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IRADe Integrated Research and Action for Development

'Economic Benefits from Nepal–India-Bangladesh Electricity Trade'

South Asia Regional Initiative for Energy Integration (SARI/EI)

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Electricity for Nepal's Growth

- Bhutan and Nepal have huge hydro potential
- Bhutan has gained from electricity trade with India. Its per capita income is higher than india's and so its HDI
- Nepal needs resources to develop its hydro potential
- Nepal by itself cannot provide the needed market to exploit full hydro potential
- Electricity trade can provide not only market but resources to develop the hydro potential and boost Nepal's growth

The Objective of the study

- Assess Techno economic Feasibility of Cross Border Electricity Trade (CBET)
- What are the economic gains to Nepal of such trade taking in to account earnings from export and its macro-economic impact on the economy

IRADe study shows how effective electricity trade could be…

Approach

Five Inter-linked Models

- A technology model and a macro economic model for each country
- *And a Model where the two technology models are linked together.*
- *Solved in iterative manner the system of models determine electricity technology choices to meet hourly demand over 35 years*
- And volume and price of hourly trade of electricity between the countries over a 35 year period at prices which are acceptable to importing and exporting country.

Approach

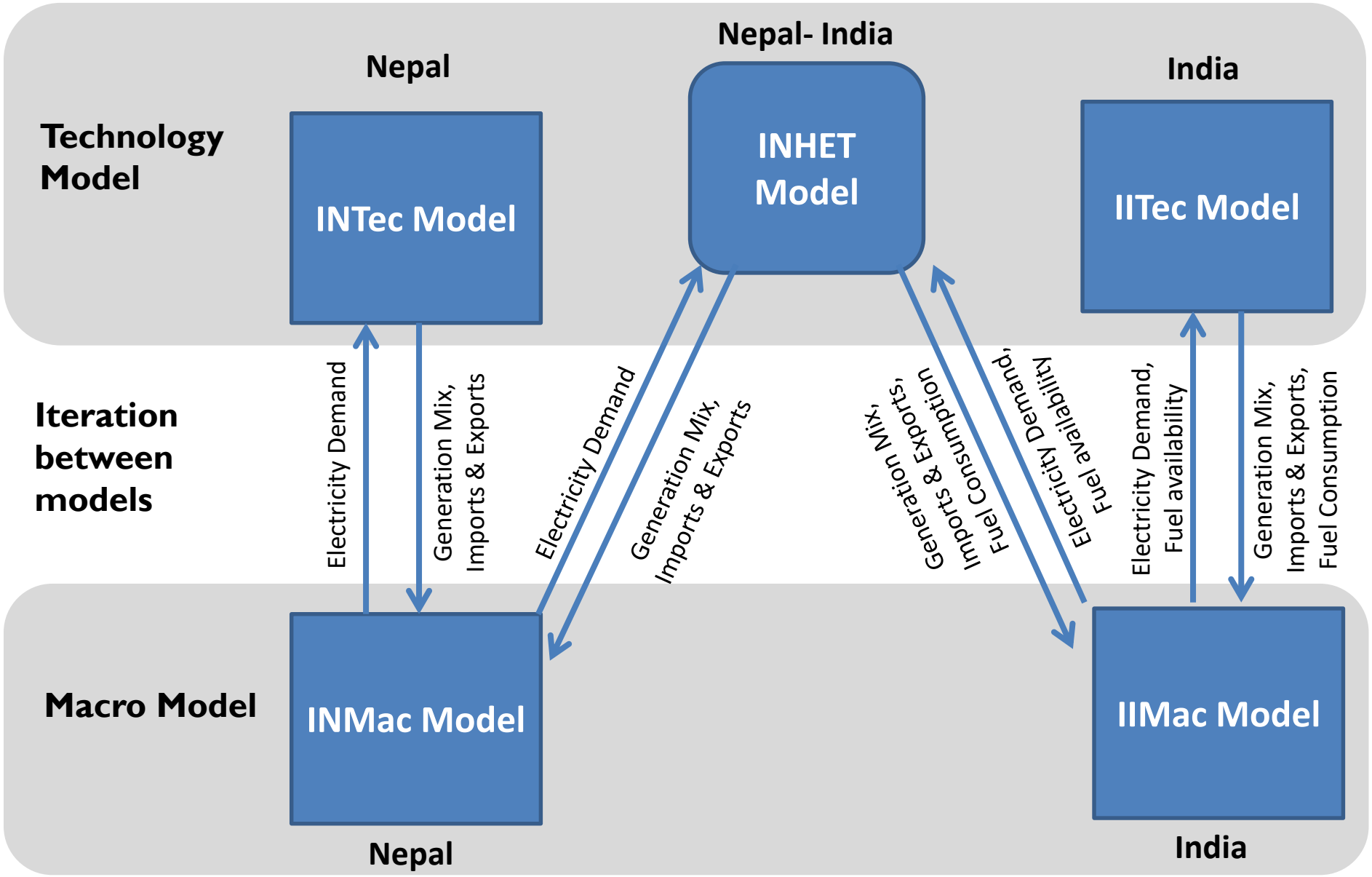
Cost Minimizing Technology Model

- Technology model for each country has detailed plant wise /technology data and options such as
  - Hydro, Nuclear, Gas, Coal, Solar, Wind, Biomass etc
  - Imports, Exports
- Minimizes cost to meet specified demand and provides optimal solution for 35 years till 2045
- Demand is determined by the Macro model
- For each hour demand must equal supply

Approach (Continued)

Macro-economic Model

- The macro- economic model covers the whole economy, balances supply and demand for each sector, also investment and savings, balance of payment for each year, etc.
- So earnings from electricity export increases flexibility to import and more resources to invest
- Higher Growth and higher domestic demand for electricity
- Iterate between the two models to get economically viable and technically feasible scenarios.



