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Low Carbon Development Scenarios for Nepal to Attain a 2°C Target

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Key Issues in This Study

- How much reduction in GHG emission would be required with 2 degree C target under SSP5?
- How would this compare with GHG emissions under the present NDC from energy using sectors?
- Implications for energy mix, investment requirement, energy security and local pollutant emissions?

Analysis using AIM/Enduse model of Nepal

Scenario Description

Three scenarios are considered:

1. BAU scenario: does not consider any climate change policy (e.g., GHG emission reduction targets and carbon tax); the technology and energy use follows the historical change pattern
2. BREF scenario: does not consider any climate change policy; shares of energy resources and technologies depends not limited to their historical levels.
3. 2 degree-SSP5 scenarios: Similar to BREF but considers carbon price profiles for Asia under SSP5 scenario from three different models: AIM-CGE ("AIMC"), GCAM4 ("GCAM") and REMIND-MAGPIE ("RMDM")

Socio-economic parameters in BAU

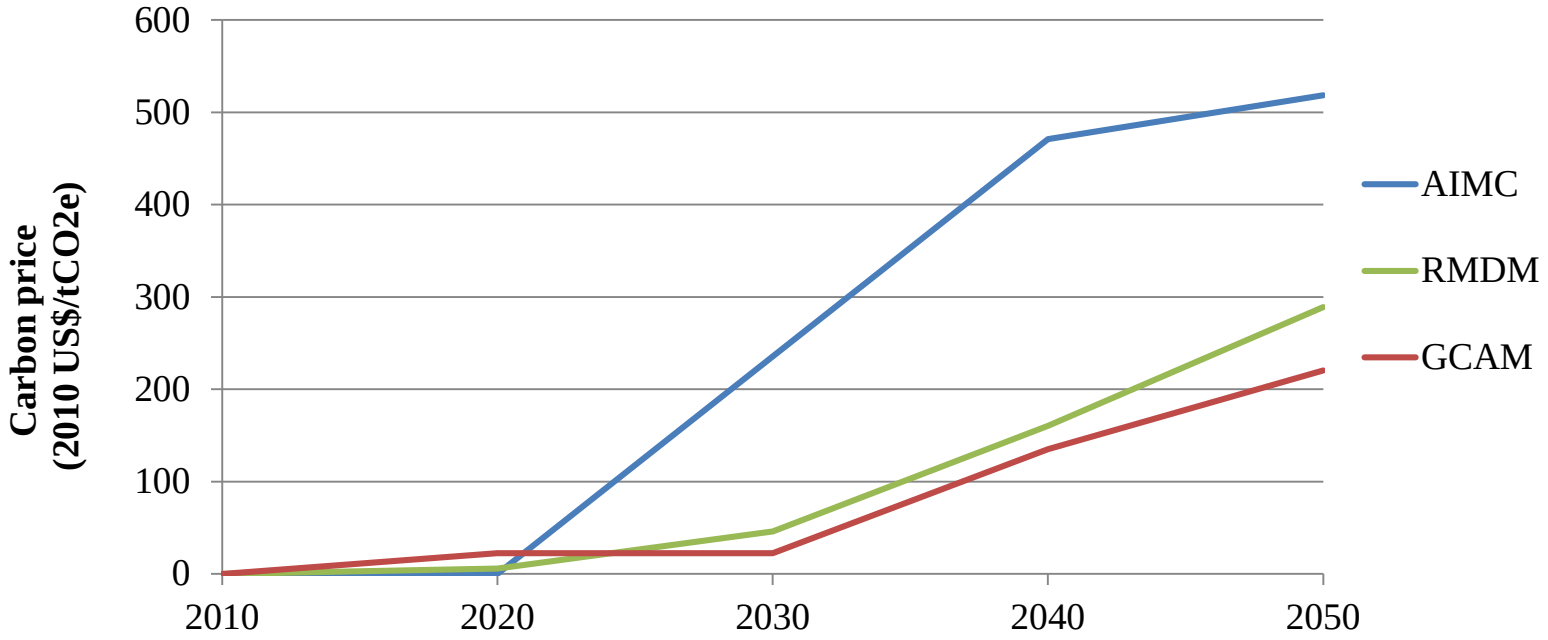
	2010	2020	2030	2040	2050
GDP (2010 USD)	18.9	30.8	51.1	96.0	181.0
GDP/capita (2010 USD/cap.)	723.0	1,014.2	1,511.6	2,646.8	4,793.2
Population (million)	26.1	30.4	33.8	36.3	37.8
Urban (million)	4.4	7.4	11.1	15.3	19.3
Rural (million)	21.7	23.0	22.7	21.0	18.4

Population, urban population and GDP growth rates are based on SSP5 scenario.

Socio-economic growth rates in SSP5

	2010-2020	2020-2030	2030-2040	2040-2050
GDP growth (%)	5.01	5.18	6.51	6.54
Population growth (%)	1.52	1.07	0.71	0.40
Urban population growth (%)	5.2	4.2	3.2	2.4

Carbon price in SSPS5 scenario for Asia



	2010	2020	2030	2040	2050
AIMC	0	0	235	471	518
RMDM	0	6	46	160	289
GCAM	0	22	22	135	220

Source: SSP Public Database Version 1.1. https://tntcat.iiasa.ac.at/SspDb

Cleaner options considered in different sectors

Transport Sector:

- Fuel cell vehicle
- Biofuel vehicle
- MRT
- Trolley bus
- Electric ropeway
- Electric rail

Industrial Sector:

- Efficient electric motor
- Vertical shaft brick kiln in brick industry
- Energy efficient boilers (coal, fuelwood and bagasse)
- CCS in cement industry

Residential and Commercial Sector:

- Electric stove
- Briquette stove
- Solar cooker
- LED display TV
- Energy efficient air conditioner/fa
- LED lamp

Agriculture Sector:

- Solar water pump
- Energy efficient electric pump
- Energy efficient diesel pump

*BECCS in power and industry sector has not been considered in this study

Energy and Environmental Implications

Cost-effective Mitigation Options in 2 degree Scenarios

Mitigation options in the Transport Sector:

- Biofuel vehicles (ethanol and biodiesel blend),
- **Flexi-fuel vehicles in AIMC**
- Electric cars in all three scenarios;
- **Electric buses in AIMC and RMDM**
- Gasoline hybrid vehicles (i.e., car and taxi)
- Diesel hybrid vehicles (i.e., Pickup)
- Diesel hybrid vehicles (i.e., Trucks)

Mitigation options in the Industrial Sector

- Electric motor (motive power)
- Improved fixed chimney brick kiln
- Energy efficient coal boiler
- Bagasse and Fuelwood boiler
- **CCS in cement industry (from 2025 in AIMC, 2037 in RMDM and 2039 from GCAM)**

