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Bridging the gap between NDCs & Paris Ambition:
equitable finance for pathways well below 2°C
(Work in progress, please don't cite)

James Glynn, Socrates Kypreos, Maurizio Gargiulo, Brian Ó Gallachóir

Tokyo, JAPAN | 14th December 2016

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Research Context

- We normally focus on **least cost** optimised solutions for a future **decarbonised** energy system.
- How do we account for **equity and fairness** for deep decarbonisation of the global energy system in the post Paris Agreement era?
- In this paper we focus on a least cost energy system solution and **capital transfers based on equitable effort sharing rules** to quantify the range of finance required under the Paris agreement, and assess whether $100bn/yr is appropriate.

Post Paris Policy Context –COP21

Highlight figures.

- CP21, Article 2.1.a Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit temperature increase to 1.5 °C would significantly reduce risks and impacts of climate change.
- Article 4.2 Each party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.
- Article 4.3 Each Party's successive nationally determined contribution will represent a progression beyond the party's then current nationally determined contributions and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities in the light of different national circumstances.

Post Paris Policy Context –COP21

Climate Finance

- Also decides that, in accordance with Article 9, paragraph 3, of the agreement developed countries intend to continue their existing collective mobilisation goal through 2025 in the context of meaningful mitigation actions and transparency on the implementation: prior to 2025 the conference of the parties serving as the meeting of the parties to the Paris agreement shall set a new collective quantified goal from a floor of USD 100billion per year, taking into account the needs and priorities of developing countries.

