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'Integrated Assessment of Economic Benefits from Nepal–India Electricity Trade'

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The Objective of the study

- Assess Techno economic Feasibility of Cross Border Electricity Trade (CBET) between Nepal and India- a case of small country and large country trade
- What are the economic gains to Nepal of such trade
- What is volume of trade and direction of trade at each hour and the long term implications for the power systems of each country
- What are the economic benefits and implications for India

Electricity for Nepal's Growth

- Nepal has huge hydro potential (43 GW)
- But a low level of electricity supply
- 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

Approach

Cost Minimizing Technology Model

- Technology model for each country has detailed plant wise /technology data and options
  - Detailed TIMES-MARKAL model with 288 time-periods per year
  - 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

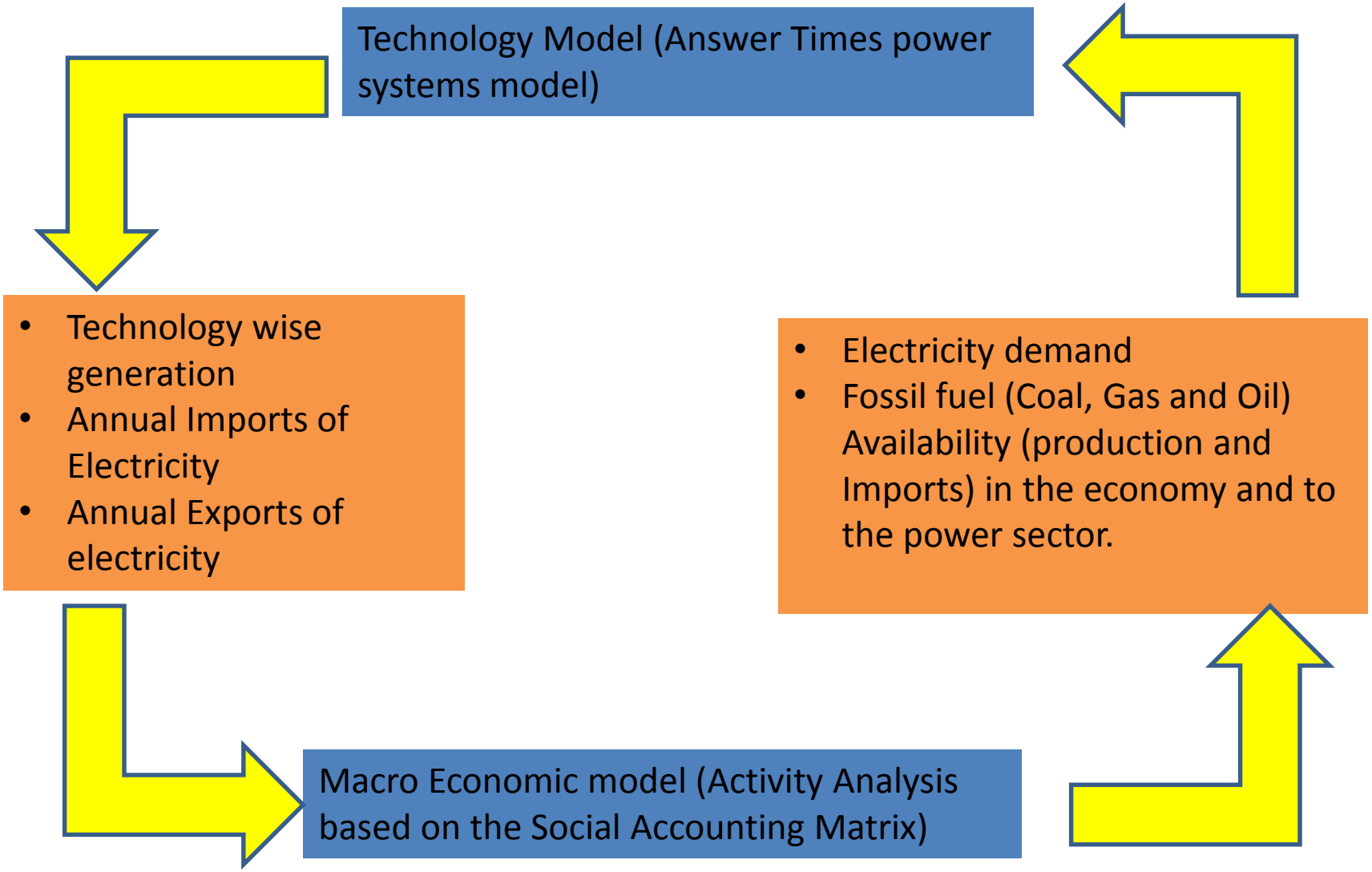
- The macro- economic model is a activity analysis model which covers the whole economy, balances supply and demand for each sector, also investment and savings, balance of payment for each year, etc.
- So earnings from electricity export increases flexibility to import and more resources to invest
-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