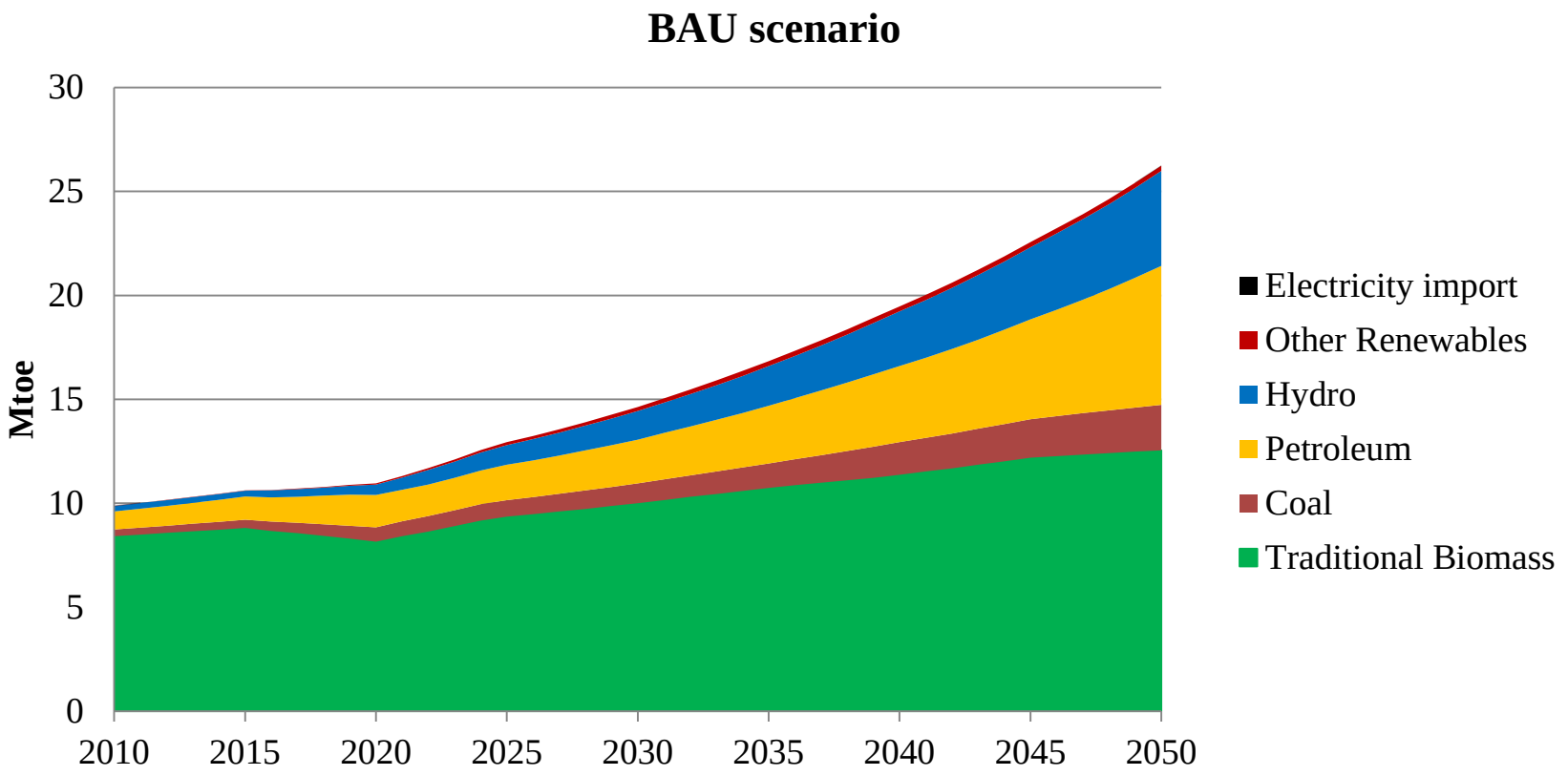
Mitigation options in the Residential and Commercial Sectors:

- Improved cook stoves
- Biogas cooking
- Electric cooking
- Solar water heater
- LED lamps in lighting

Mitigation options in Agriculture

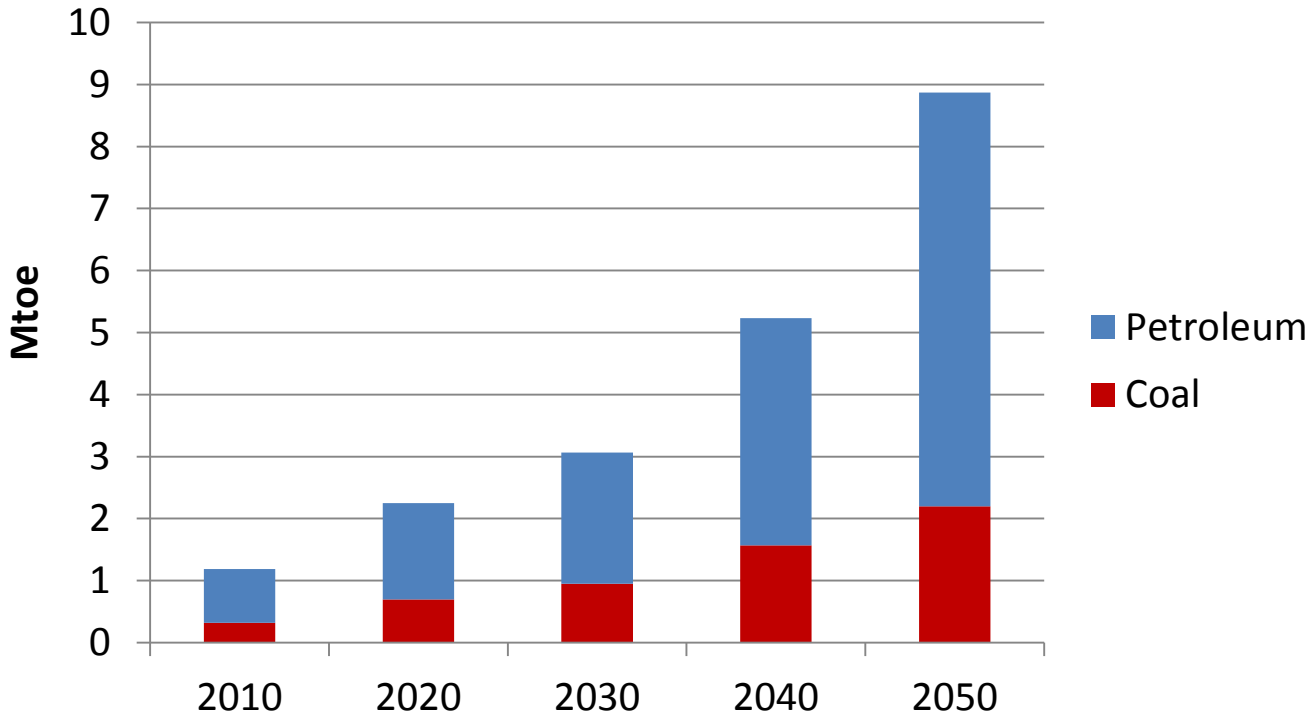
- Electric pumps
- **Solar pumping in AIMC and RMDM**

Declining Dominance of Traditional Biomass in TPES in BAU Scenario



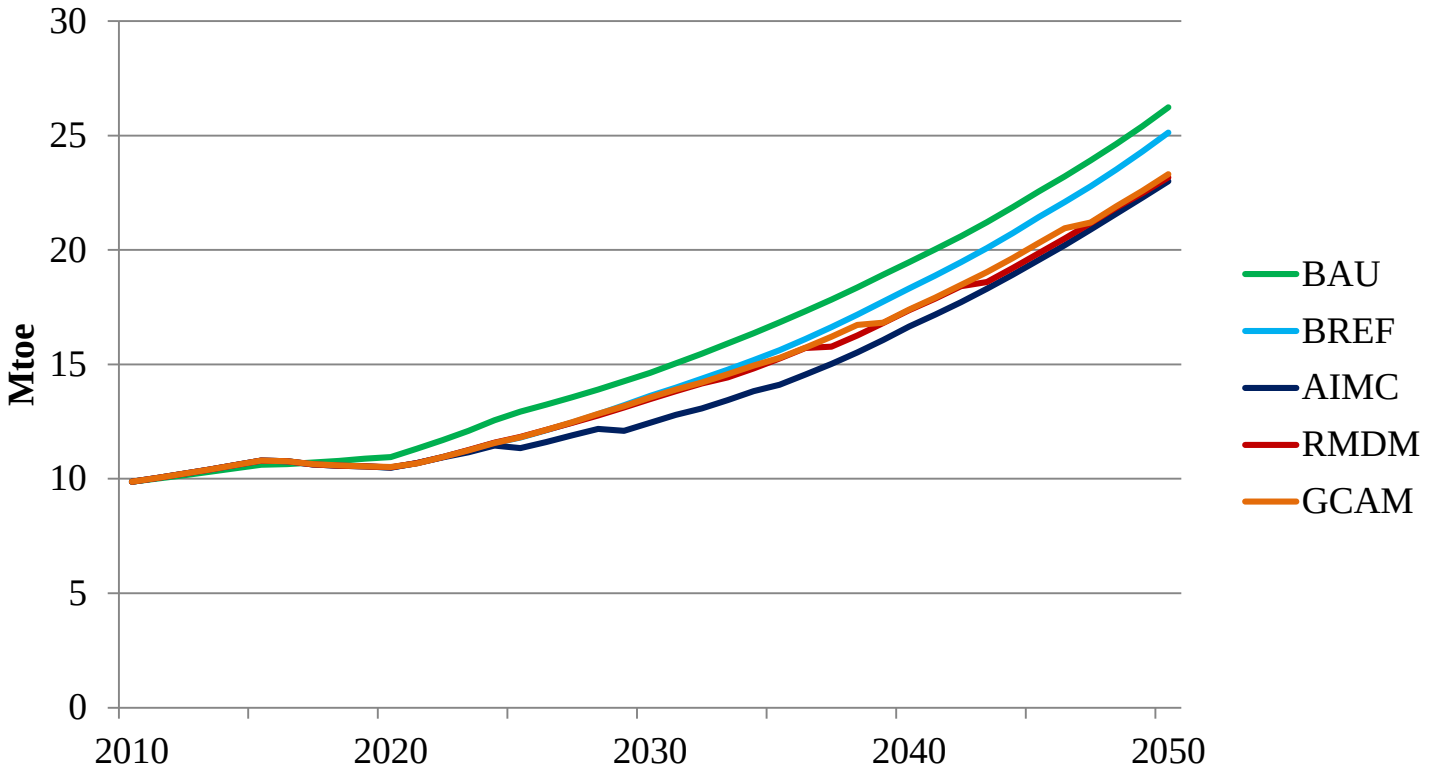
- Traditional biomass share decreases from 85% to 48% during 2010-2050
- Oil product share increases from 9% to 25%
- share of renewables (mainly hydropower) increases from 3% to 18%