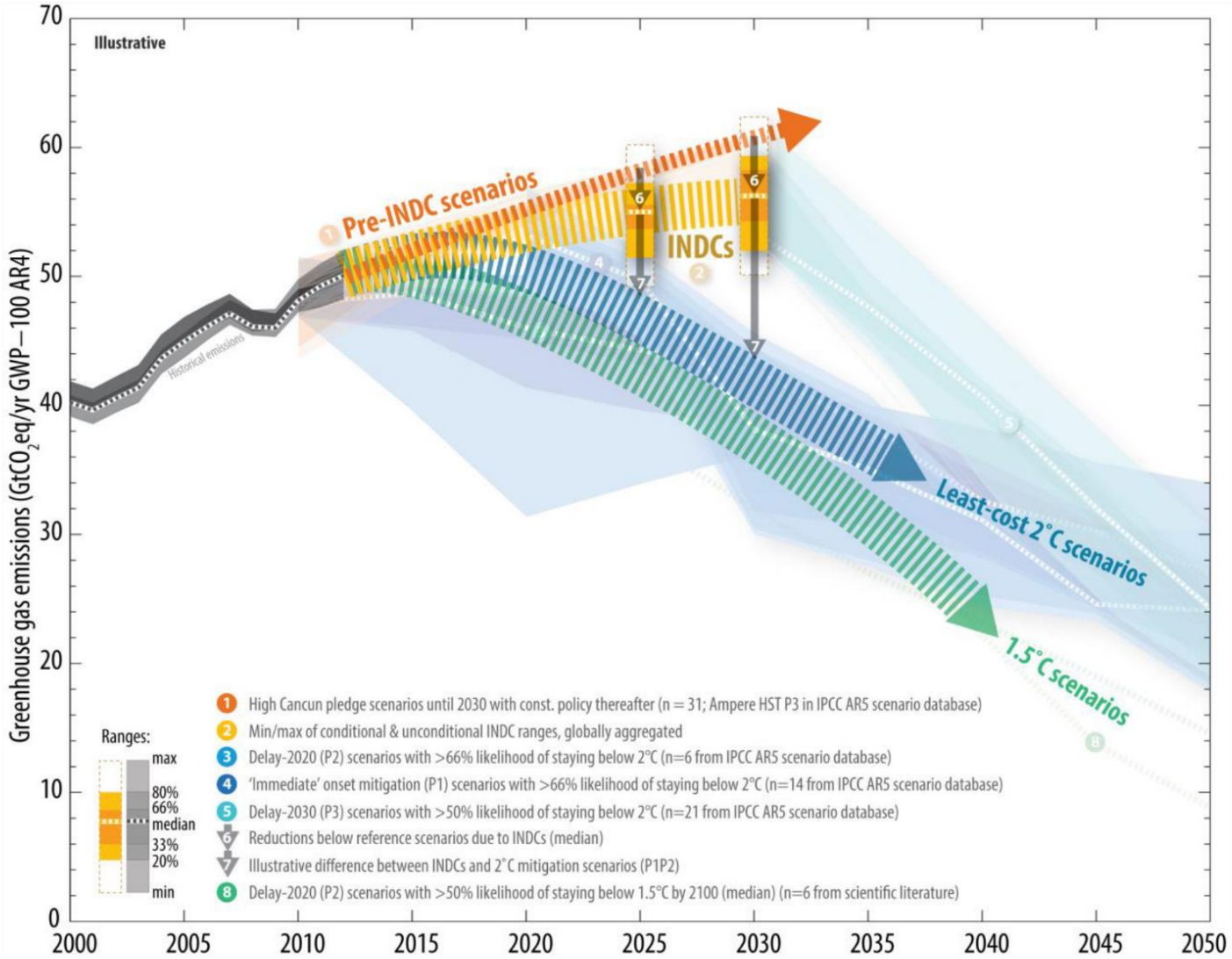
Post Paris Policy Context –COP21

Carbon Budgets & Nationally Determined Contributions

- AR5 carbon budget for the total global cumulative emissions since 2011 that are consistent with a global average temperature rise of 1.5C above pre industrial levels with 50% probability is 550GtCO_2.
- Considering the aggregate effect of INDCs, global cumulative CO_2 emissions are expected to equal 97% by 2025 and 134% by 2030 of the cumulative emissions consistent with achieving a temperature increase of less than 1.5°C
- INDCs are estimated to result in global annual ~52GtCO_2e/yr in 2030
  - Not on a 2 °C least cost consistent path