Approach

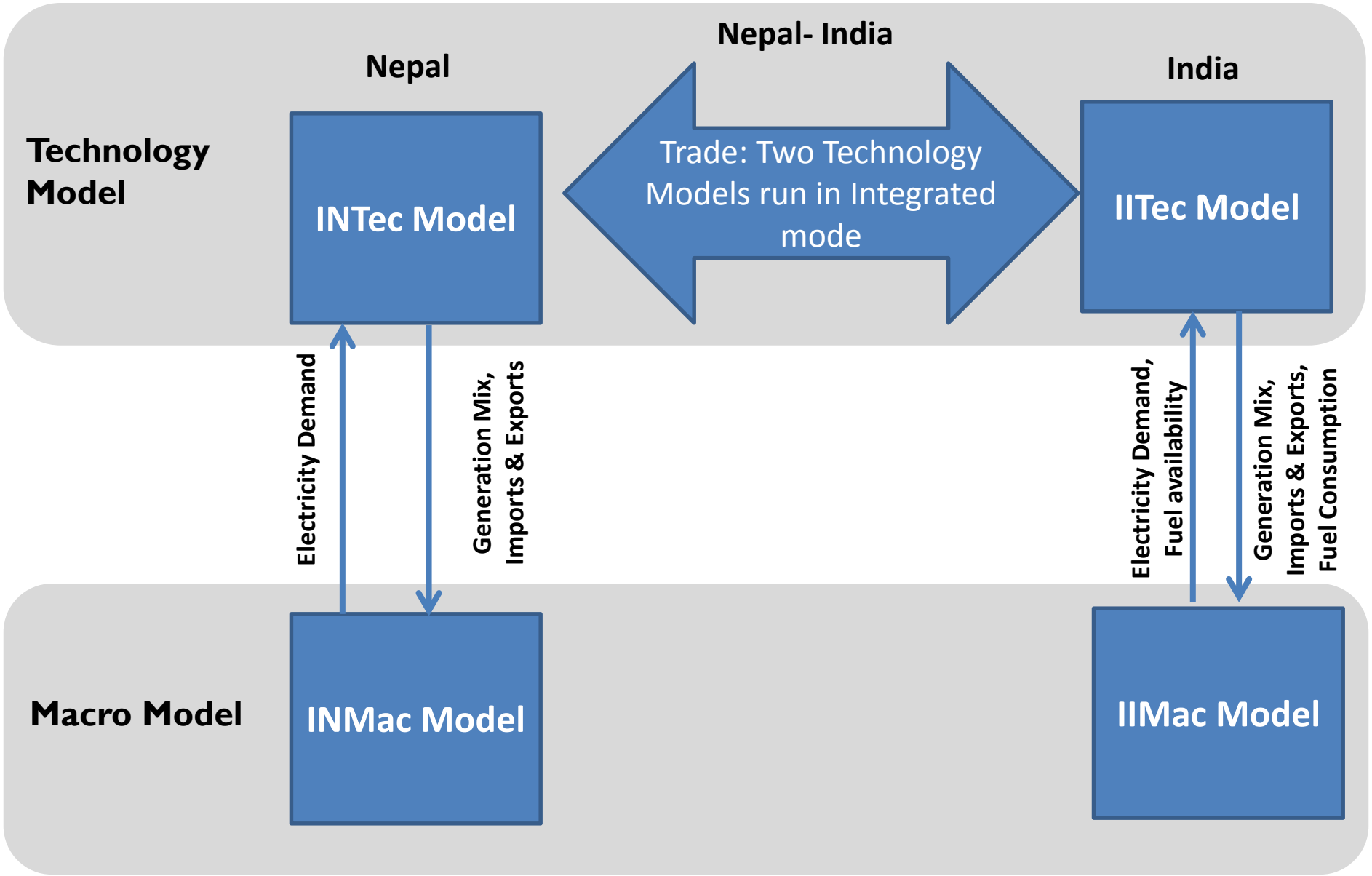
Five Inter-linked Models

- Hybrid model- A technology model and a macro economic model for each country
- *And a Model where the two technology models of the hybrid model are run on a integrated mode together for trade.*
- *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.

Working of the Hybrid Model for each country



India-Nepal Hourly Electricity Trade (INHET) Model



Approach

Why Integrated Assessment model?

- Power systems model provide for impact on technological choices for generation and capacity, volume of trade and price at which electricity trade takes place at each hour
- *However Electricity trade would also have the standard economic gains of production specialisation and welfare gain cannot be provided by a power systems model.*
- *A Macro economic model provides the production specialisation gain and welfare gain of trade but it cannot model the granular details of the power sector like hourly workings of a power system.*
- A linked hybrid model in the form of a macro economic model linked to a power systems model can be used to asses both technological implication and economic gains.