Fossil fuel Consumption in BAU



- **Total fossil fuel (coal and petroleum) would increase at CAGR of 5.1%.**
- Coal consumption would increase at CAGR of 4.9% *(mainly cement industry, shift from clinker import to limestone based cement manufacturing)*
- Petroleum product consumption would **increase** at 5.2%

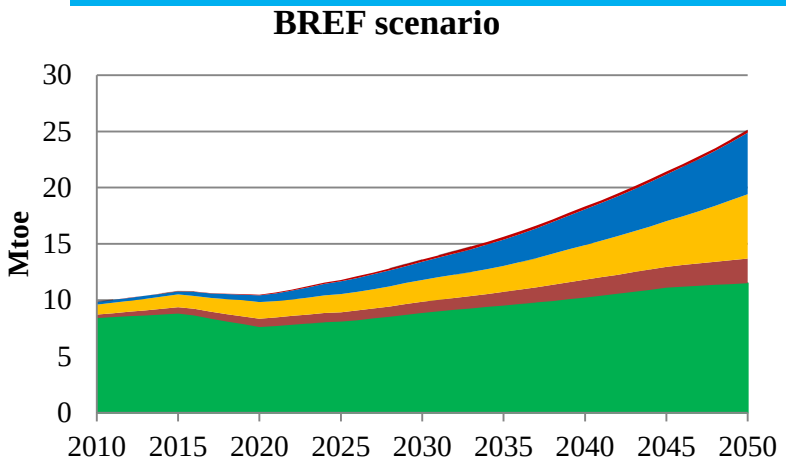
Total Primary Energy Supply in BAU and 2°C Scenarios

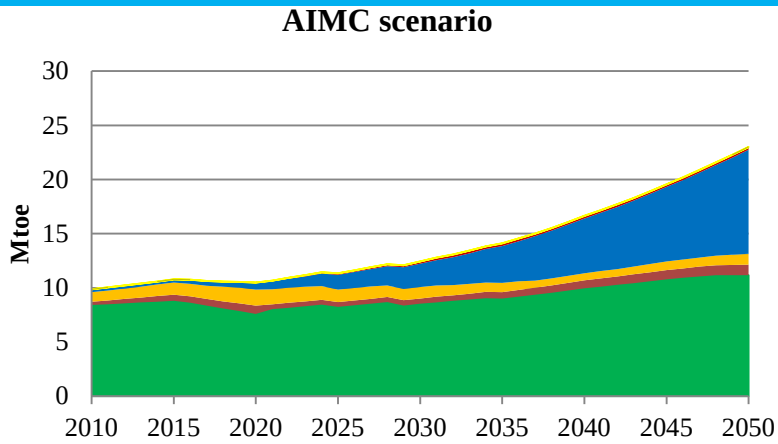


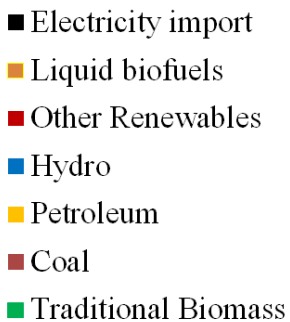
In 2050, TPES

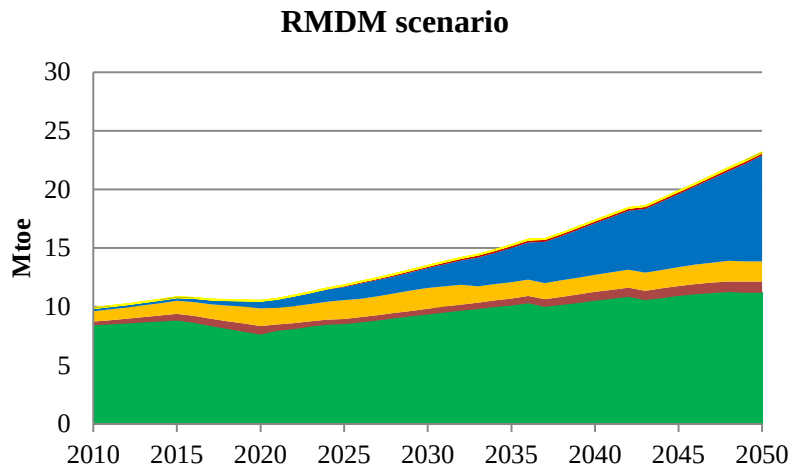
- In AIMC is 12.4 % below that in BAU
- 11.7% lower in RMDM and 11.2% lower in GCAM
- 4.3% lower in BREF

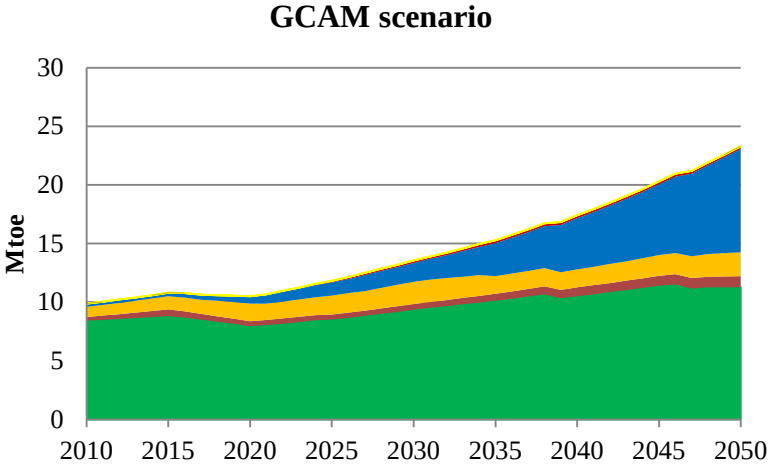
Lower total primary energy supply and higher share of hydropower in 2° C Scenarios











During 2010-2050 Cumulative TPES reduced by

- 11% in AIMC
- 8.3% in RMDM
- 7.8% in GCAM ; 5.1% in BREF

Primary Energy Supply during 2010-2050 under Different Scenarios

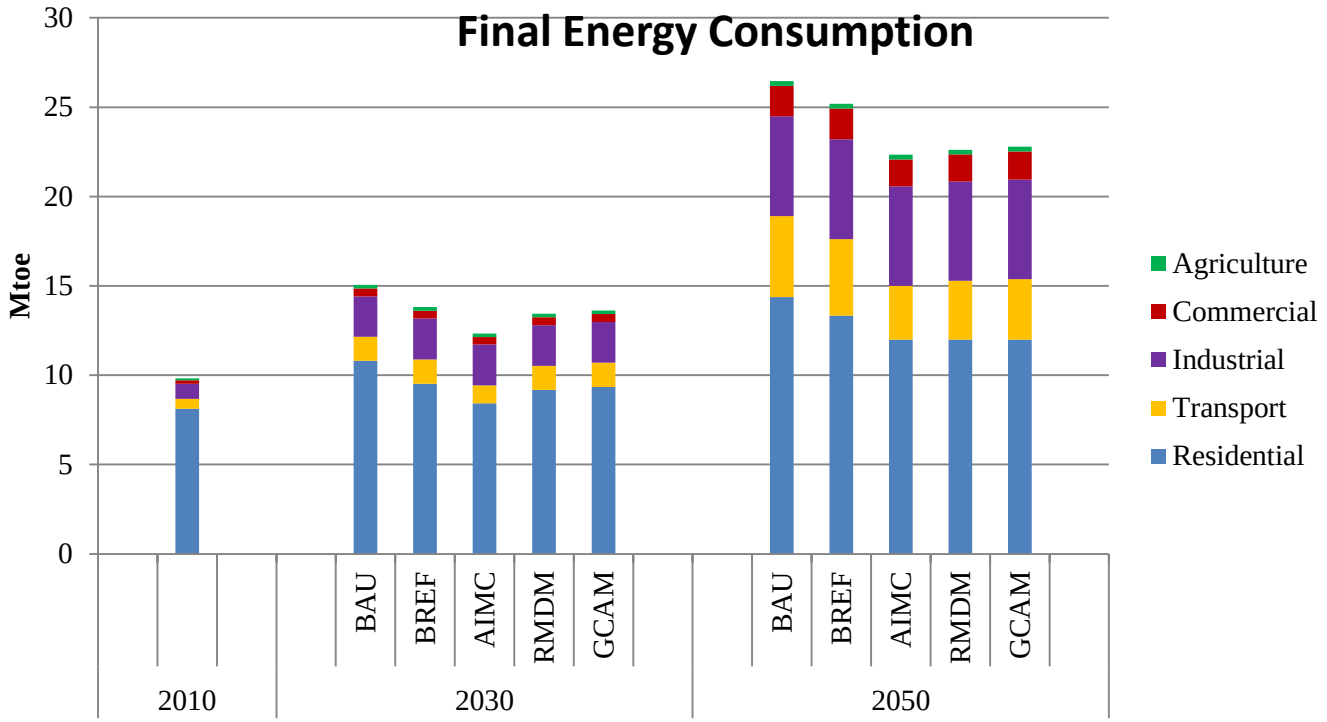
Compared to BAU:

- Cumulative use of traditional biomass during 2010-2050 to decrease by 5.6 % in GCAM to 9.6% in AIMC
- Cumulative fossil fuel supply during 2010-2050 to decrease by 43.4% in GCAM to 57.4% In AIMC,

- Cumulative use of RE (mainly from hydropower generation) to increase by 52.9% in GCAM to 75.2% in AIMC

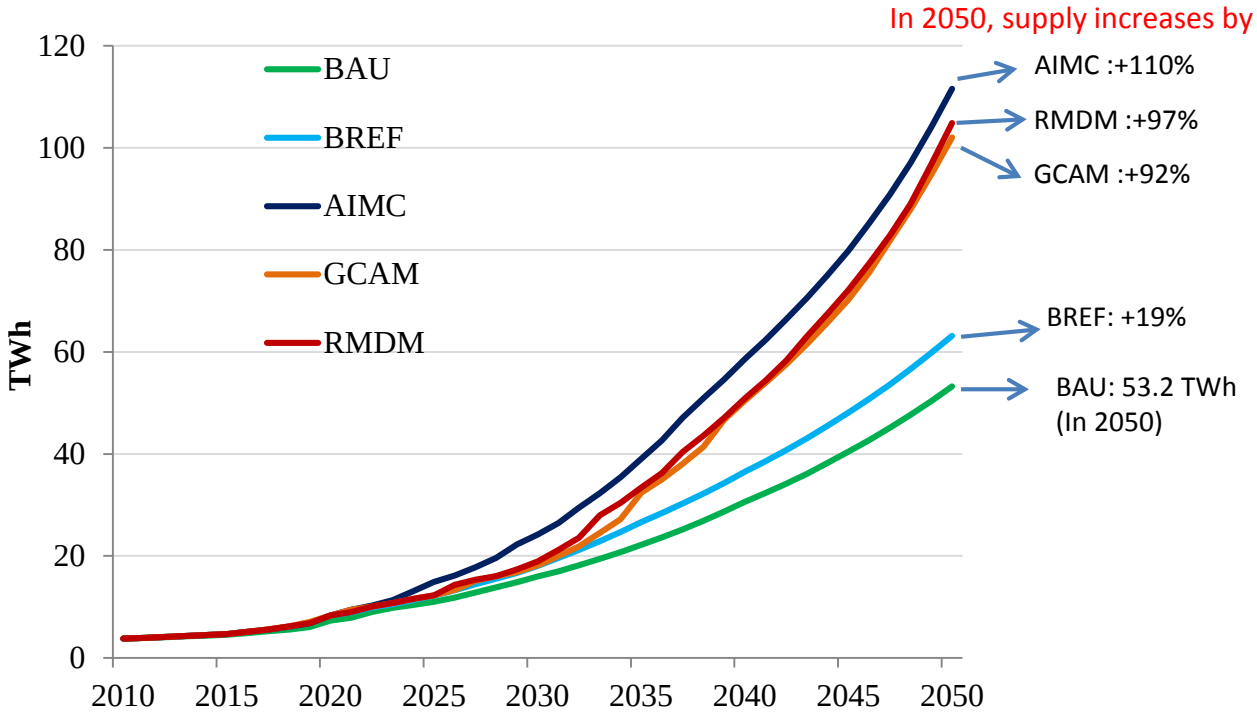
Fossil fuel consumption lowest under AIMC
and highest under GCAM among the 2 degree scenarios.
Highest increase in the use of RE (mainly hydro) under AIMC
(Highest reduction in biomass use under AIMC *since CH4 and NOx emissions from biomass is considered)*

Need for energy efficiency improvement in final energy use under 2°C scenarios



- Final energy consumption would be smaller in 2 degree cases (with largest reduction in AIMC) indicating improved energy efficiency in the endues sectors
- In 2030, FEC would decrease by (than in BAU)
  - 18.1% in AIMC, 10.7% in RMDM and 9.5% in GCAM; 8.3% in BREF
- In 2050, FEC would decrease by (than in BAU)
  - 15.6% in AIMC, 14.5% in RMDM and 13.9% in GCAM; 4.8% in BREF

Requirement for huge increase in electricity supply under 2 degree scenarios



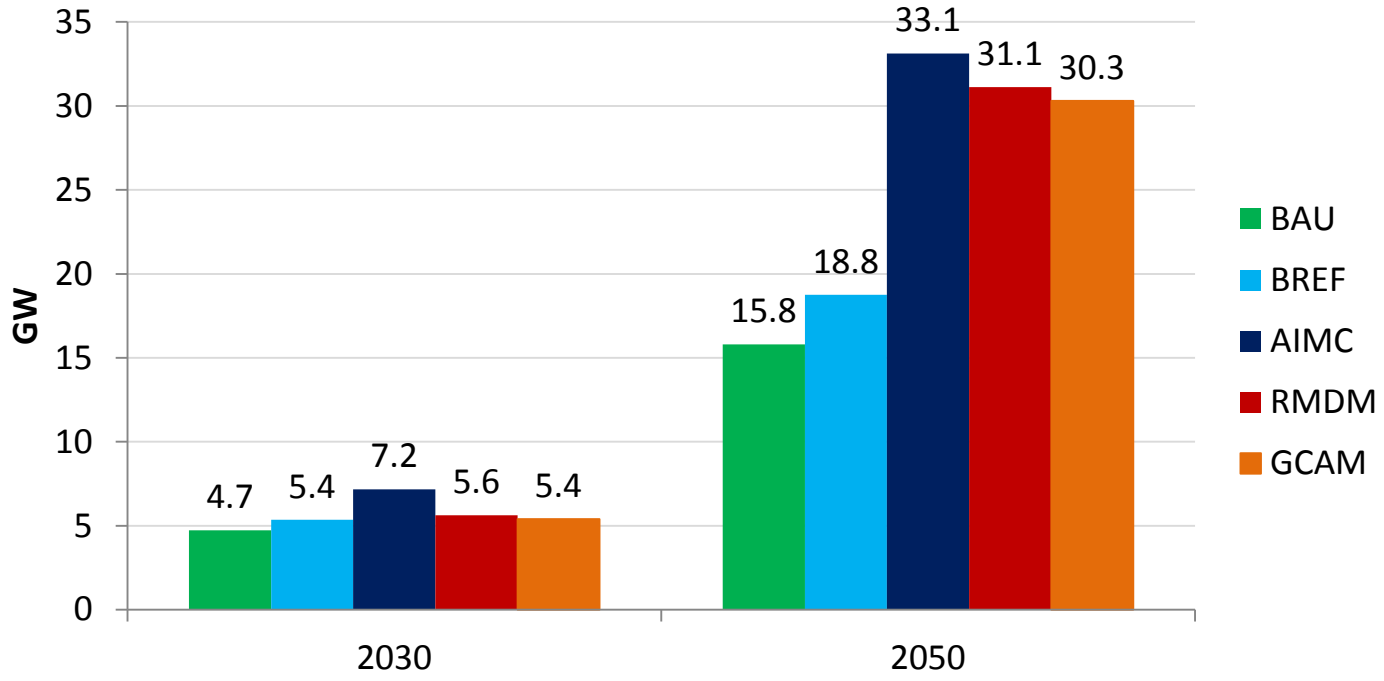
Electricity supply in the BAU in 2050 would increase by more than 13 times compared to 2010 level

Cumulative electricity supply during 2010-2050 in BAU: 825 TWh

Cumulative electricity supply during 2010-2050 would be

- 79% higher in AIMC (than that in BAU)
- 59% higher in RMDM and 55% higher in GCAM

Massive increase in power generation capacity required!