Macro Model Names:

IIMac- IRADe India Macro

INMac- IRADe Nepal Macro

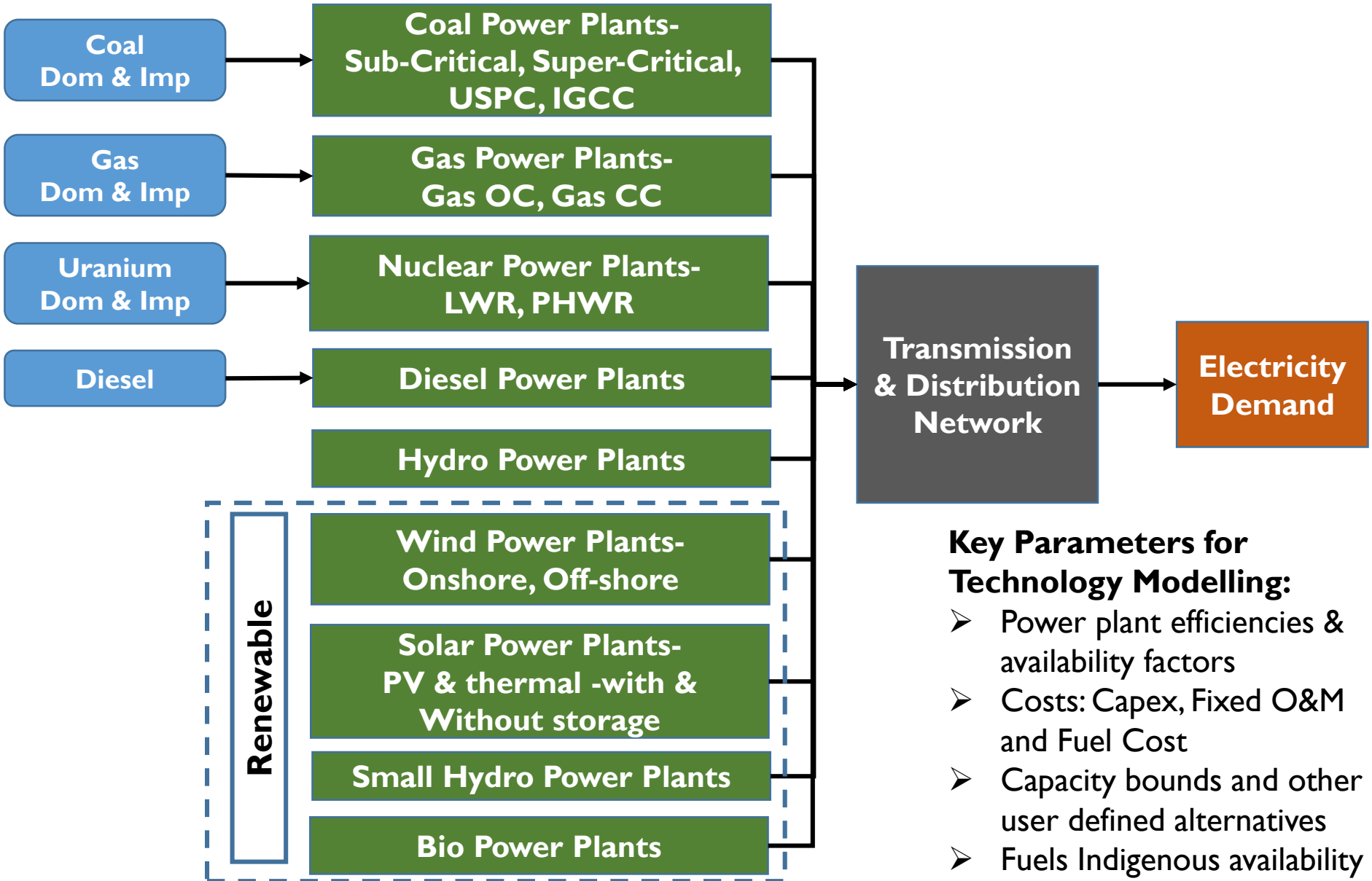
Technology Model Names:

IITec- IRADe India Technology

INTec- IRADe Nepal Technology

INHET- India-Nepal Hourly Electricity Trade Model

Structure of Energy System (Electricity) Considered For India Model



Key Parameters for Technology Modelling:

- Power plant efficiencies & availability factors
- Costs: Capex, Fixed O&M and Fuel Cost
- Capacity bounds and other user defined alternatives
- Fuels Indigenous availability

Three Scenario's

- **BASE** – Trade at current level
- **APT** – Accelerated Power Trade (APT)
- **DCA** – Delayed Capacity Addition (DCA) by 5 years