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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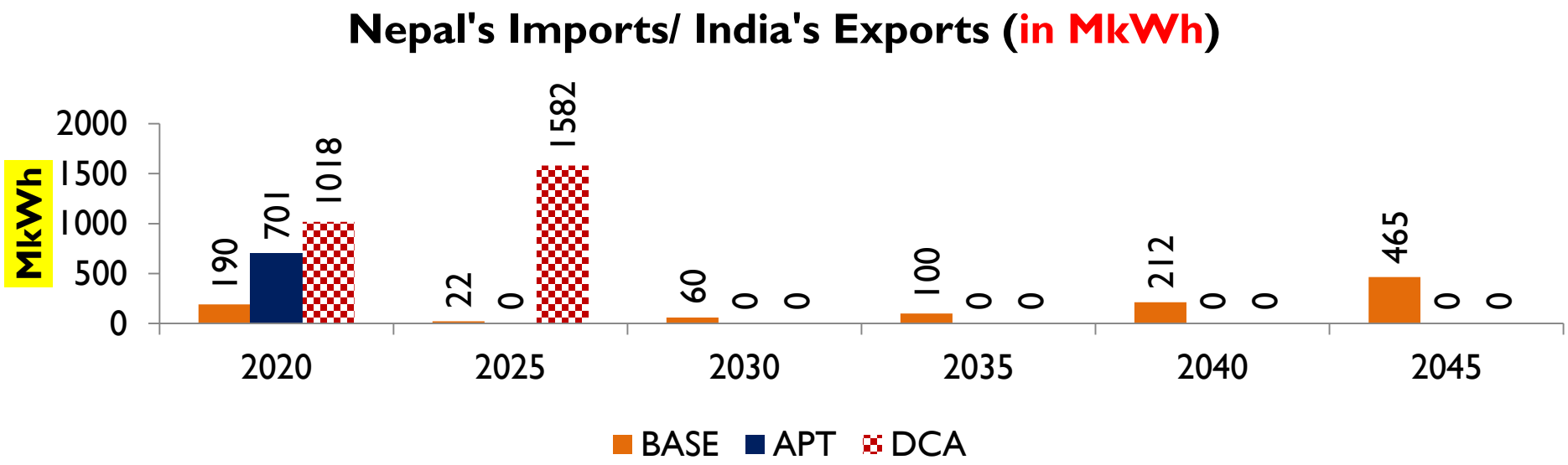
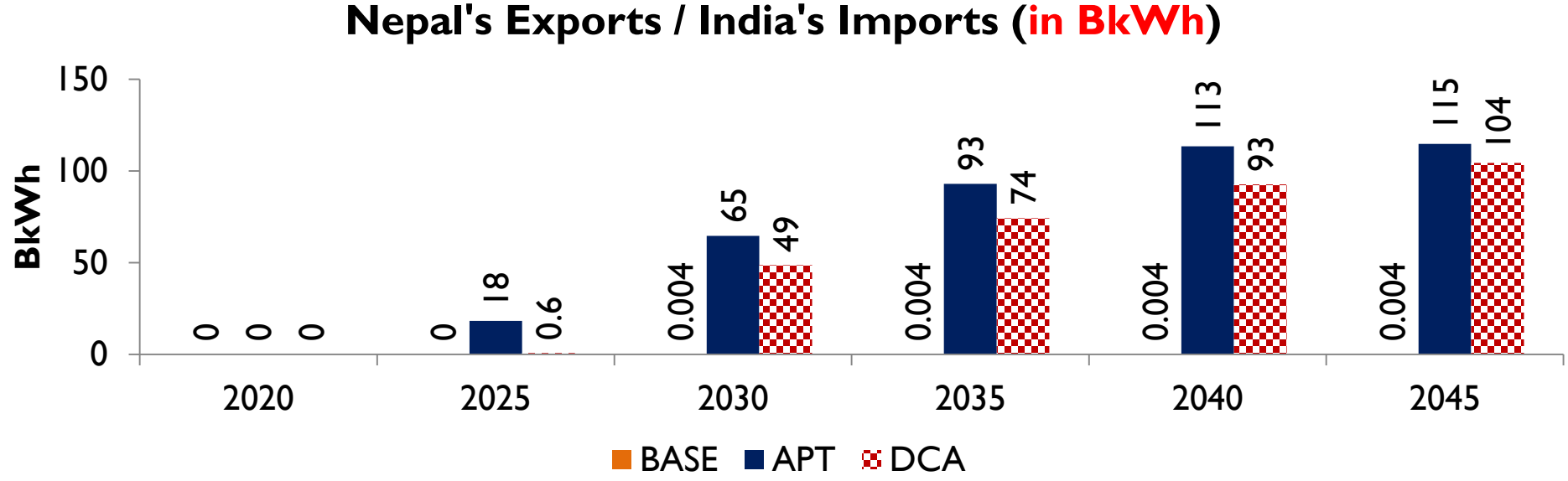
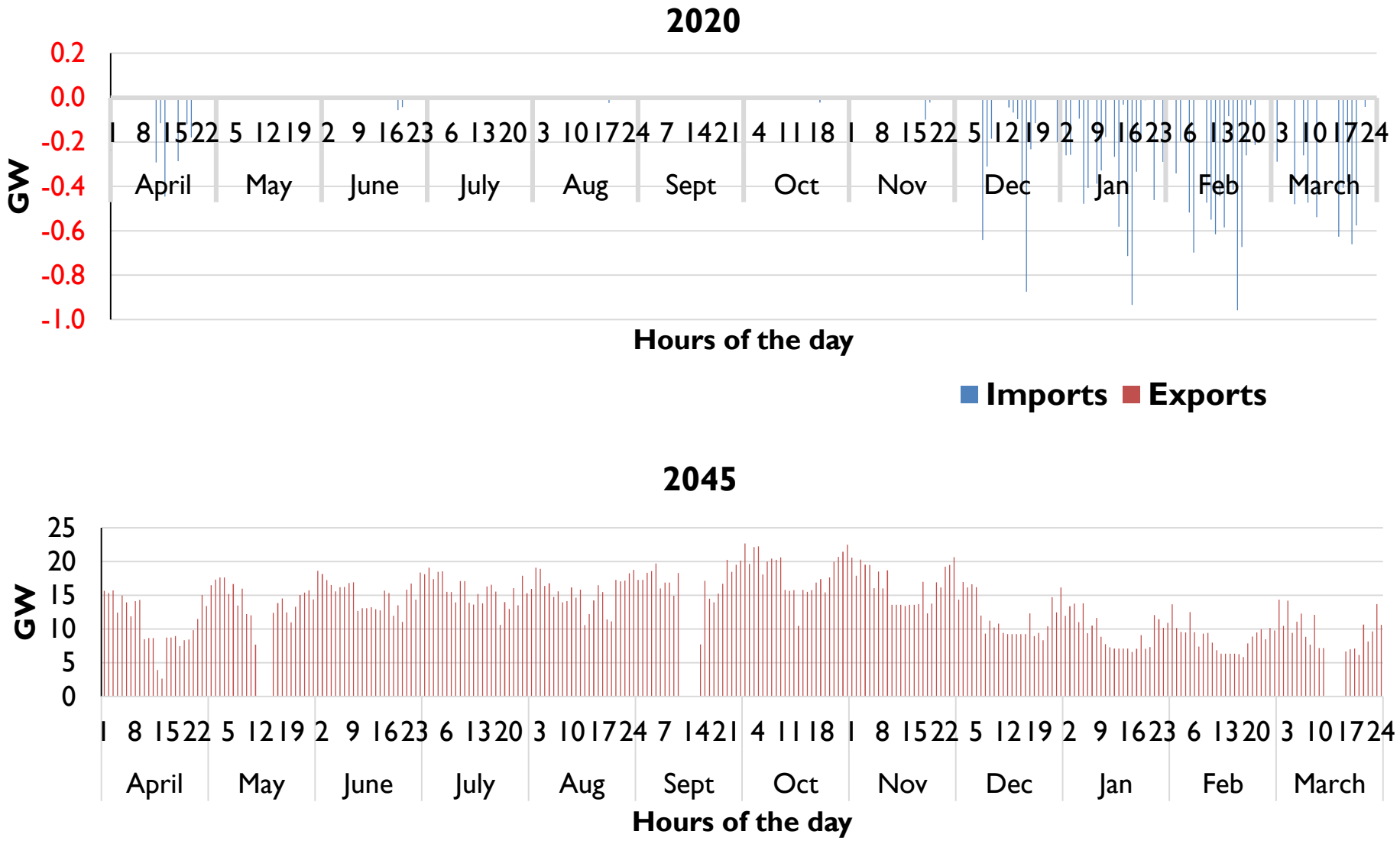
Impact of Electricity Trade on Nepal