Compared to BAU,, installed generation capacity in 2030 needs to increase by

- 14% in GCAM to 51% in AIMC

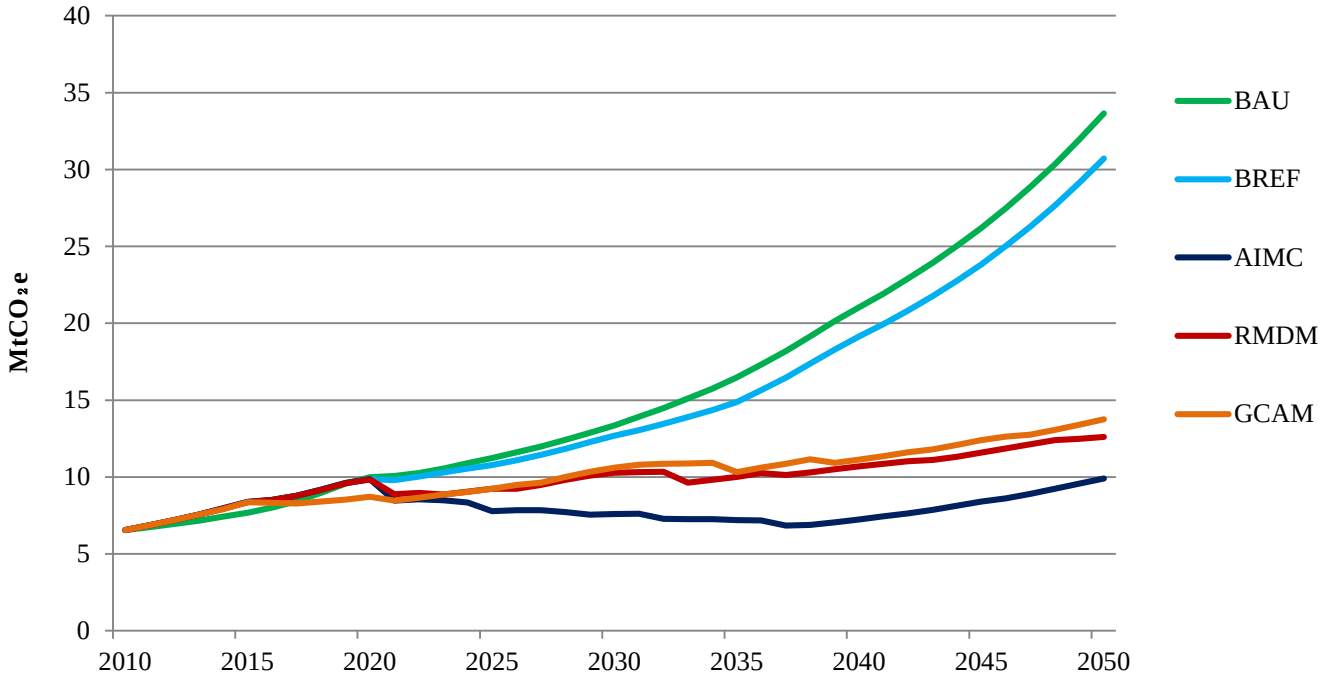
In 2050, installed capacity needs to increase by

- 92% in GCAM to 110% in AIMC

*Assuming capacity factor of 50% and additional power required to support peak load is 30%