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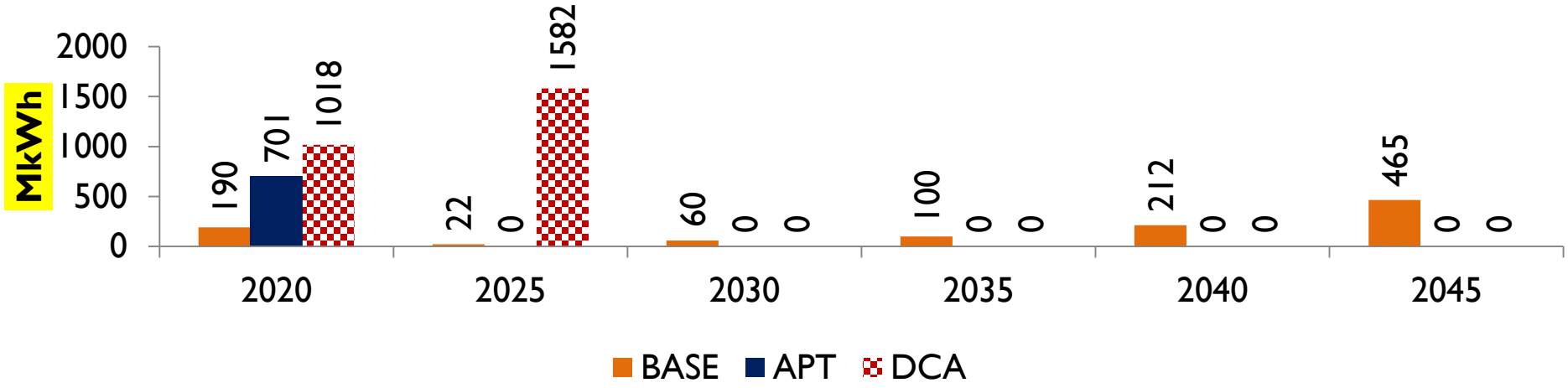
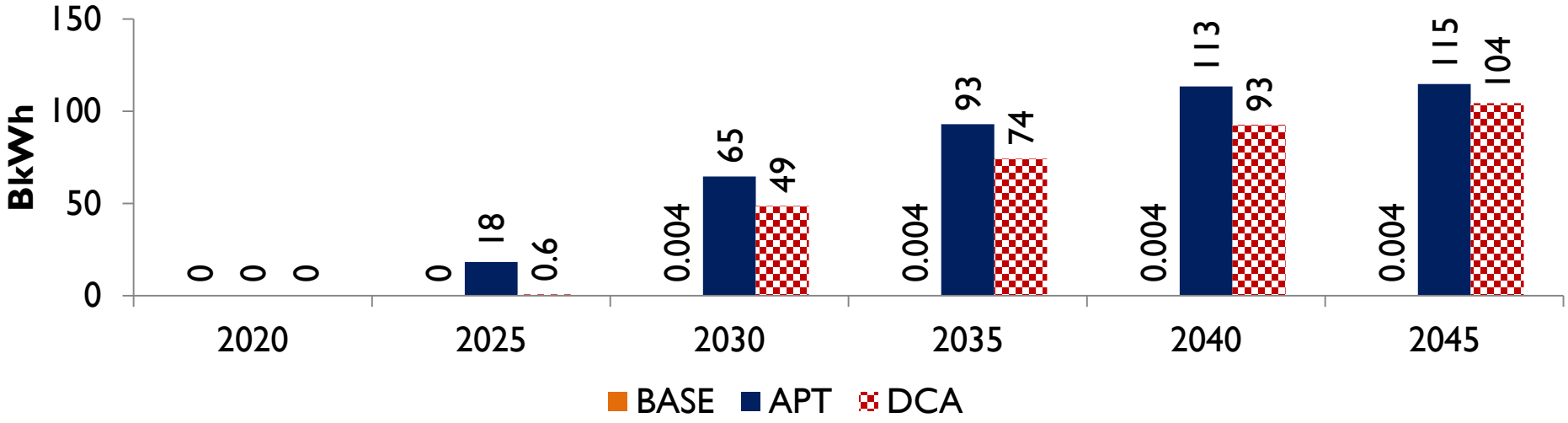
Impact of Electricity Trade on Nepal

Nepal's Imports/ Exports

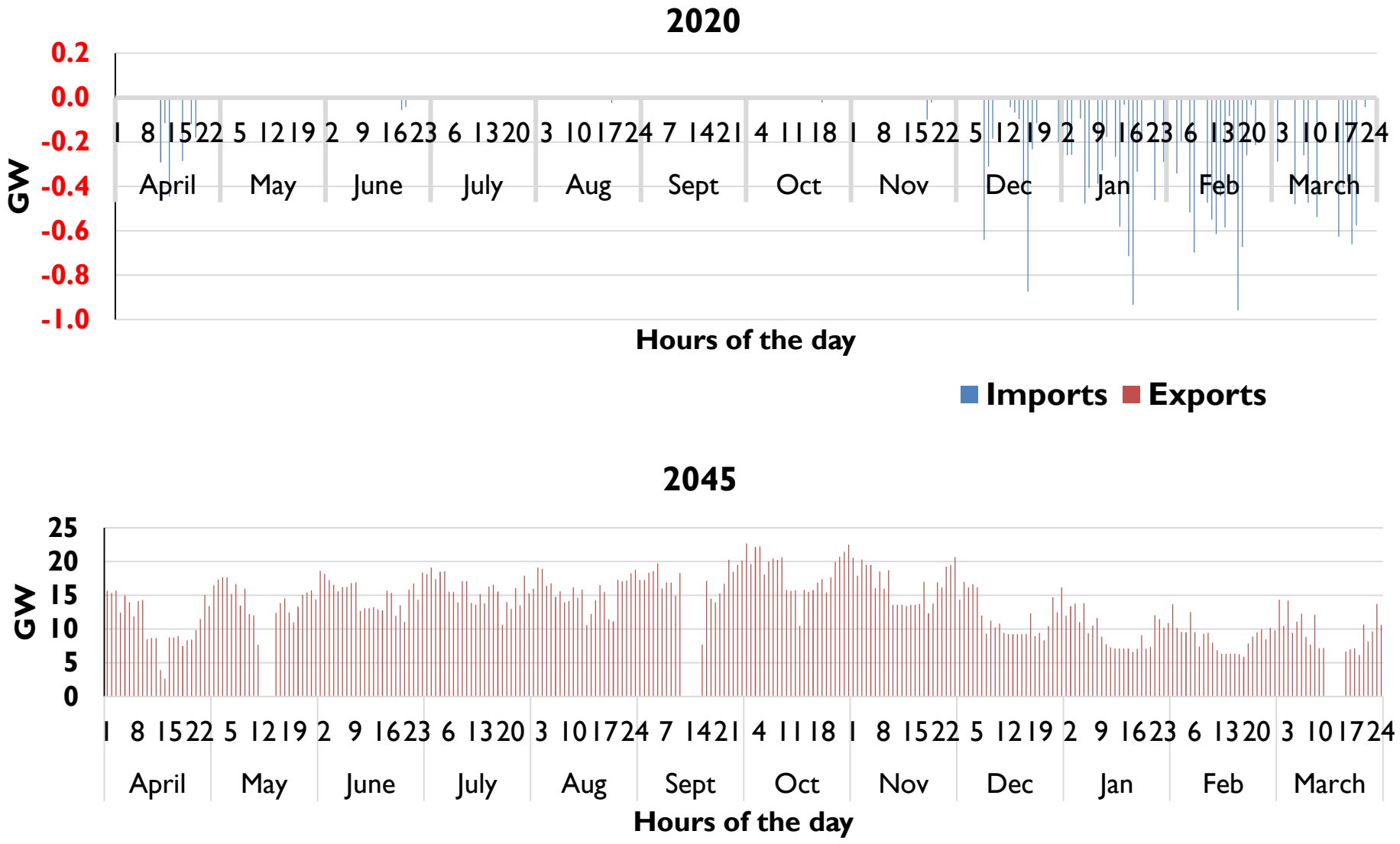
Nepal's Imports/ India's Exports (in MkWh)



Nepal's Exports / India's Imports (in BkWh)