Nepal's Imports/ Exports



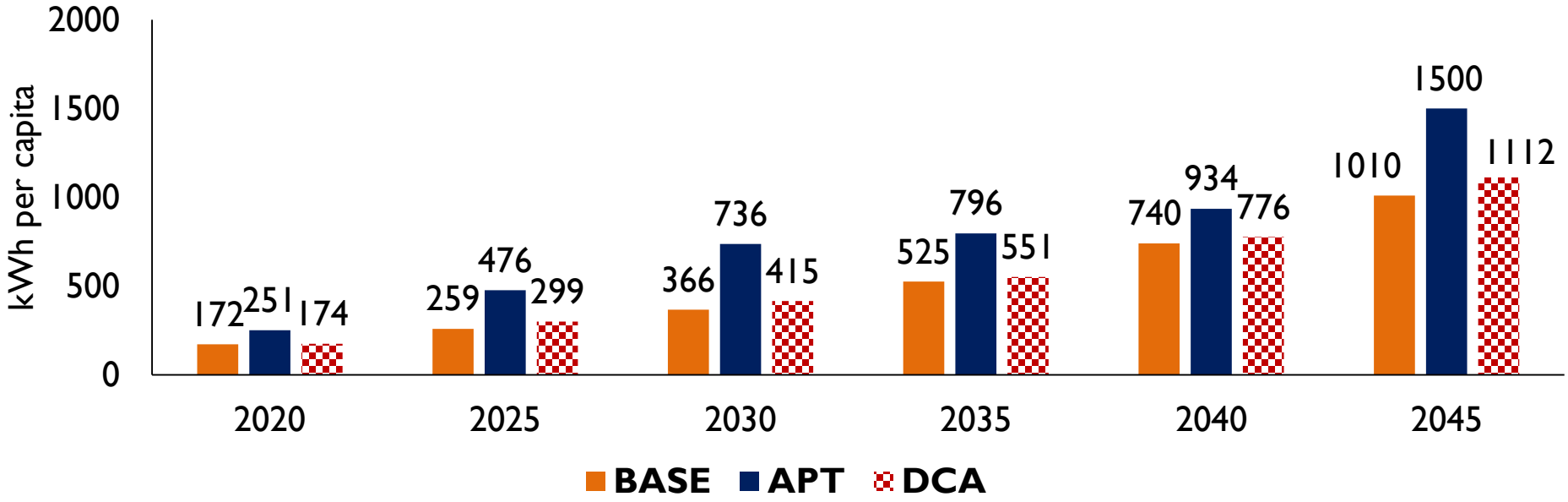


Selected Years Nepal's Imports/ Exports in APT



Developmental Impact on Per Capita Electricity Demand

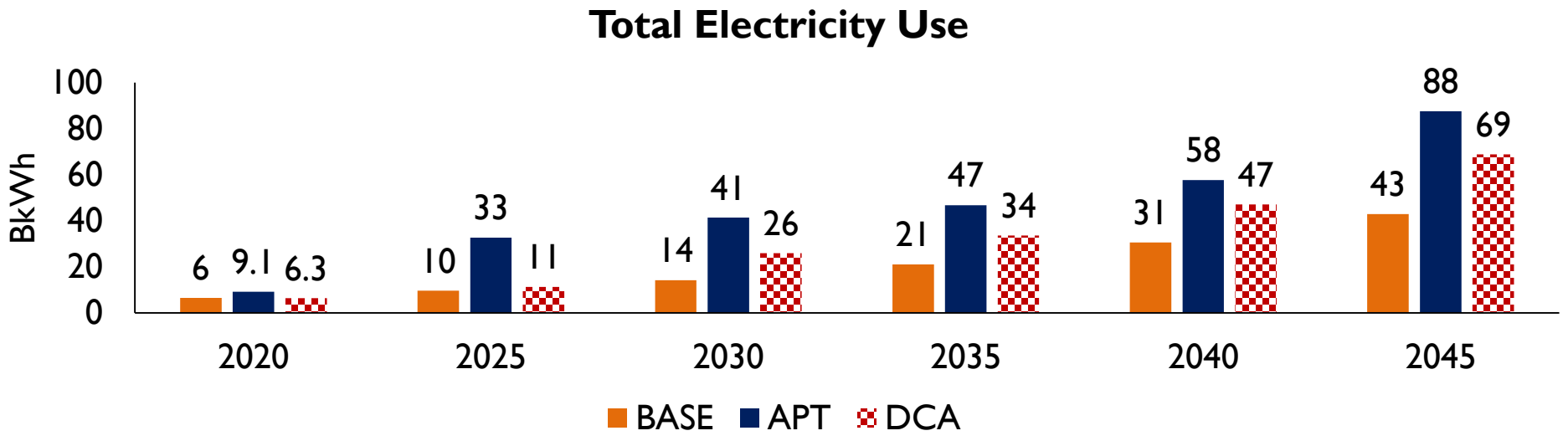
Change in Nepal's Per Capita Electricity Demand