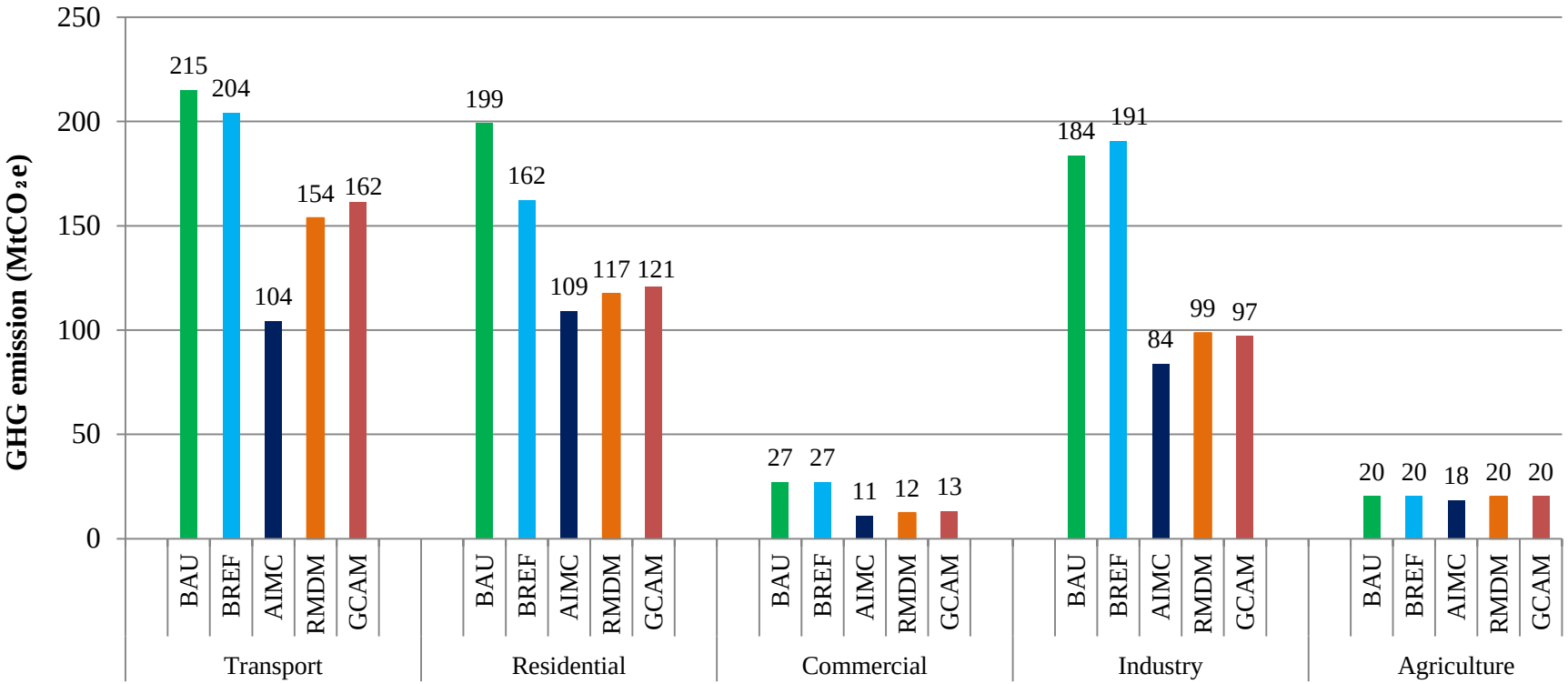
GHG implications

GHG emission from energy use in different scenarios



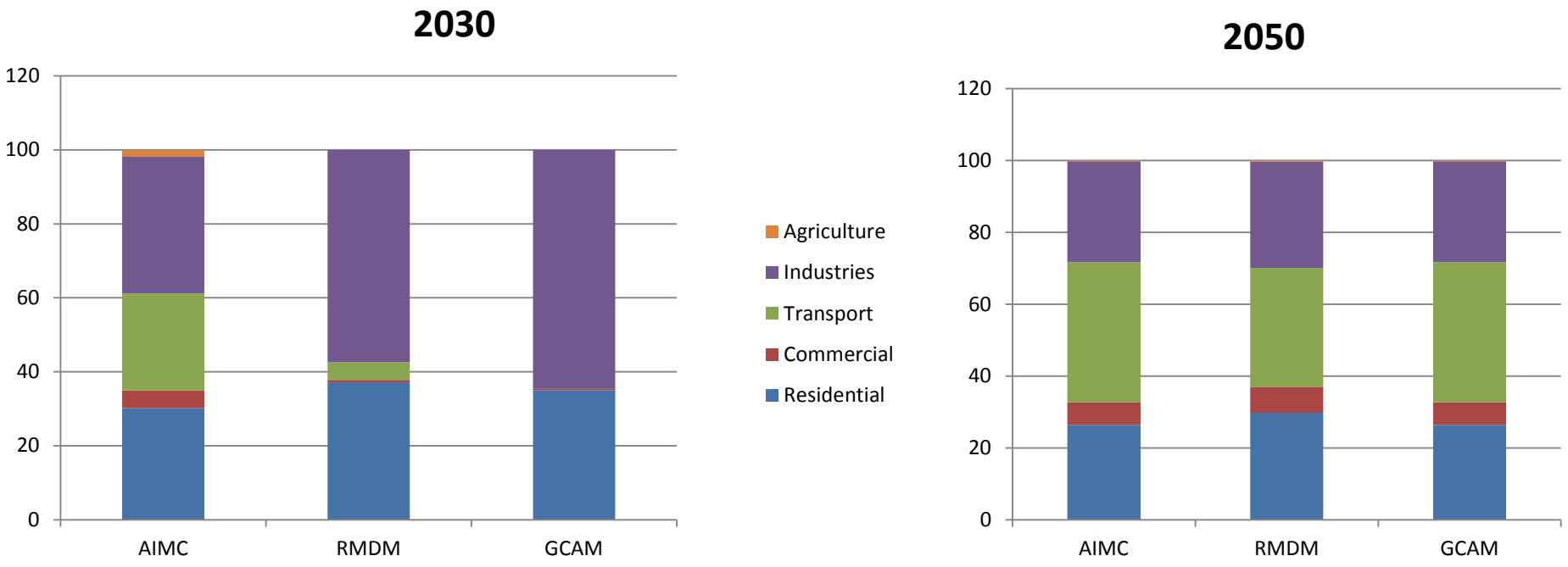
- In 2050 GHG emission in BAU would be 5 times of the emission level in 2010.
- In 2050, the emission would 70.6% less in AIMC, 62.5% less in RMDM and 59.2% less in GCAM
- Cumulative GHG emissions during 2010-2050 would be 647 MtCO2e in the BAU
- Cumulative GHG emissions would be 6% less in BREF, 49% less in AIM-CGE, 38% less in RMDM and 36% less in GCAM than that in the BAU

Sectoral Cumulative GHG Emissions during 2010-2050



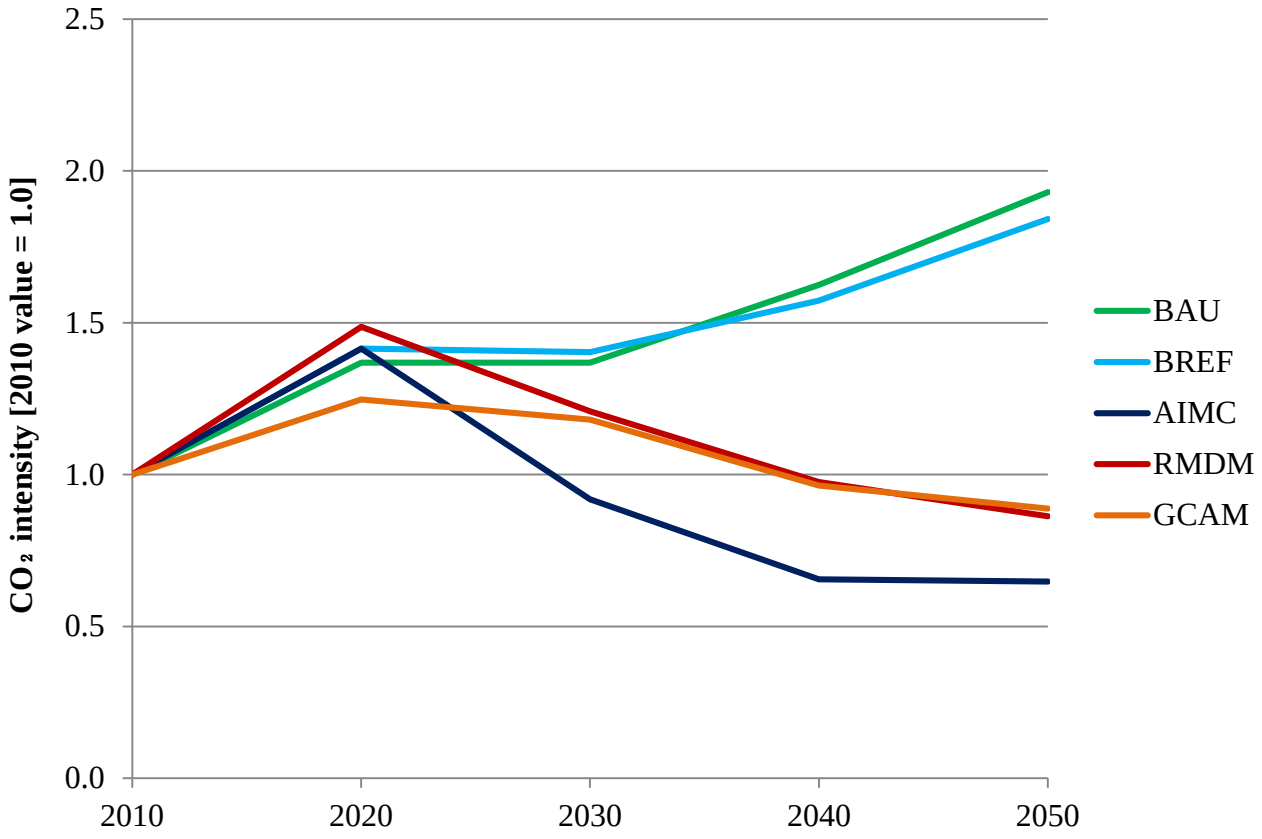
- Largest reduction in GHG emission from the industry sector
- **Compared to the BAU, cumulative GHG emission during 2010-2050 would decrease :**
  - in Transport sector: by 25% in GCAM to 51% in AIMC ;
  - in Industry sector: by 47% in GCAM to 54% in AIMC;
  - in Residential sector: by 39% in GCAM to 45% in AIMC;
  - in Commercial Sector: by 52% in GCAM to 59% in AIMC;
  - in Agriculture Sector: by 0.8% in RMDM to 9% in AIMC.