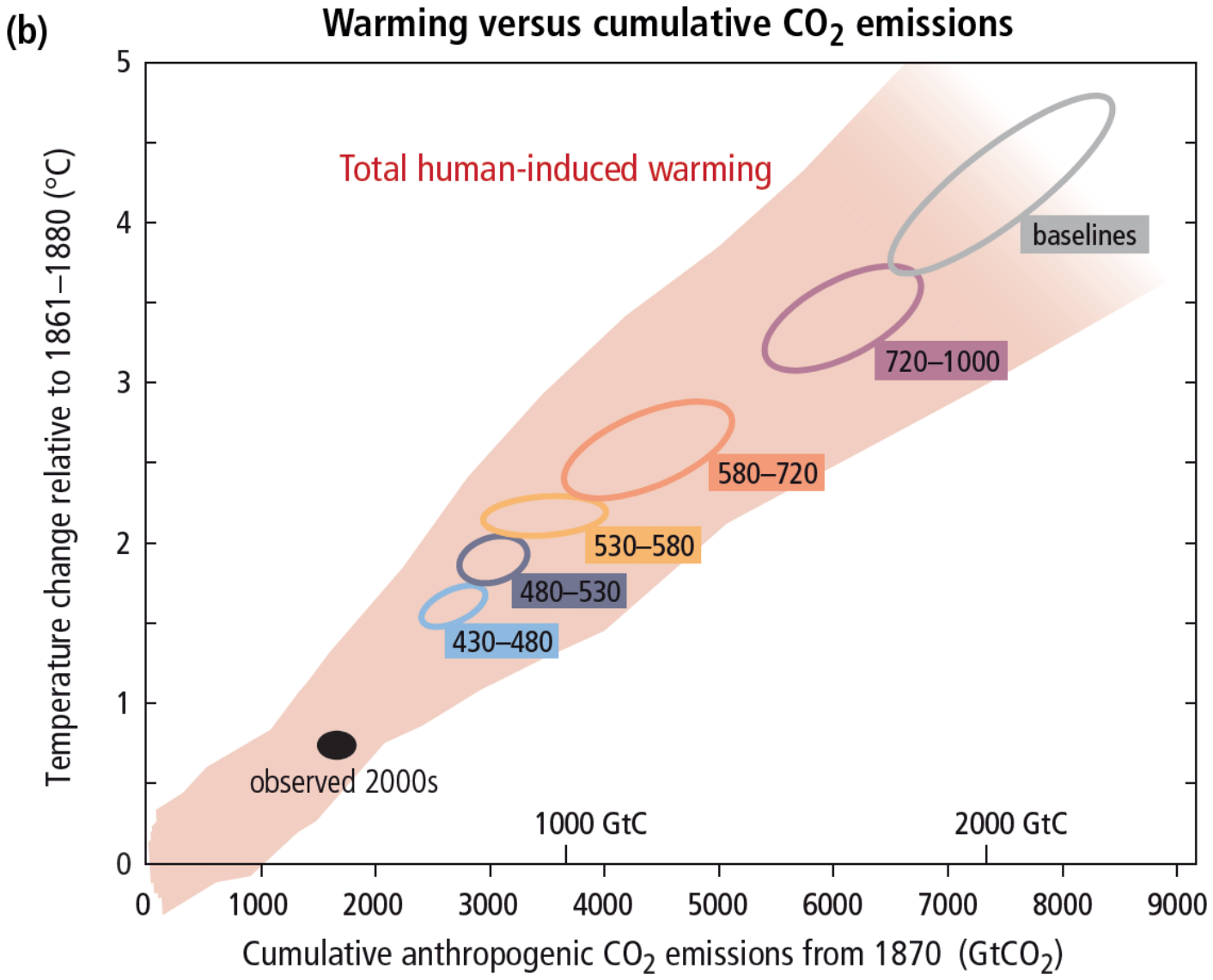
INDC action is not fast enough

UNFCCC INDC Synthesis Report



Cumulative CO_2 vs Linear T°C

IPCC AR5