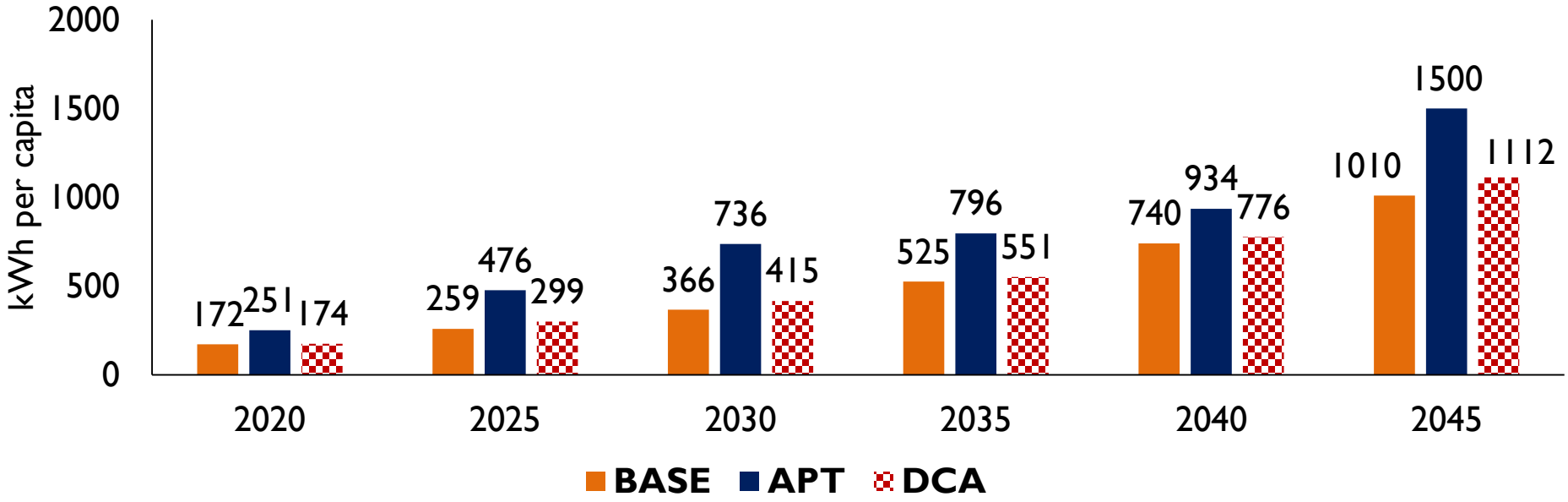


Selected Years Nepal's Imports/ Exports in APT



Developmental Impact on Per Capita Electricity Demand

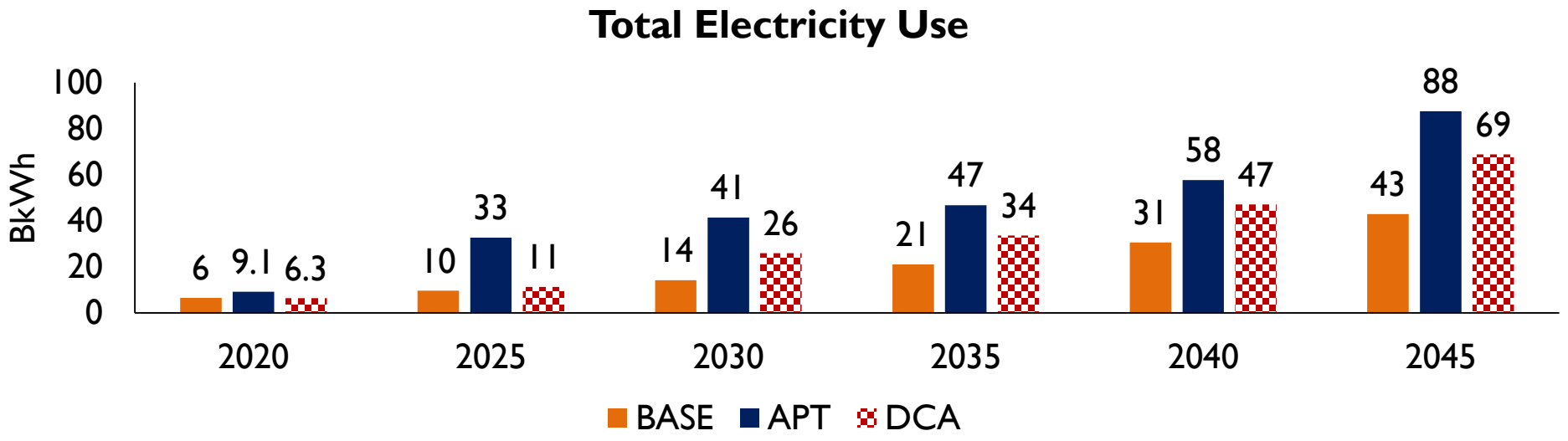
Change in Nepal's Per Capita Electricity Demand