Sectoral contributions to total GHG reduction in 2030 and 2050, %



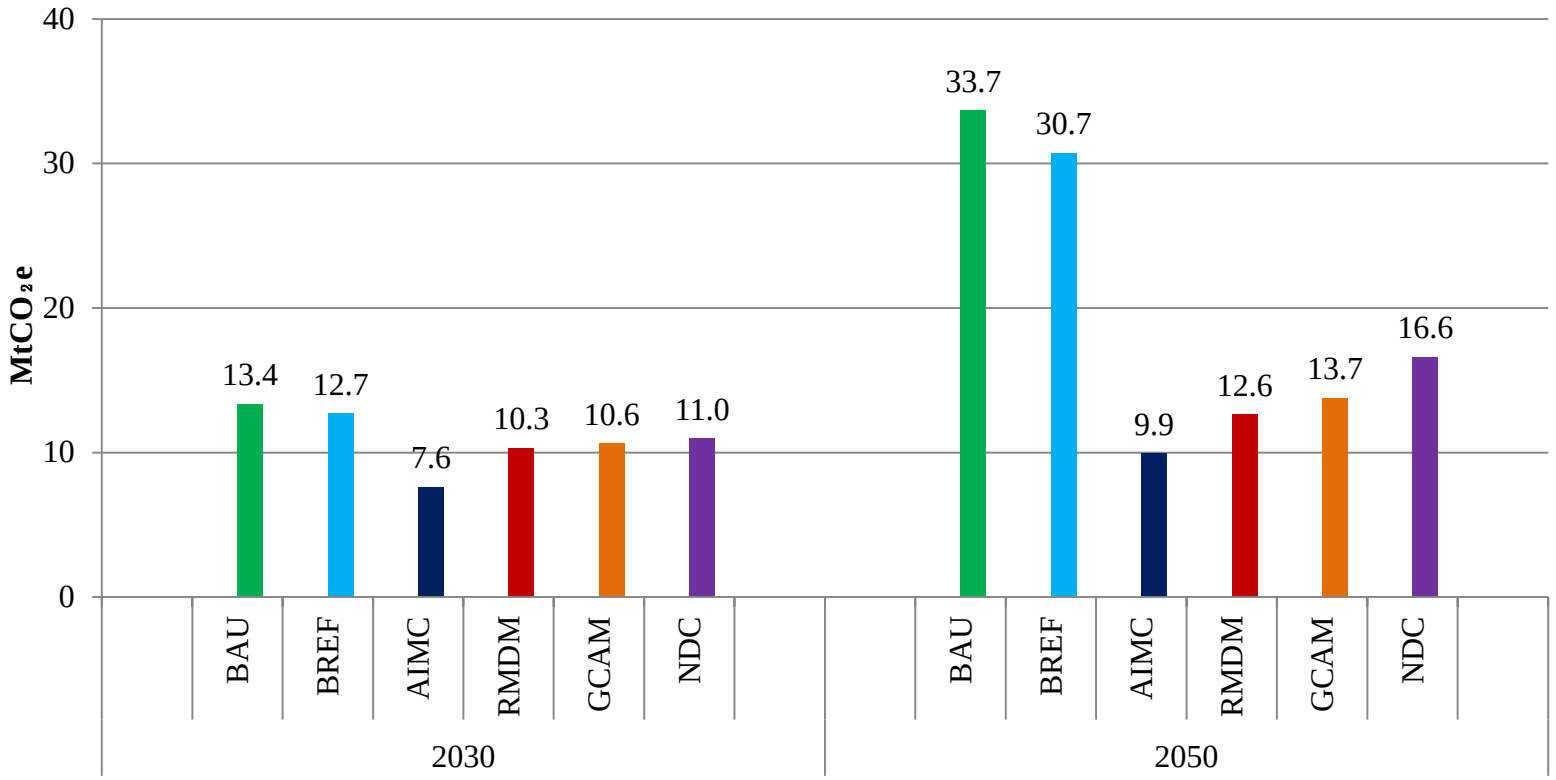
- In 2030: GHG reduction mostly from industry and residential sectors at the lower tax scenarios (GCAM and RMDM),
- In 2050: largest reduction from the transport sector in all three tax scenarios

Overall CO_2 Intensity



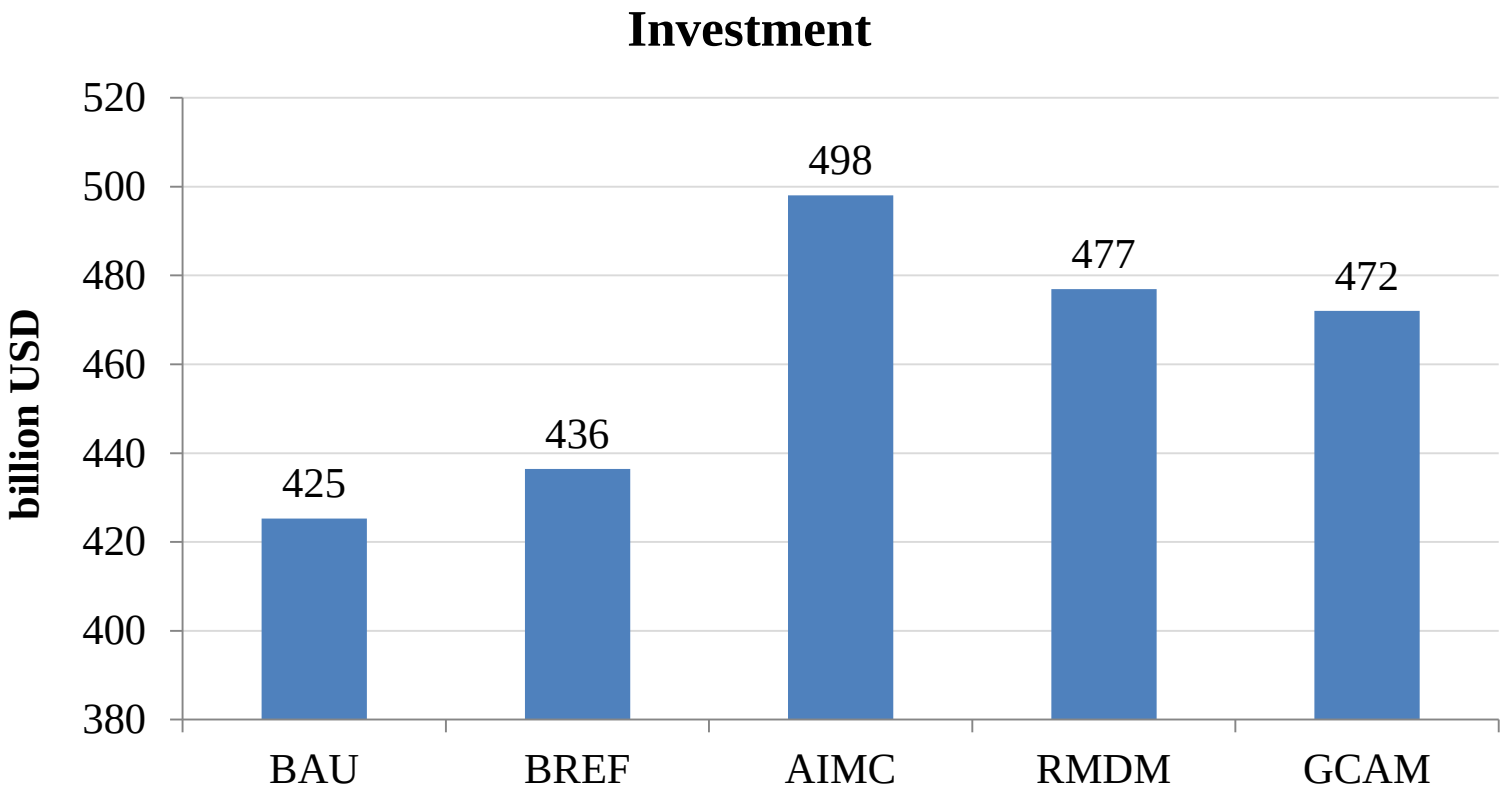
- In the BAU, by 2050 CO2 intensity would be increased by 90% compared to the 2010 level.
- By 2050, CO2 intensity would have to be reduced by 68%, 58% and 54% in AIMC, RMDM and GCAM scenarios respectively compared to the intensity under BAU.
- Up to 35% reduction in the CO2 intensity would be required during 2010-2050.

How good are present NDCs to meet the 2^{o} target?



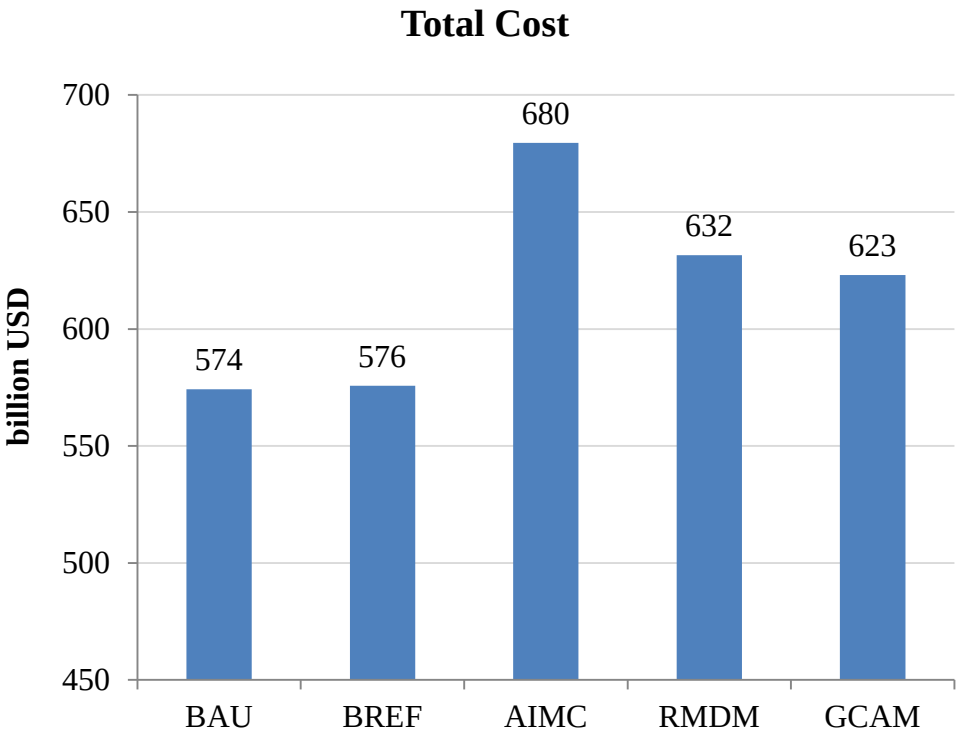
- In 2050, in GHG emission in high NDC scenario would be
  - 68% higher than emission level in AIMC
  - 31% higher than that in RMDM
  - 21% higher than that in GCAM