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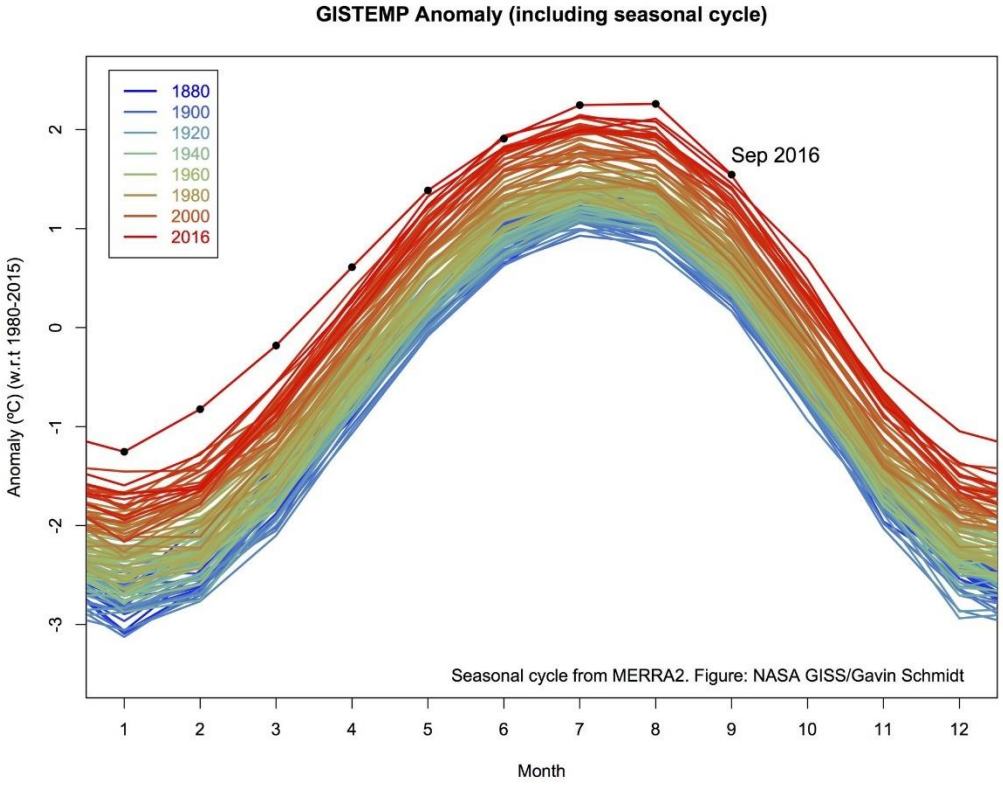
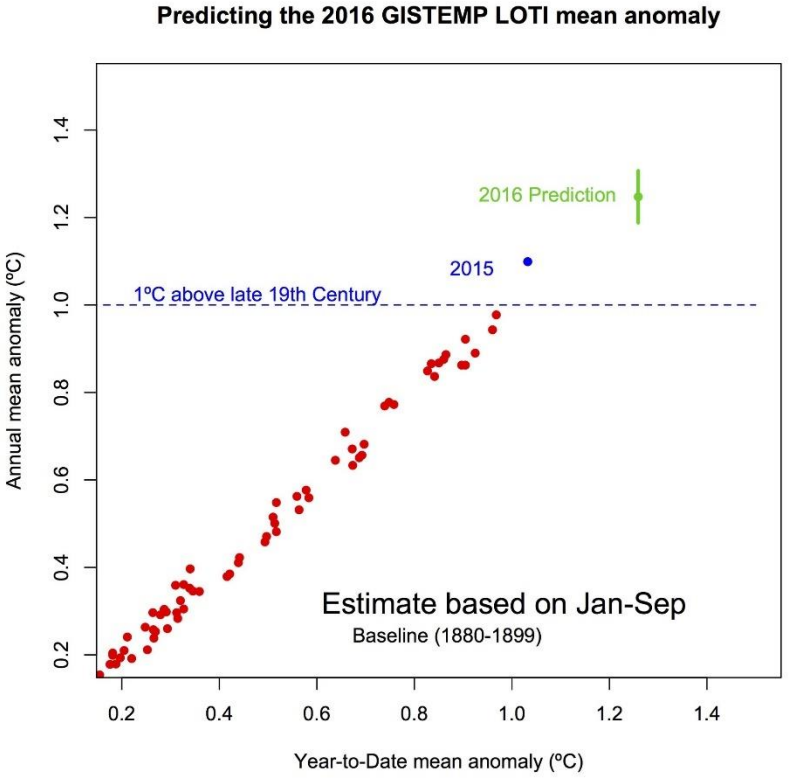
Temperature Anomaly