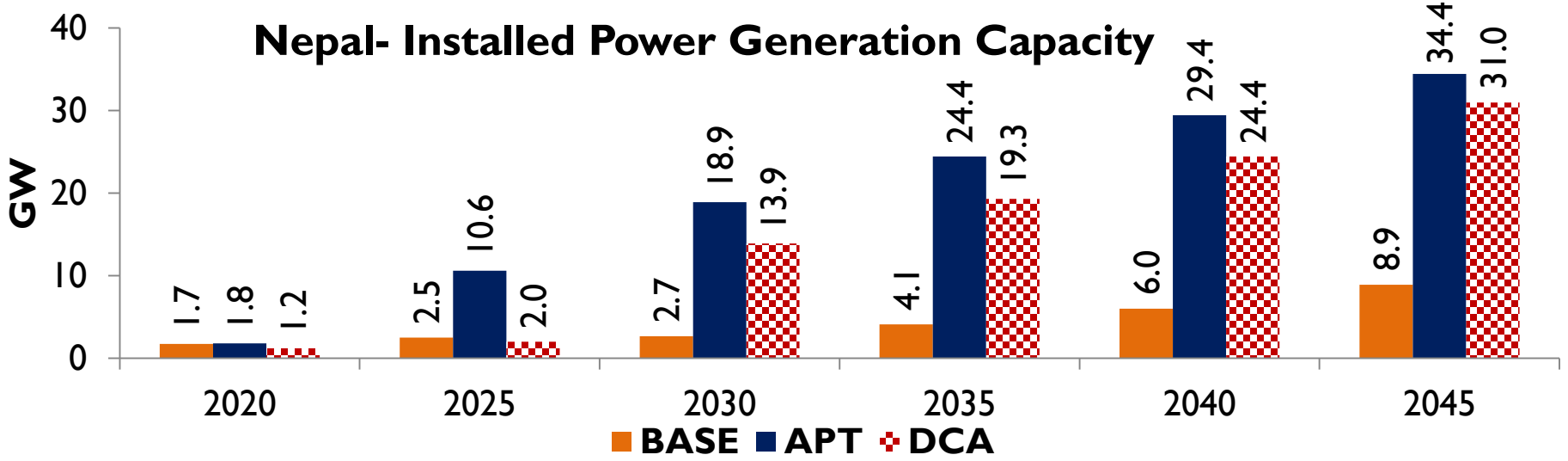


Gains over BASE in Per Capita Electricity Demand

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%

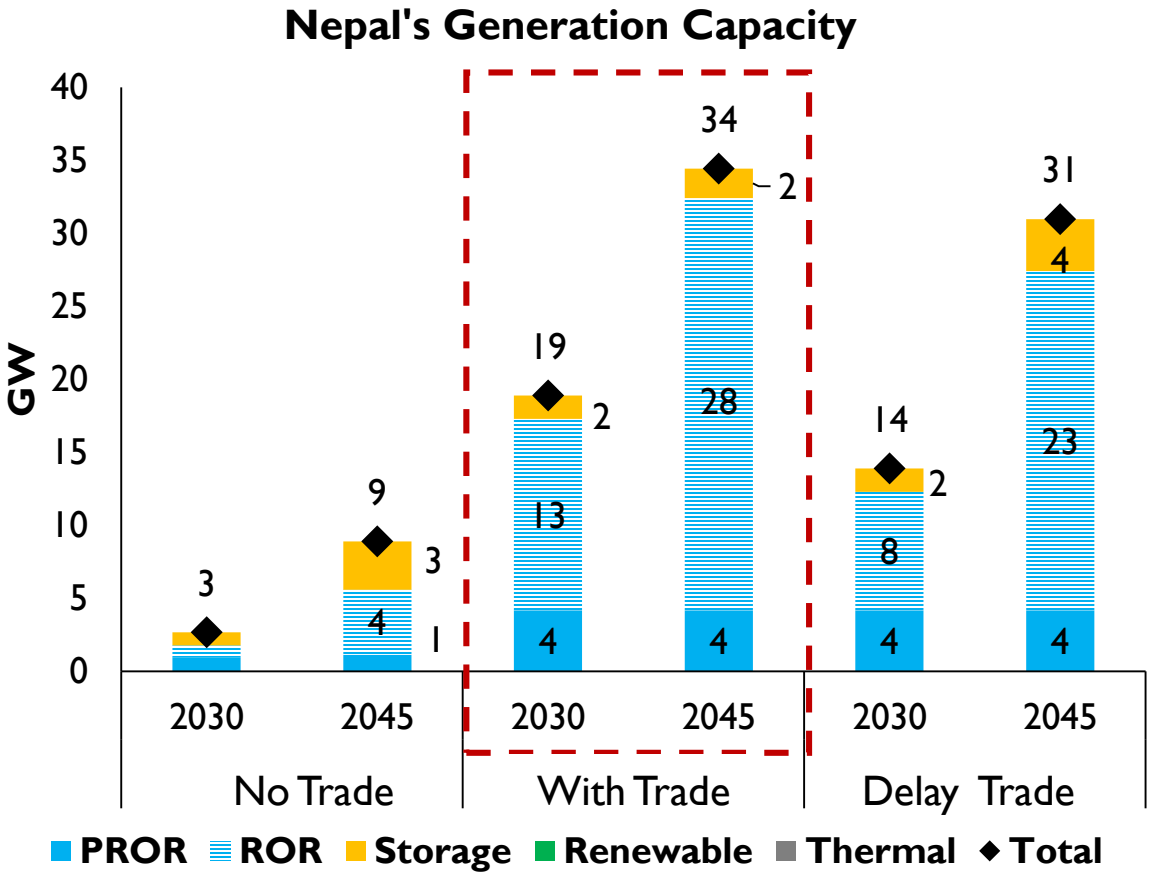
Developmental Impact on Total Electricity Use





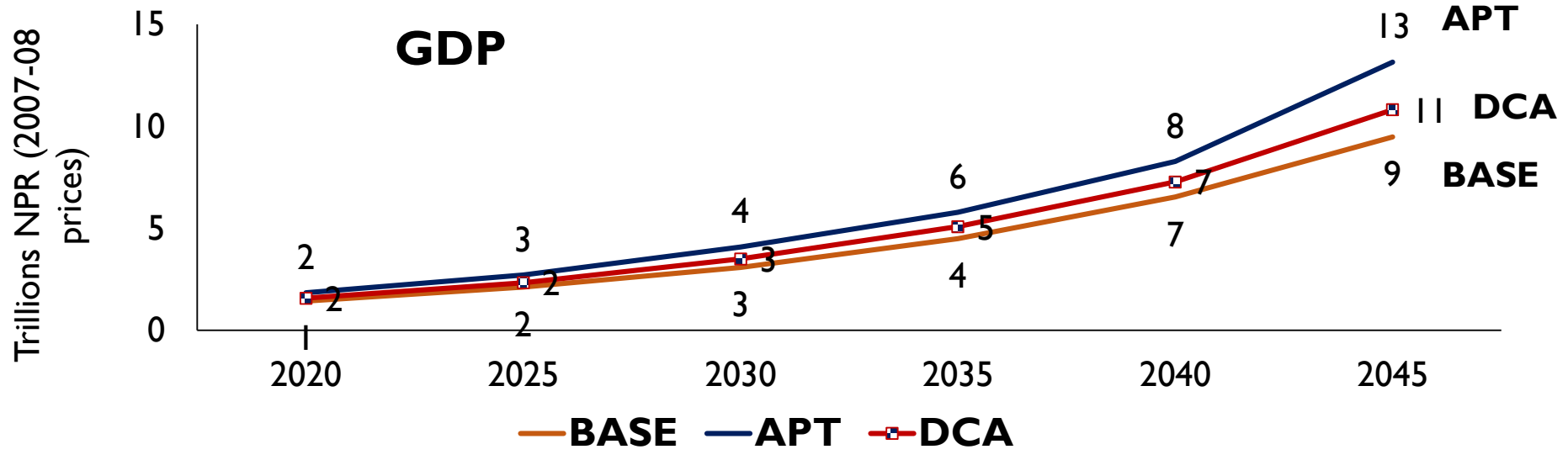
Bilateral Study: Benefits of India-Nepal Trade to Nepal

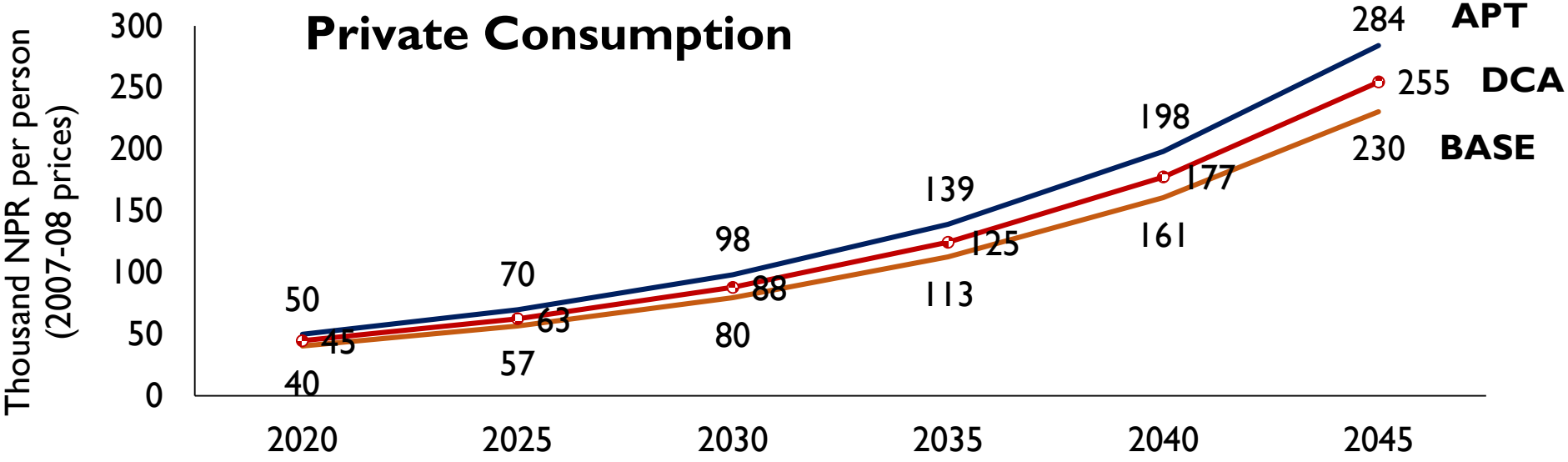
- Power cuts restricts growth. Initially Nepal imports and later exports
- Trade market develops Nepal's hydro potential sooner
- By 2045, with trade, 34.4 GW is exploited out of its total hydro potential of 43 GW compared to only 9 GW with out trade
- Even a delay of 5 years in Trade reduces the hydro potential exploited to 31 GW by 2045