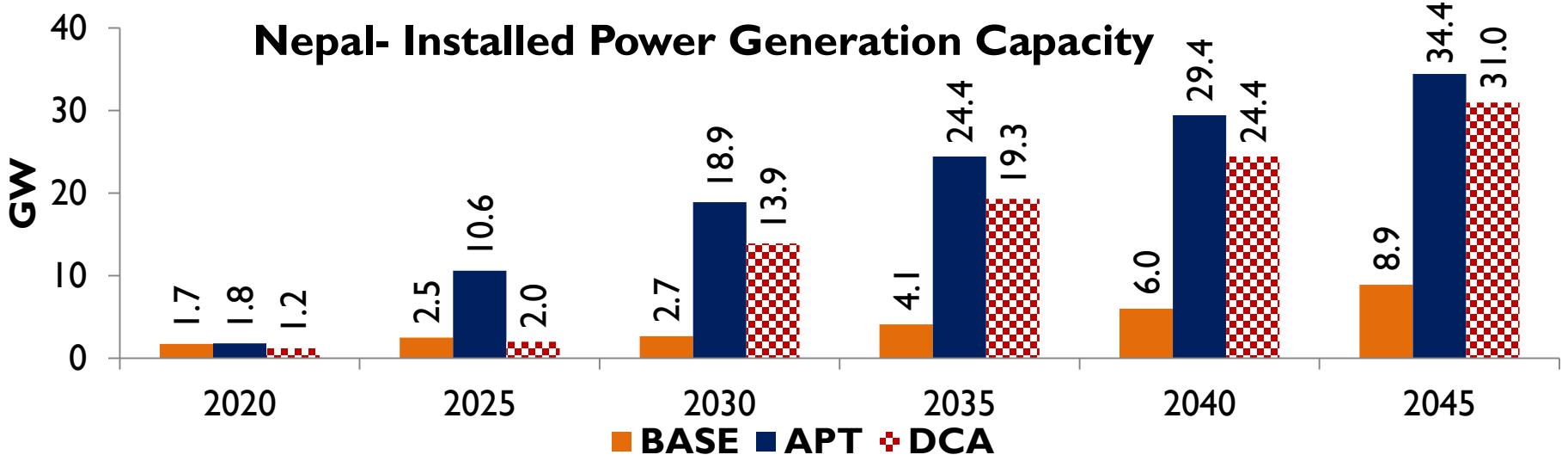


Gains over BASE in Per Capita Electricity Demand

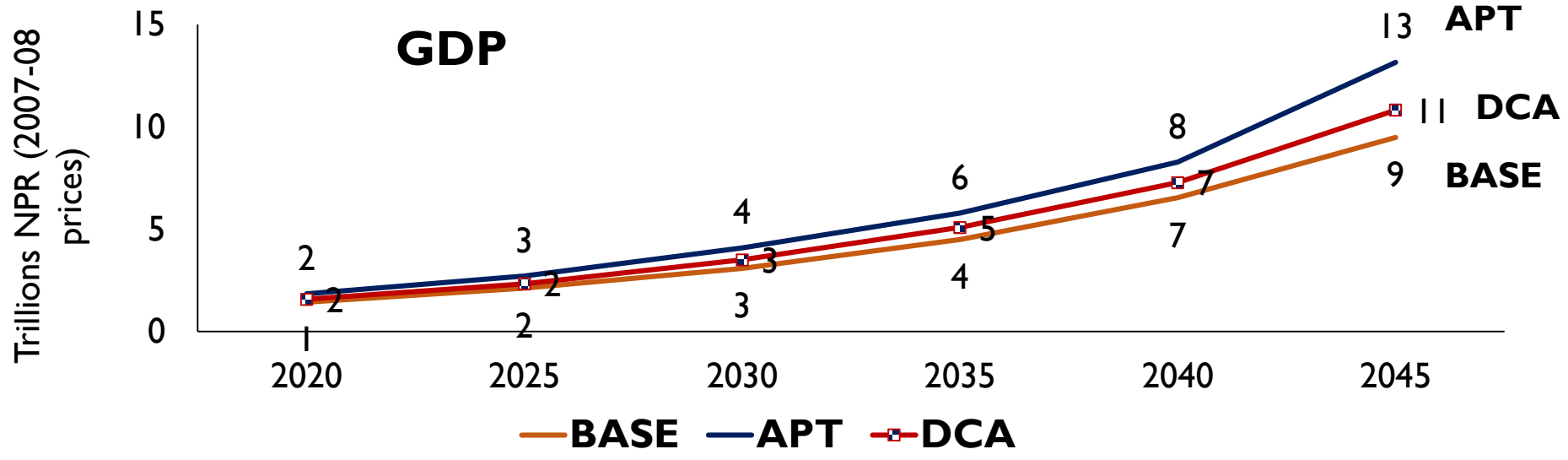
Year	Base	APT		DCA	
	kWh per capita	Change over Base	% Change	Change over Base	% Change
2030	366	369	101%	49	13%
2045	1010	490	49%	102	10%

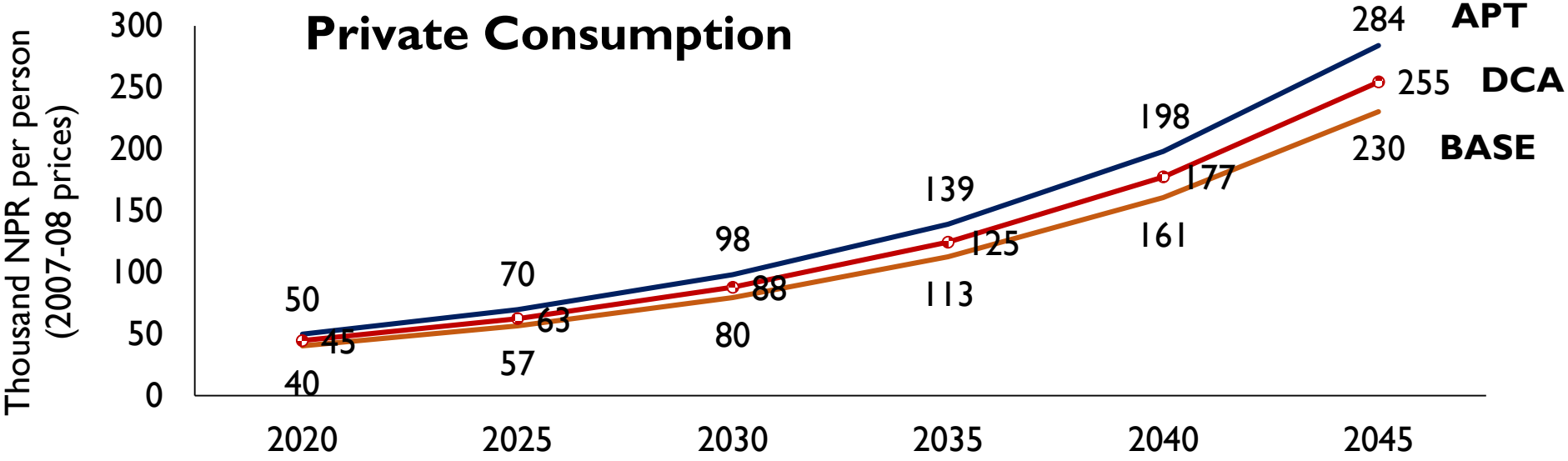
Developmental Impact on Total Electricity Use





Economy wide Impact





Gains over BASE in GDP at (2007-08 Constant Prices)

Year	Base	APT		DCA	
	billion NPR	Change over Base	% Change	Change over Base	% Change
2020	1432	406	28%	136	10%
2025	2109	593	28%	222	11%
2030	3082	995	32%	414	13%
2035	4490	1297	29%	590	13%
2040	6537	1741	27%	733	11%
2045	**9484**	**3666**	**39%**	**1328**	**14%**
Cumulative 2012-2045	121589	35347	**29%**	14098	**12%**

Key Findings for Nepal

- Nepal's hydro potential – a valuable resource

- Early development of trade infrastructure necessary
  - To import in the short or medium term during the construction of hydro projects and export when hydro plants are ready.