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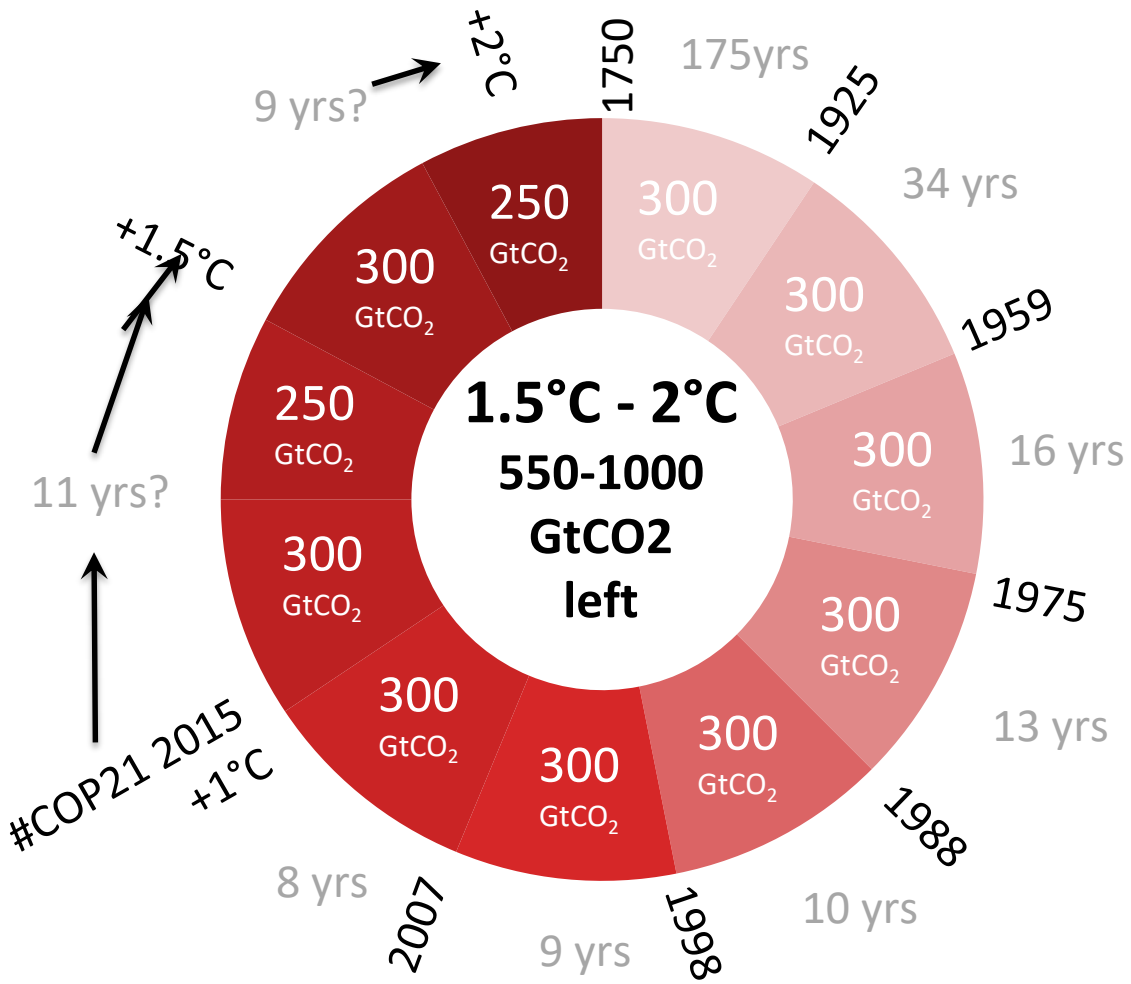
Global Carbon Clock