- Without trade, Nepal needs to more on rely on storage plants to meet the seasonal variability
- With trade, the bulk of the capacities is from ROR plants which are cheaper and have less environmental consequences

Economy wide Impact



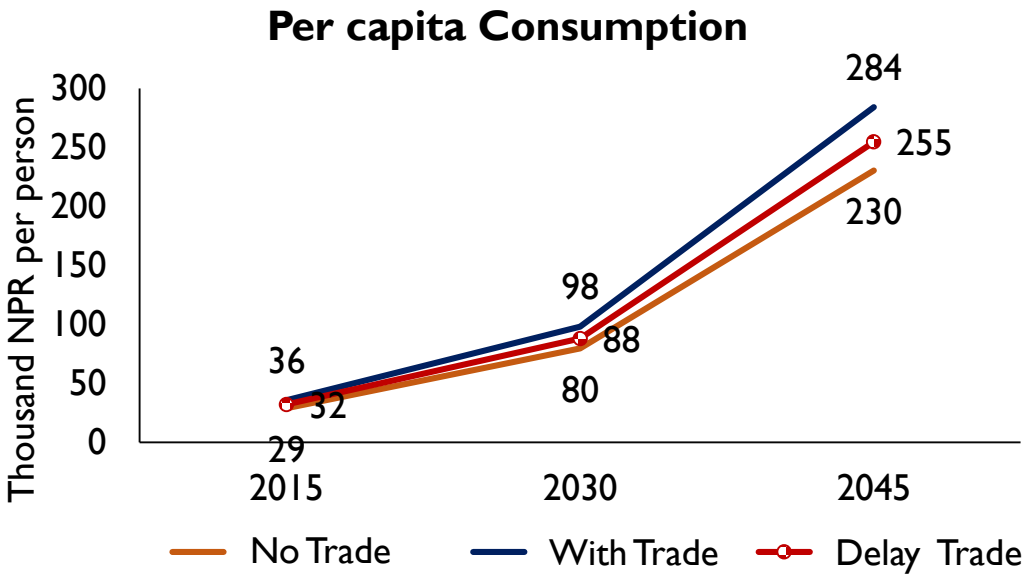


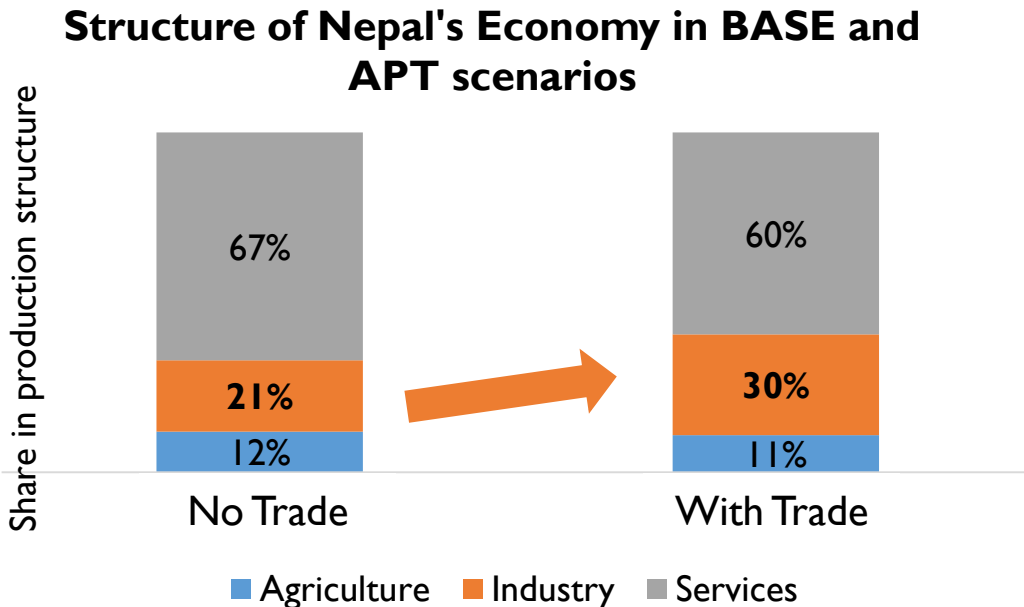
Gains over BASE in GDP at (2007-08 Constant Prices)

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%**

Bilateral Study: Benefits of Trade to Nepal

- With trade Nepal increases its GDP by 40% and per capita household consumption by 23% by 2045
- Even a 5 year delay in trade will result in GDP gain only by 14% and per capita consumption by 13%
- In addition, with trade share of industry sector in GDP increases to 30% compared to 21% in BASE
- In absolute terms, with 40 per cent higher GDP, industrial GDP will be twice as large as without trade