- With APT per capita consumption, an indicator of improvement in well-being, increases by 23% over the BASE scenario.

- Per capita electricity consumption, strongly correlated with human development, increases by 50% in 2045

Key Findings for Nepal

- With APT, net annual export revenue from the electricity trade is NPR 310 billion in 2030, NPR 840 billion in 2040 and NPR 1069 billion in 2045.
- GDP in 2045 with trade in APT is 39% higher than in the BASE scenario.
- Investments in 2045 with APT becomes 33% of GDP, suggesting even more robust economic growth in the future.
- Trade promotes industrialisation, which creates better paying employment
- Share of industry in GDP becomes 30% compared to 21% in BASE and since GDP is 39% larger, the level of industrial GDP doubles in APT.

Key Findings for Nepal

- The power capacity increases to 34.4 GW in 2045 with APT compared to only 8.9 GW without trade (BASE)

- With APT, substantial power capacity is built through foreign direct investment.
  - The value of foreign inflow over 2012 to 2045 is 28,931 billion NPR.
  - 51% of the total investment in power sector is through outside support

- Even a five-year delay in capacity creation in DCA reduces these benefits substantially. In 2045 GDP is higher compared to BASE by only 14% (39 % in APT) and per capita consumption by only 10% (23% in APT).

Key Findings for Nepal

- Without electricity trade in the BASE scenario a number of storage type hydro projects are required to meet domestic demand.

- With trade in APT, exploitation of hydro potential is through run of the river (ROR) type plants, which are the cheapest and easiest to construct.

- In addition, ROR plants cause less environmental externality and human displacement compared to storage type plants.

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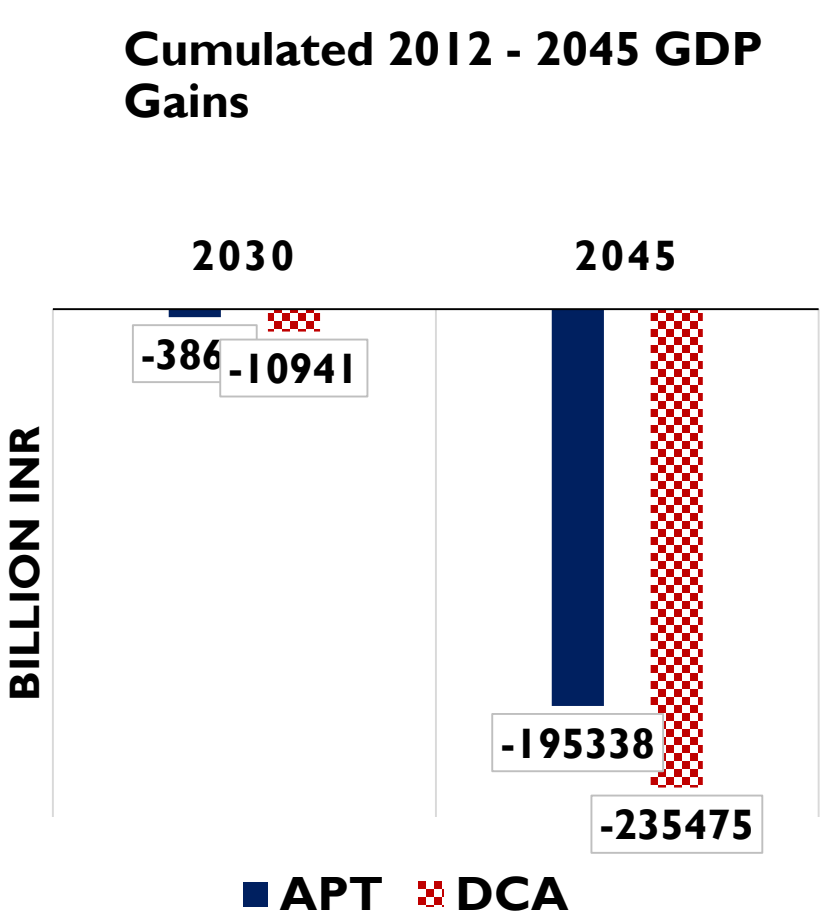
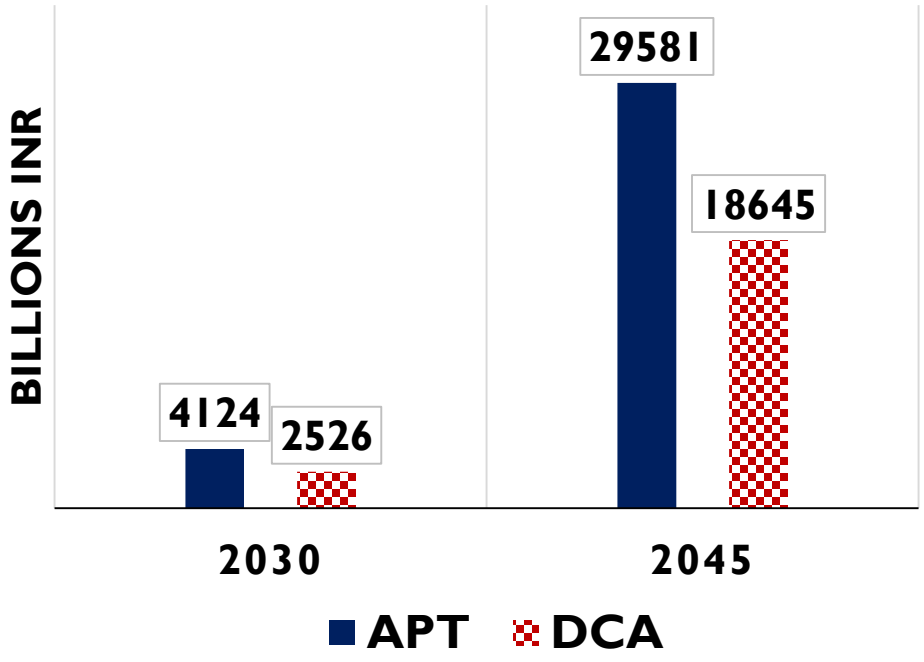
Impact of Electricity Trade on India