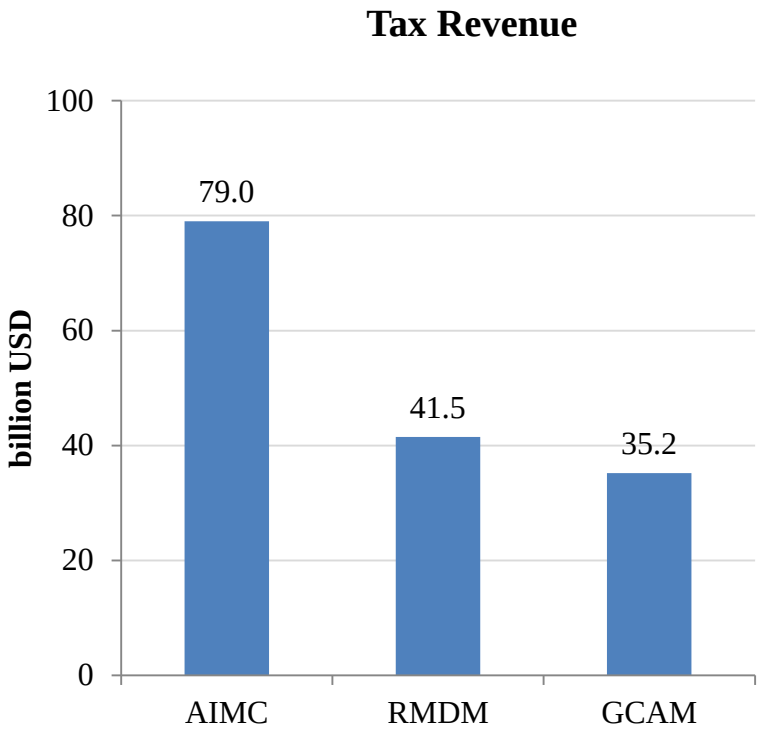
Total investment requirement during 2010-2050



- Total investment requirement would increase by 11% in GCAM to 17% in AIMC; 3% in BREF.

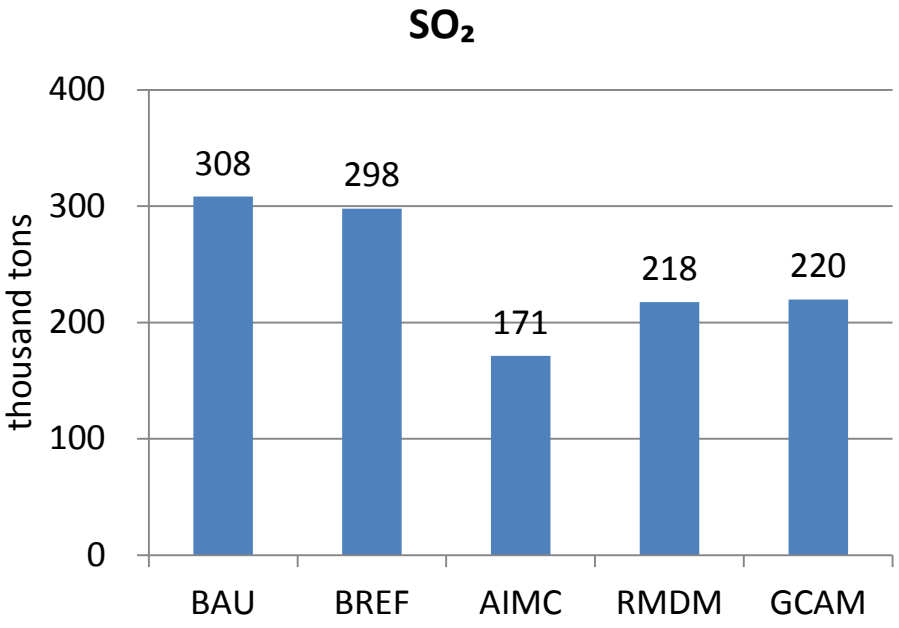
Total cost and tax revenue during 2010-2050

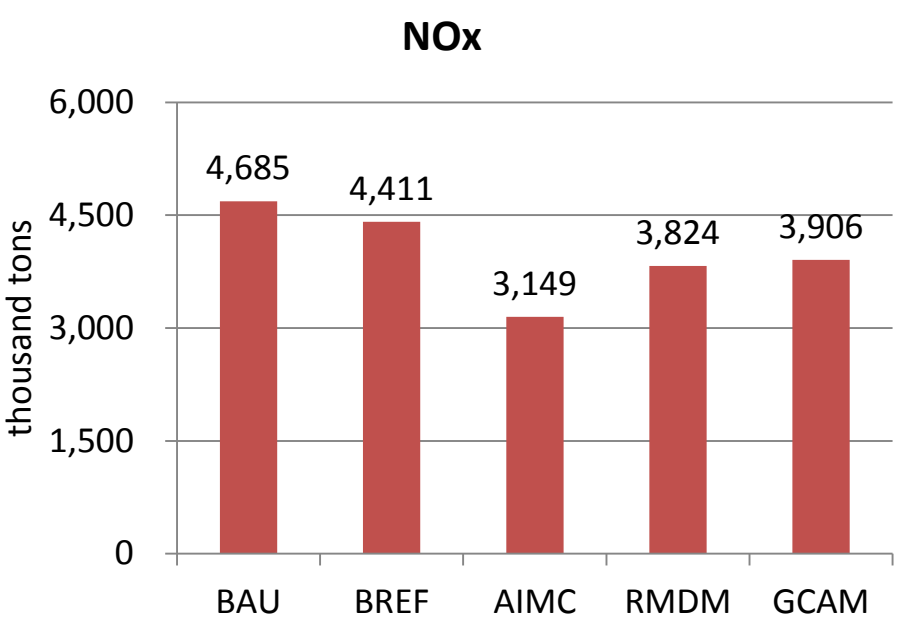




- Total cost would increase by 8% in GCAM to 18% in AIMC scenarios
- Total tax revenue as % of total cost varies from 11.6% in GCAM to 12.6% in AIMC scenarios.

Cumulative SO_2 and NOx emissions





- Compared to BAU, SO_2 emissions (cumulative during 2010-2050) would decrease by
  - 29% in both RMDM and GCAM to 44% in AIMC; 3% in BREF
- NOx emissions (cumulative 2010-2050) would decrease by
  - 17% in GCAM to 33% in AIMC; 6% in BREF

Energy Security

Shannon Weiner Index (SWI)					
	BAU	BREF	AIMC	RMDM	GCAM
2010	0.6				
2030	1.1	0.6	1.0	1.0	1.0
2050	1.4	1.4	1.1	1.1	1.1

Net Energy Import Dependency (NEID), %					
	BAU	BREF	AIMC	RMDM	GCAM
2010	12.0				
2030	20.9	21.5	12.4	16.7	17.5
2050	33.8	31.5	8.6	11.6	12.9

- Reduced dependency in imported energy; but more concentration on hydropower (and reduced diversification of energy resources!)
- NEID would decrease from 32.6% in BAU to 8.6% in AIMC, 11.6% in RMDM and 12.9% in GCAM in 2050.

Summary of Key findings

- Large shift to hydropower based electrification required to meet the 2 degree target.
- Electricity generation capacity under the 2 degree cases would be about twice as high as the capacity in BAU.
- Biomass share in TPES would be reduced under the 2 degree tax scenarios and increased role of electricity.
- Total cost during 2010-2050 under the three 2 degree tax scenarios would be 8 to18% higher than that in BAU case.
- Total investment requirement would be 11 to 17% higher than that in the BAU scenario.
- GHG emission intensity by 2050 would have to be reduced by up to 35% from the 2010 level.
- Present energy related NDCs are largely inadequate to meet GHG emission reduction requirement to meet even 2 degree target (not to mention the 1.5 degree target)
- The GHG emissions under energy related NDCs are 21% to 68% higher than the total allowable emissions under the three 2 degree scenarios considered.

  => Need for larger interventions

Thank You!!

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