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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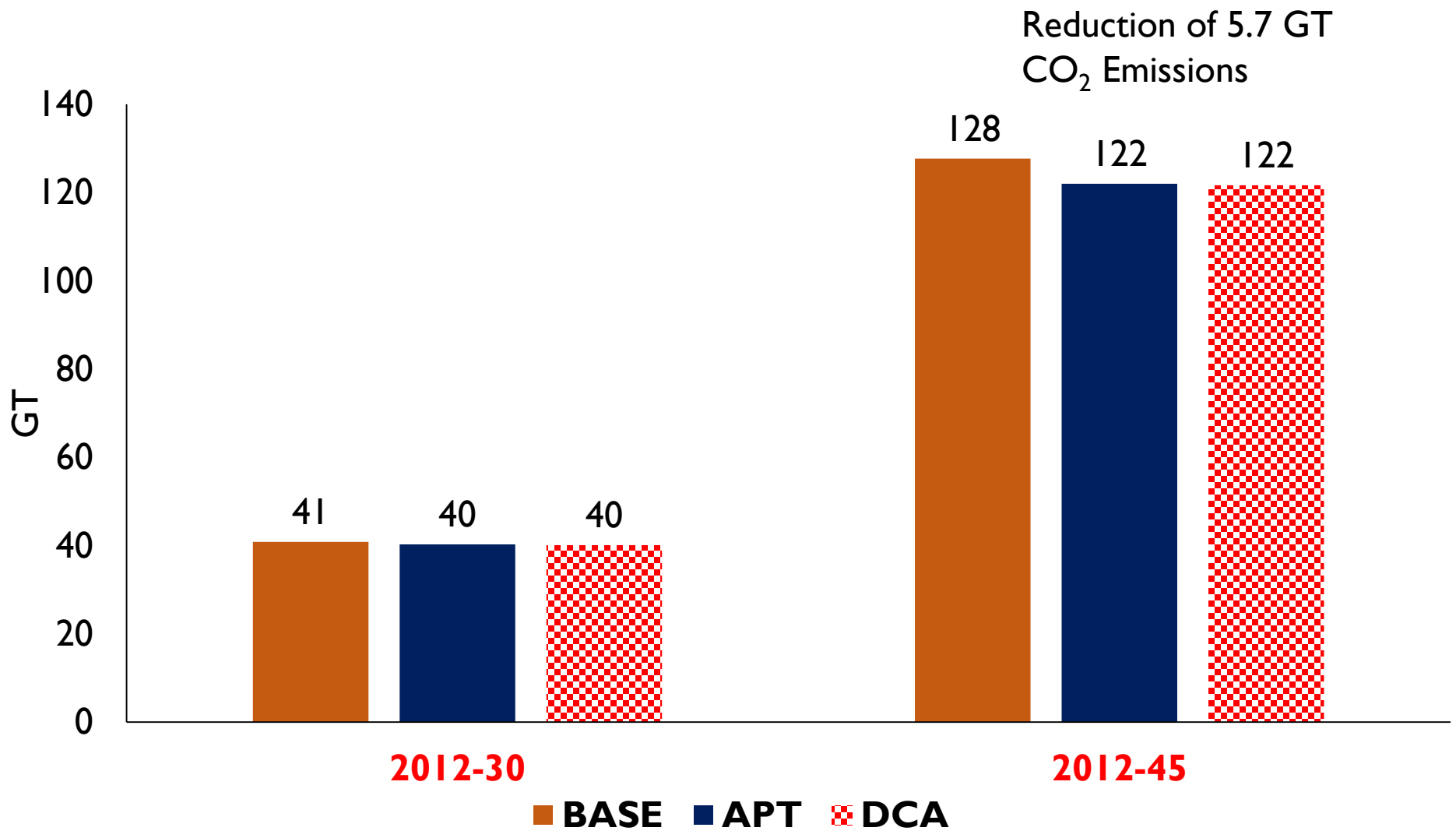
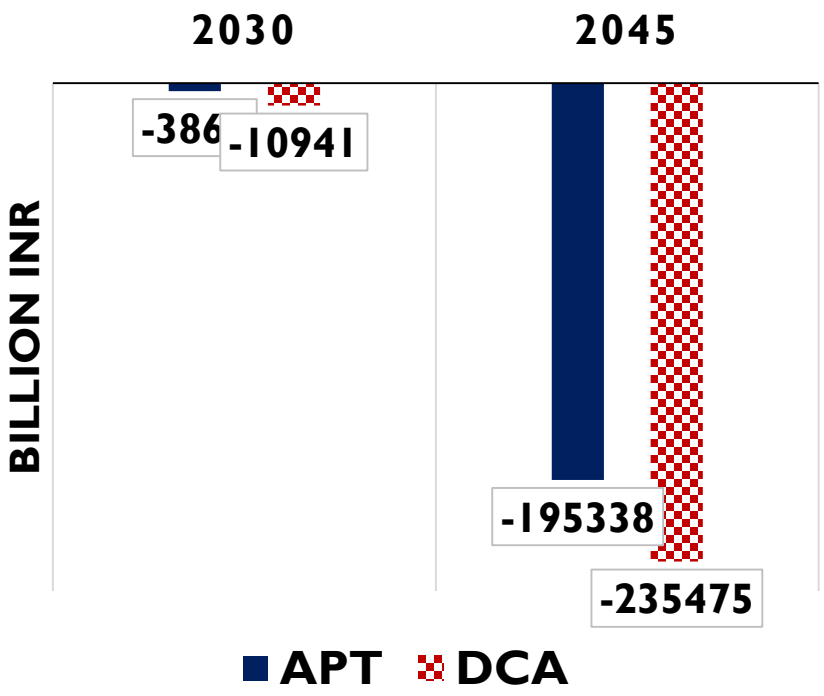
Impact of Electricity Trade on India