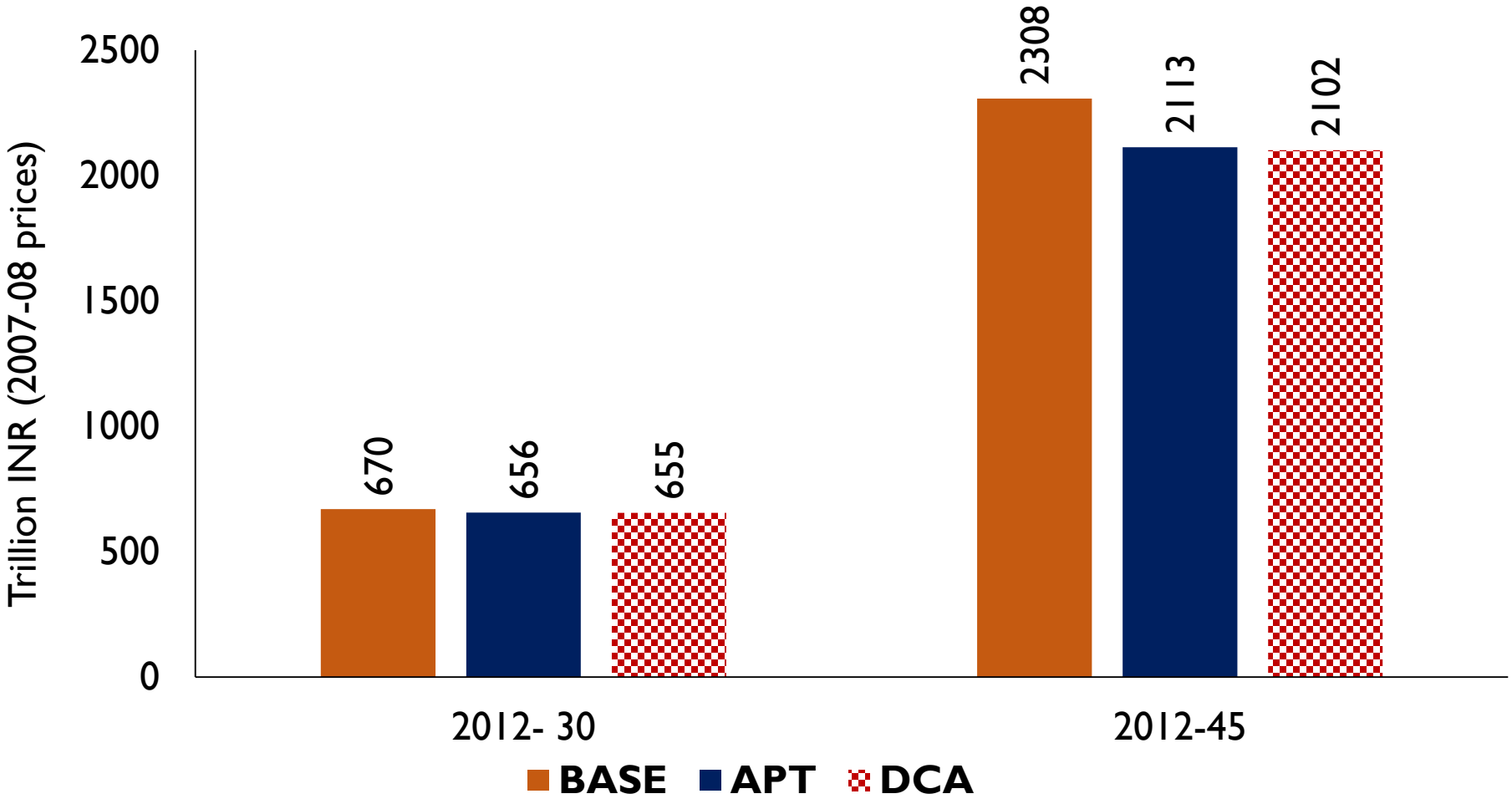
Economy wide Impact Compared to Base
Lower GDP - Higher Consumption