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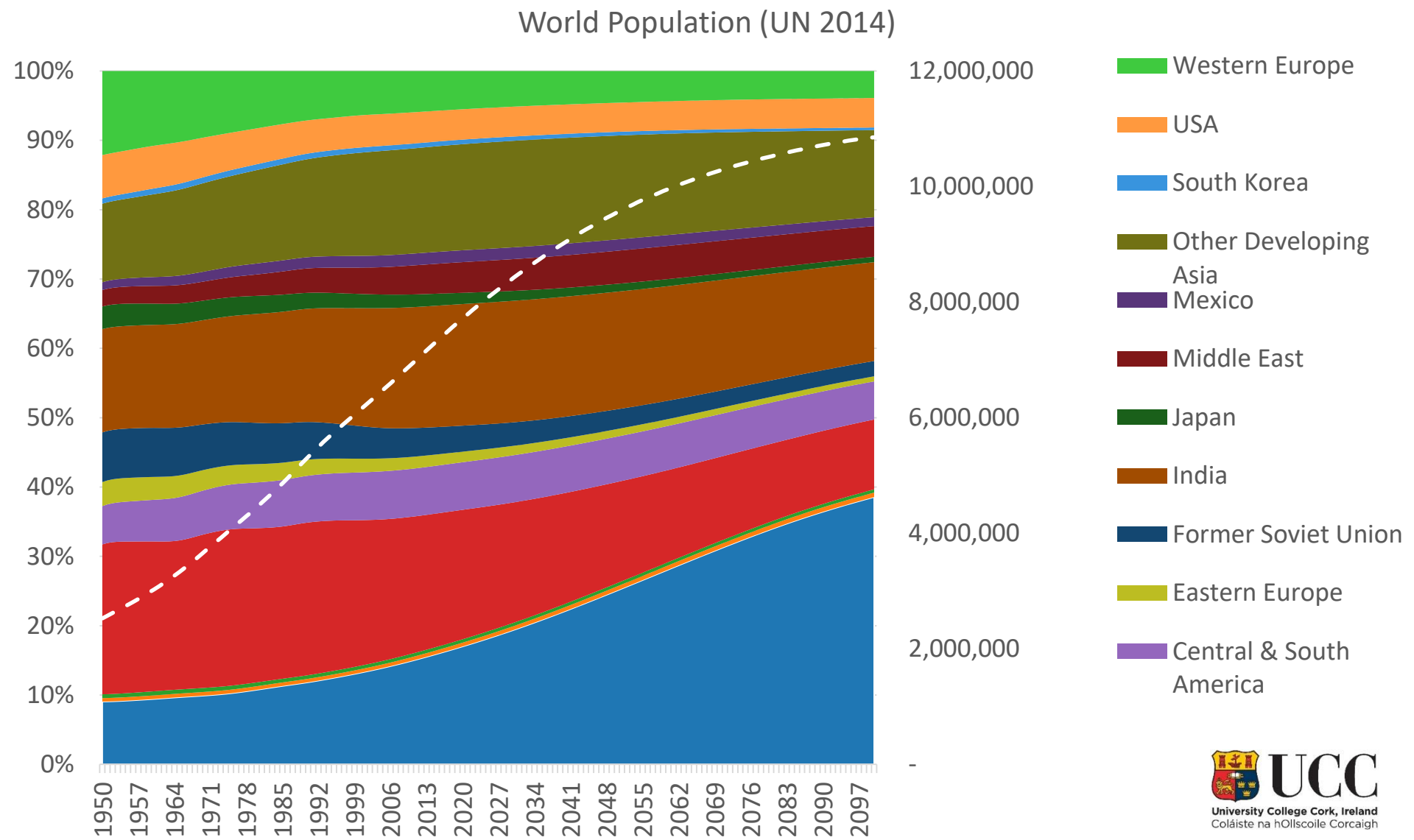
Population proportion trends



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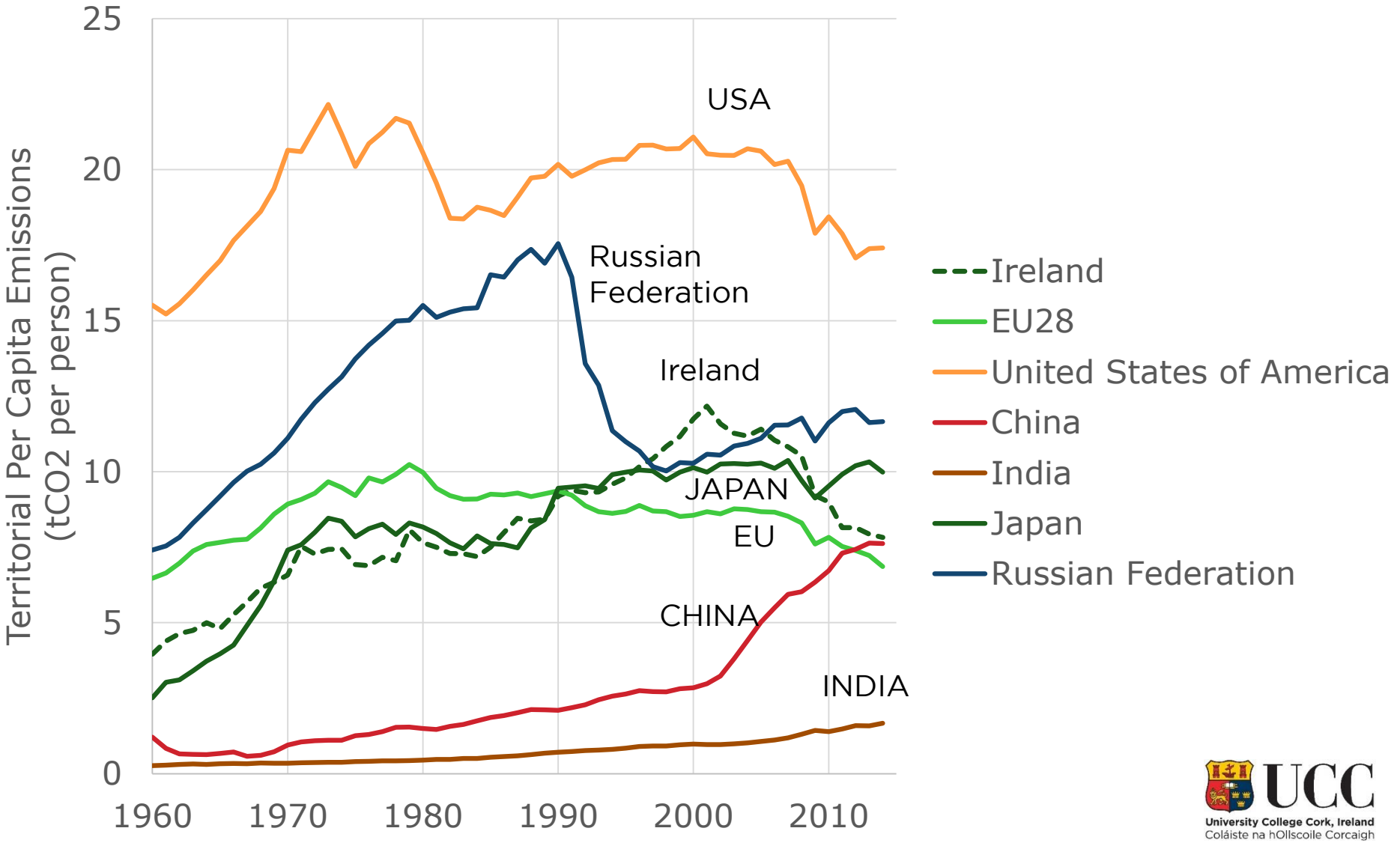
CO_2 emission per Person