India's Cumulated CO2 Emissions- Economy Wide

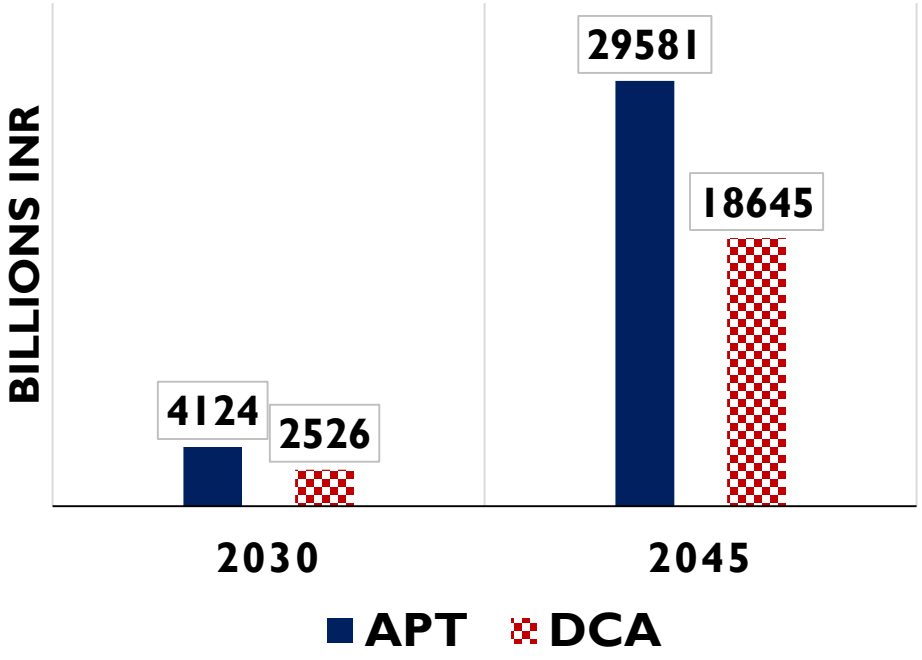


Economy wide Impact Compared to Base

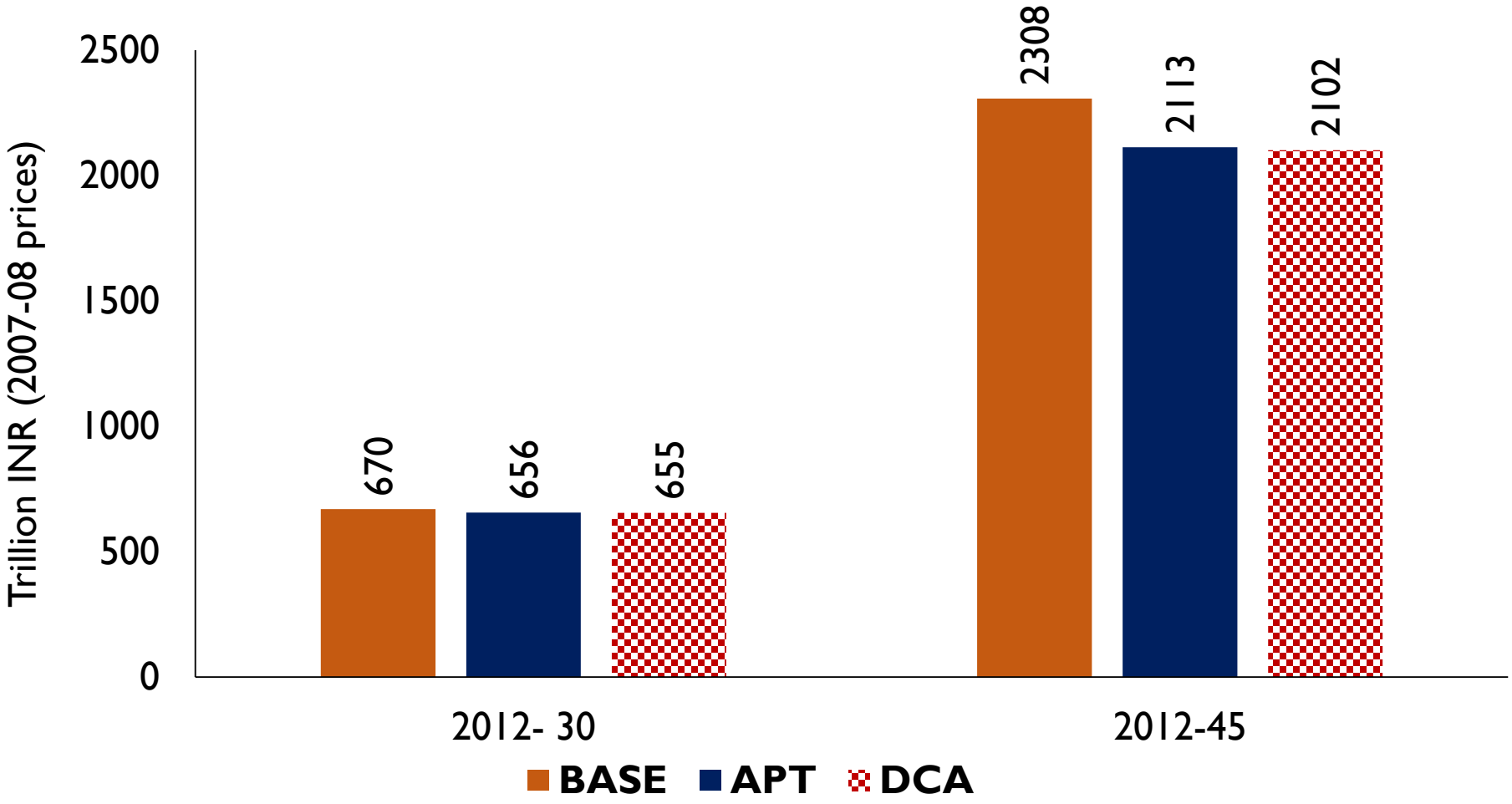
Cumulated 2012 - 2045 GDP Gains



Cumulated Consumption Gains



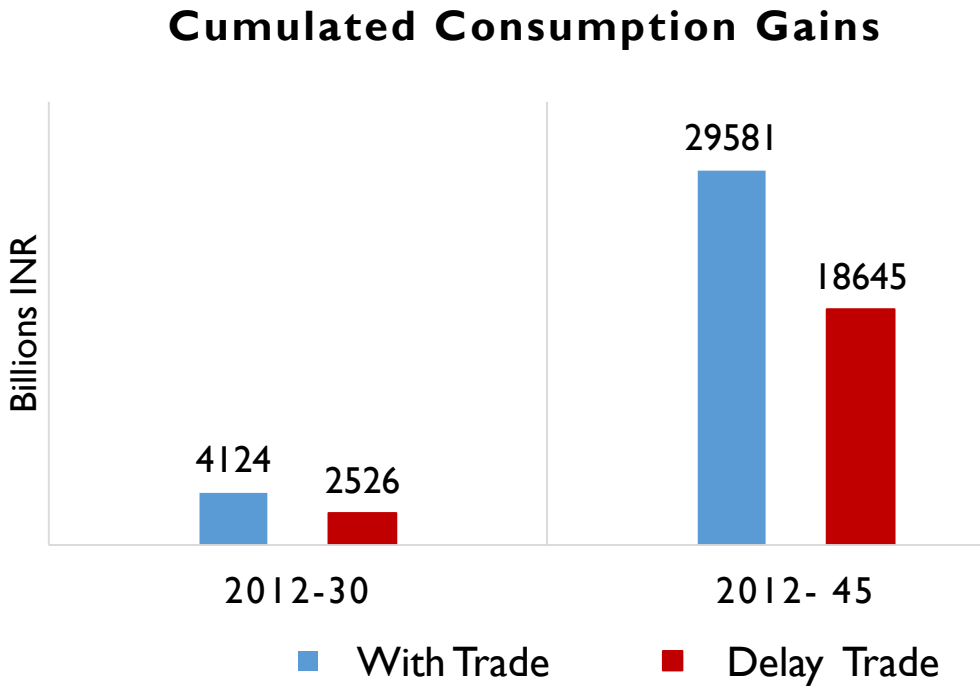
India's Cumulated 2012-2045 Total Investment in Economy



Bilateral Study: Benefits of Trade to India

IND- NEP Bilateral Study

- With imports from Nepal, generation, capacity creation and investment in the power sector are reduced
- Cumulated Investment cost over 2012-45 in Power sector decreases by 4% in 2045
- Imports reduces fossil fuel consumption in general
- CO2 emissions reduce by 572 Million tonnes in 2045
- Electricity supply cost is lower as imported electricity is cheaper than domestically produced one
- Trade with Nepal increases India's cumulated consumption by 1.43% in 2045
- Investment requirement in India's economy decreases by 8.6% due to lower capacity requirement
- Cumulated GDP decreases by 2.6% in 2045 due future capacity requirement savings and shift of resources from power sector to non power sectors and household consumption



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
- We are carrying out a similar study for India-Bangladesh trade
- We can extend it to multilateral trade – Nepal-Bhutan-Bangladesh-India
- And hopefully to BIMSTEC countries

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