Cumulated Consumption Gains

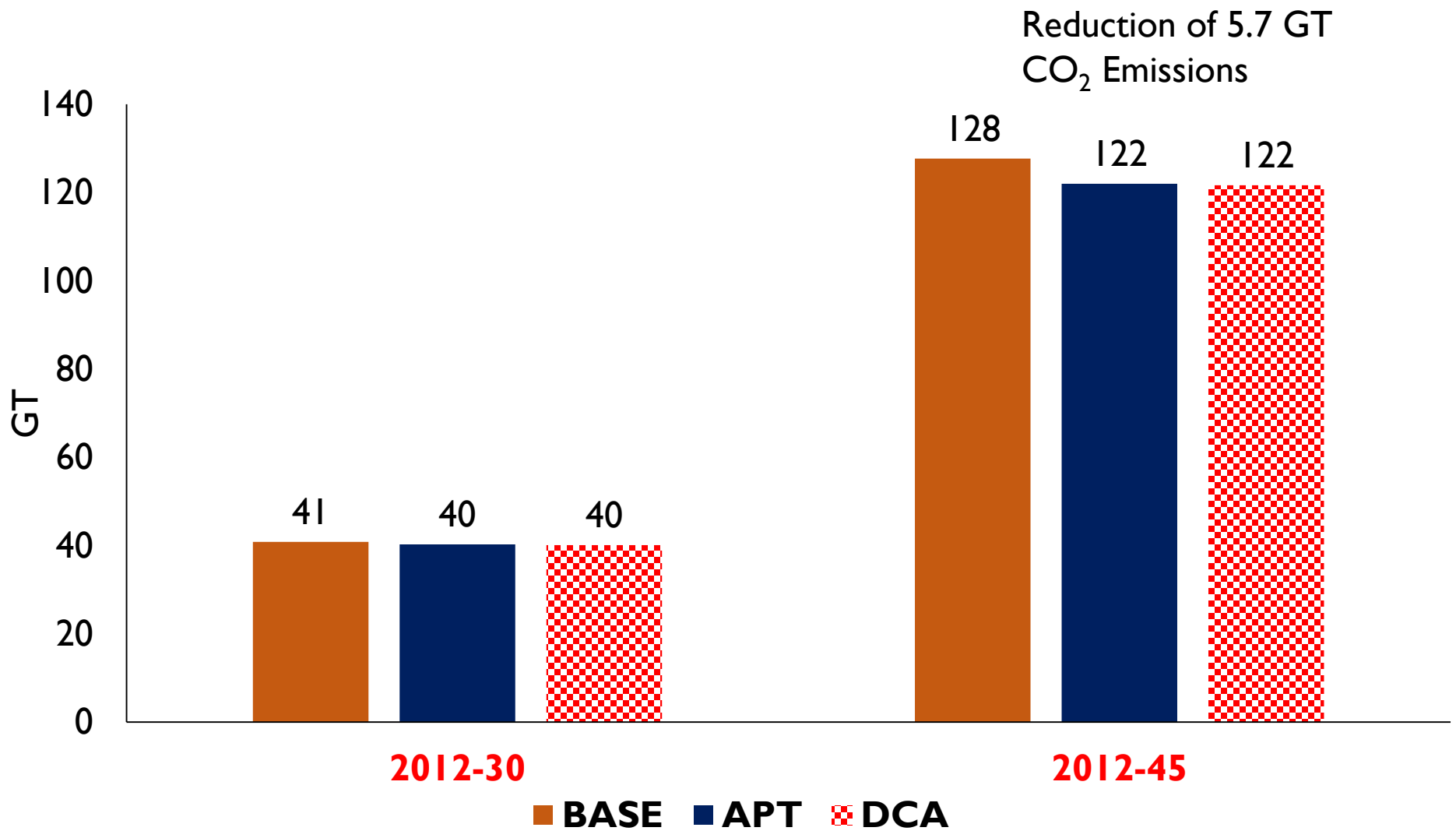




India's Cumulated 2012-2045 Total Investment in Economy



India's Cumulated CO2 Emissions- Economy Wide



Gains from Trade for India

- Electricity supply cost lower
- Investment in domestic generation, capacity creation are reduced.

- Available imported capacity in the evening helps to encounter solar intermittency and meeting peak helps meet ambitious renewable target
- It may be noted that India imports electricity from Nepal even when its own hydro potential of 145 GW is fully utilized.

- In APT, per capita consumption in 2045 increases by 1.7% though GDP reduces by 6.33% compared to BASE. In absolute terms however, the gain in cumulated consumption over 2012-2045 are comparable for India and Nepal.

Gains from Trade for India

- Production and import needs of coal and gas are lower.
- Reduces pollution and brings environmental benefits.
- As import is sourced from hydro plants with their flexibility in generation, it helps India to meet its renewable target by providing balancing power.
- The cumulated CO2 emission from 2012 to 2045 reduces by 5.6% and 5.4% respectively in APT and DCA compared to BASE scenario. This is important for India, which is increasingly playing a leadership role on climate change issues.
- With reduced CO2 emissions by India, the world also gains.

Way Forward

- Both Nepal and India gain significantly in economic and environmental terms
- To make CBET a reality – Many steps are needed
- Task Force reports have worked out the nitty-gritty of some 20 points in the SAARC agreement
- The Mock Trading will show how trading can be done easily
- This study has shown its desirability and should help build a larger consensus

Why Electricity Trade Between India and Bangladesh

Bangladesh:

- Chronic Power Shortages
- Short of Energy Resources
- Declining gas reserves, difficult to mine coal, limited renewables
- Use costly diesel/fuel oil generation
- Plans to import Gas and Coal for power generation
- Diversification for energy security

India:

- Presently, India has Capacity Surplus
- As per various government reports India is expected to remain capacity surplus till 2027
- Economic cooperation with Bangladesh can bring other benefits

Assessing Trade Potential and Economic Benefits

- Elaborate System of Models
- Technological optimal planning models for each country that balances demand, supply trade for each hour for 35 years
- Macro economic model for each country covering the whole economy with endogenous demand, GDP, Investment determination and alternative power generation technologies. Maximizes PDV of consumption.
- Iterate between the two models
- Linked technological models of two countries

Scenarios

REF Scenario (Reference): wherein the electricity trade is **restricted to 1.1 GW (upper limit)** as per the planned interconnection capacity by 2019.

Power System Master Plan (PSMP) basic strategy is to diversify sources and import fuels and electricity

PSMP Scenario: Bangladesh Electricity mix by 2040 to be

- Coal -35%
- Gas -35%,
- **Electricity import - 16%**
- Nuclear -12% of the total availability

TRADE 30 Scenario: Electricity import scenario

- **30% upper limit on Electricity Imports for Bangladesh**
- generation mix is free

Key Results - Bangladesh

- Both electricity as well as aggregate consumption of households increase in TRADE-30 scenario. There is thus welfare gain.
- Both Trade30 and PSMP scenarios require lower investment compared to REF
- Energy import bill in PSMP scenario is larger than the other two scenarios. Increased import dependence is price for diversification.
- Saved foreign currency could be used for activities with higher socio-economic benefits.
- Enhanced electricity trade reduces fuel import for power generation, in particular that of gas, which has a more volatile market, therefore, enhancing energy security.
- PSMP scenario with higher GDP has lower welfare compared to TRADE 30 scenario

Key Results - India

- Beneficial impacts although not highly visible because of India's size.
- Indian households increase consumption due to Export revenue-earning
- Export earnings lead to higher investment in the economy and GDP increases in higher trade scenario.
- Indian power system's CO2 emissions increase. However, carbon intensity (kg/kWh) of the system declines.

Comparable Gains to Both Countries

- In percentage terms gains for Bangladesh are larger but in absolute rems they are comparable
- Cumulated over 2012-2045 household consumption gains over REF in **billions of US$ 2012 prices**

	PSMP	TRADE 30
India	160	401
Bangladesh	113	523

Way Ahead

- Greater cooperation can bring other benefits
- Transport and transmission cost reduction
- Economic benefits to North East India
- With power trade among BBIN countries Bangladesh could import power from Nepal and Bhutan reducing its dependence on import from one source.
- Greater role of hydro power will reduce CO2 emissions of the region

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