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Research Question?

- How do we account for equity and fairness for deep decarbonisation of the global energy system in the post Paris Agreement era?
- In what circumstances is the finance in the Paris agreement, $100bn/year, appropriate?

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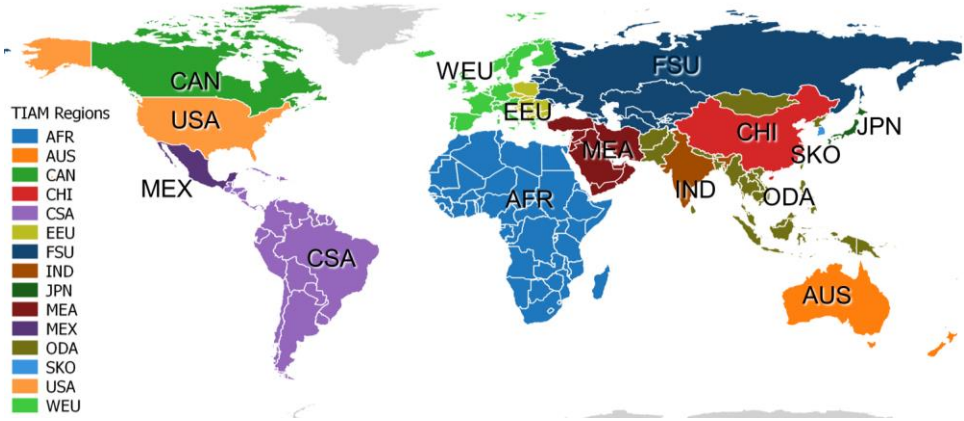
ETSAP-TIAM global model

- Linear programming bottom-up energy system model of IEA-ETSAP
- Integrated model of the entire energy system
- Prospective analysis on medium to long term horizon (2100)
  - Demand driven by exogenous energy service demands
  - OECD Env Links SSP2
- Partial and dynamic equilibrium (perfect market)
- Optimal technology selection
- Minimizes the total system cost
- Environmental constraints
  - Integrated Climate Model
- 15 Region Global Model
- Price-elastic demands

