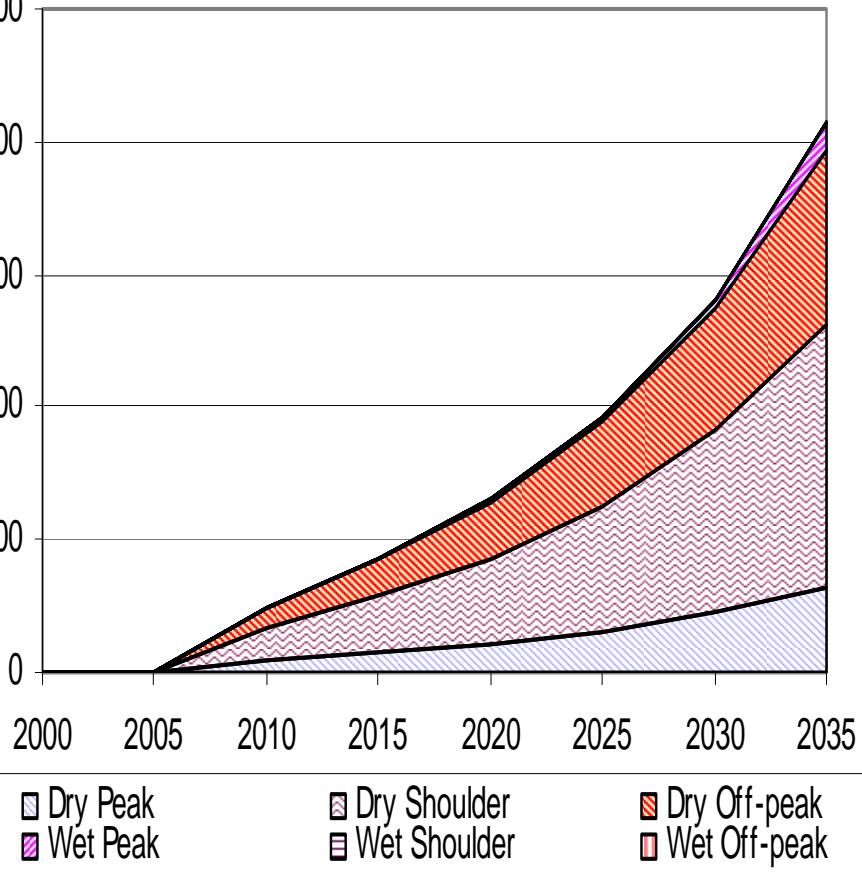
Long Run Marginal Costs at Consumer Level

Consumer LRMC contributions by time slice (Usc/kWh) - Case - BASE - Base data - Crude
40\$/bbl - No trade

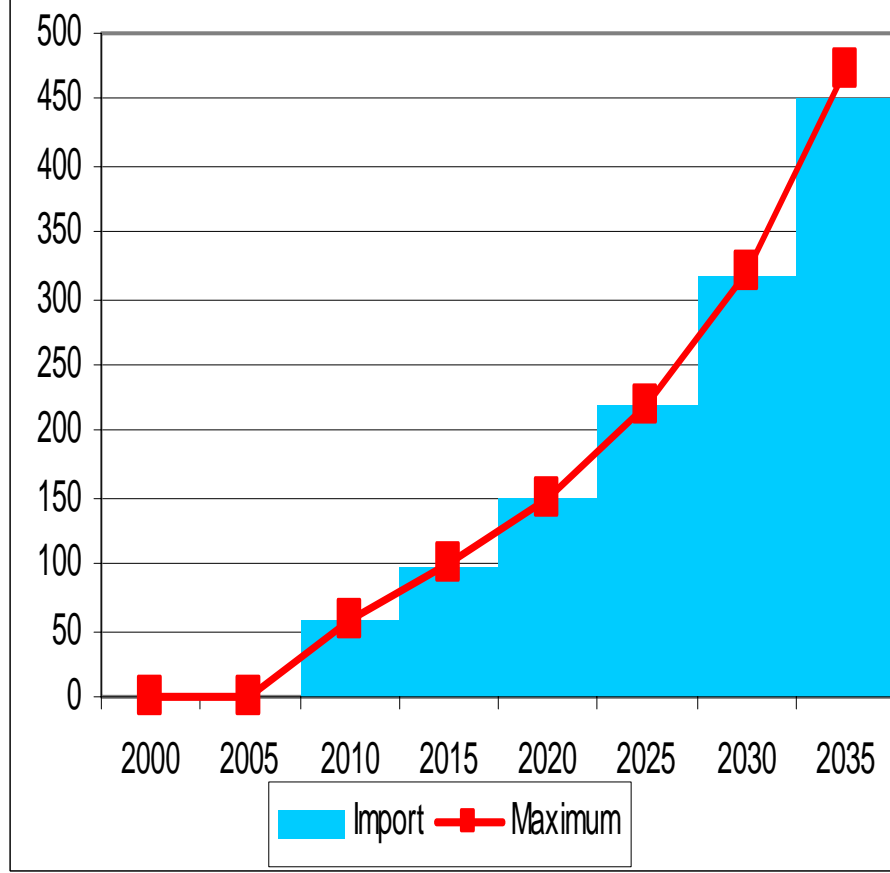


Import Energy and Capacity Contributions

Electricity Imports by Time Slice (GWh) - Case - IN50 -
Electricity import with no capacity credit

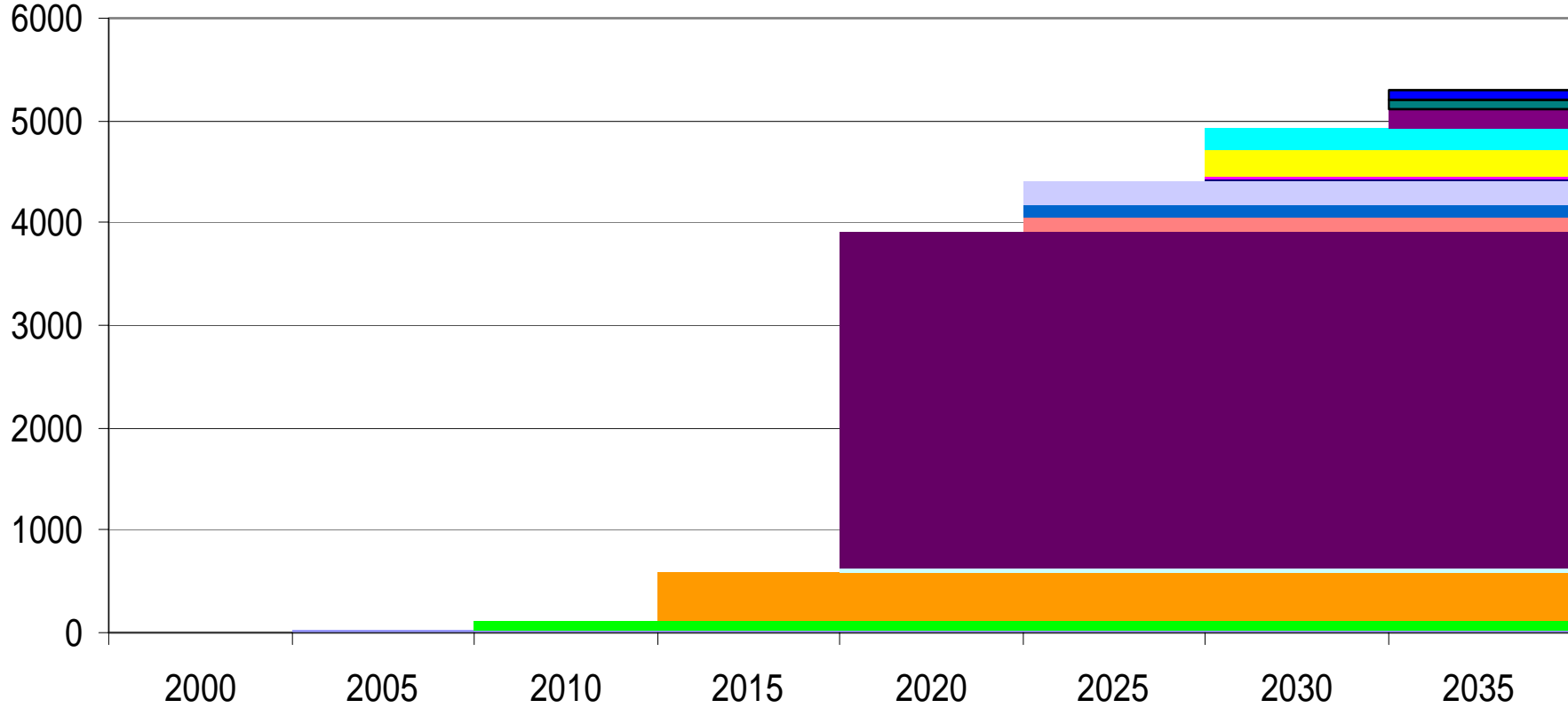


Electricity Import Capacity (MW) - Case - IN50 -
Electricity import with no capacity credit



Hydro Development Scenario for Optimum Exports

Hydro Installed Capacity (MW) - Case - X87 - Export energy 87%



- | | | | |
|---|---|---|--|
| ■ Kirirom hydro | ■ Stung Atay hydro | ■ Sambor hydro (storage) | ■ Battambang 2 hydro |
| ■ Sambor hydro (run of river) | ■ Middle Russey Chrum hydro | ■ Lower Russey Chrum hydro | ■ Lower Sre Pok 2 hydro |
| ■ Battambang 1 hydro | ■ Upper Russey Chrum hydro | ■ Stung Cheay Areng hydro | ■ Lower Sesan 2 hydro |
| ■ Kamchay hydro | ■ Battambang 3 hydro | ■ Stung Metoeuk hydro | ■ Stung Tatay |

CONCLUSIONS

1. System expansion Using Existing Supply Options

- Cambodia has the highest electricity generation cost in the region
- There is a substantial potential for developing local hydro, to operate in conjunction with the thermals. The hydro production is seen to be extremely seasonal, with the price of electricity still dictated by the HFO diesel plant in the dry season and the wet season peak. Due to this reason, even with the full flexibility of hydro development, the marginal electricity costs at consumer level is seen fall only to around 8 USc/kWh.
- The seasonality of hydro generation indicates a strong possible electricity export potential in the wet season.

CONCLUSIONS (Cont.)

2. Electricity Trade Options

- Due to the strong seasonality of hydro generation, electricity imports are only viable in the dry season and exports only in the wet season.
- With the import capacity limit of 15% of total generation, for maximum imports during dry season only, the long run average incremental value of imports is about 7.8 USc/kWh with only HFO diesels providing the thermal alternative in local generation. This means that Cambodia stands to gain for any negotiated import price of less than this amount for maximum imports during the dry season from 2010.
- The long run incremental cost of electricity exports for a 3000 MW export capacity with maximum exports during the wet season only is around 1.7 USc/kWh. This means that Cambodia stands to gain for any negotiated export price of more than this amount for maximum exports during the wet season from 2020.

Thank you for your attention