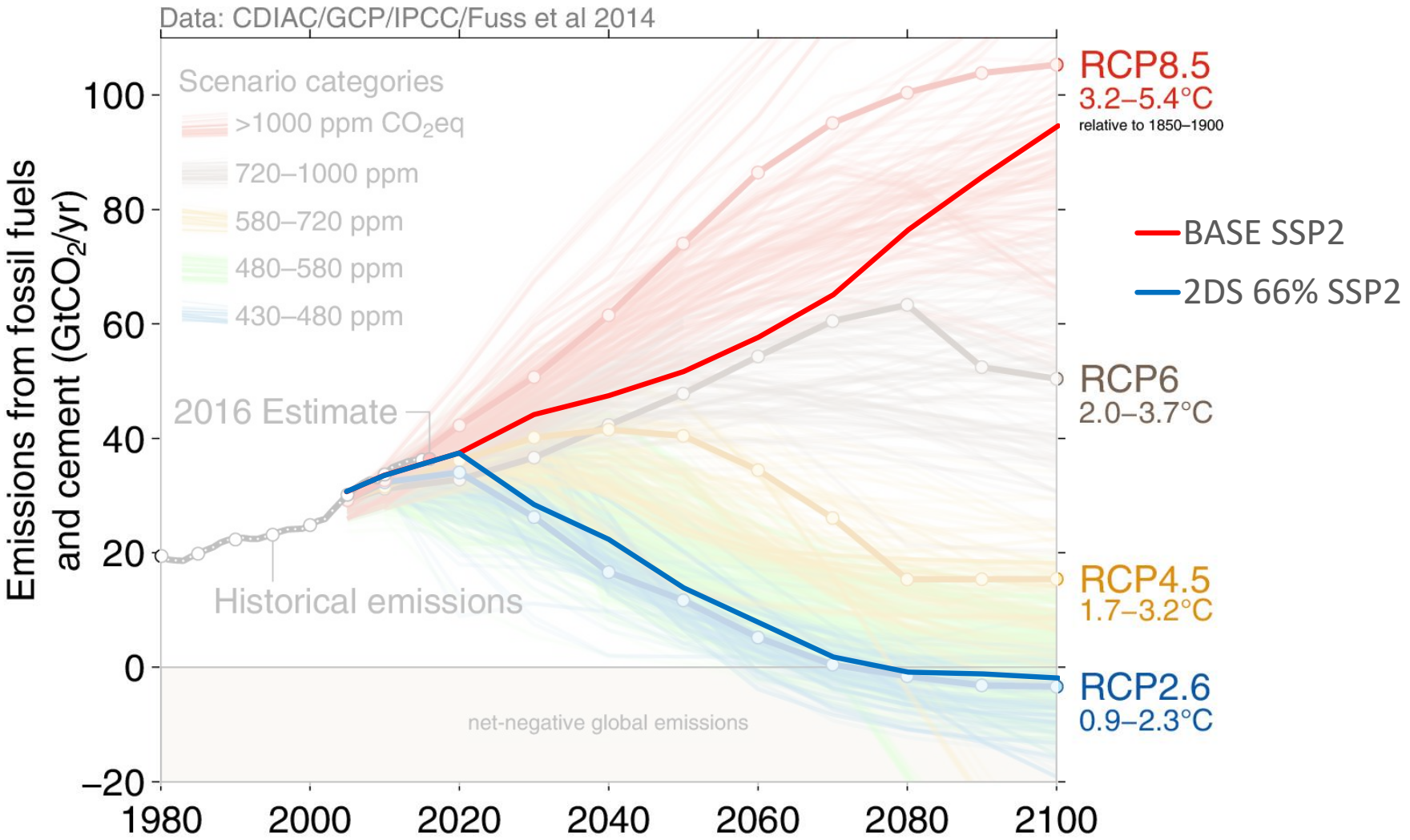


- Macro Stand Alone
  - Single consumer-producer, multi-regional, inter-temporal general equilibrium model which maximises regional utility.
  - The utility is a logarithmic function of the consumption of a single generic consumer.
  - Production inputs are labour, capital and energy.
  - Energy demand and energy costs from ETSAP-TIAM model.
  - MSA Re-estimates Energy Service Demands based on energy cost

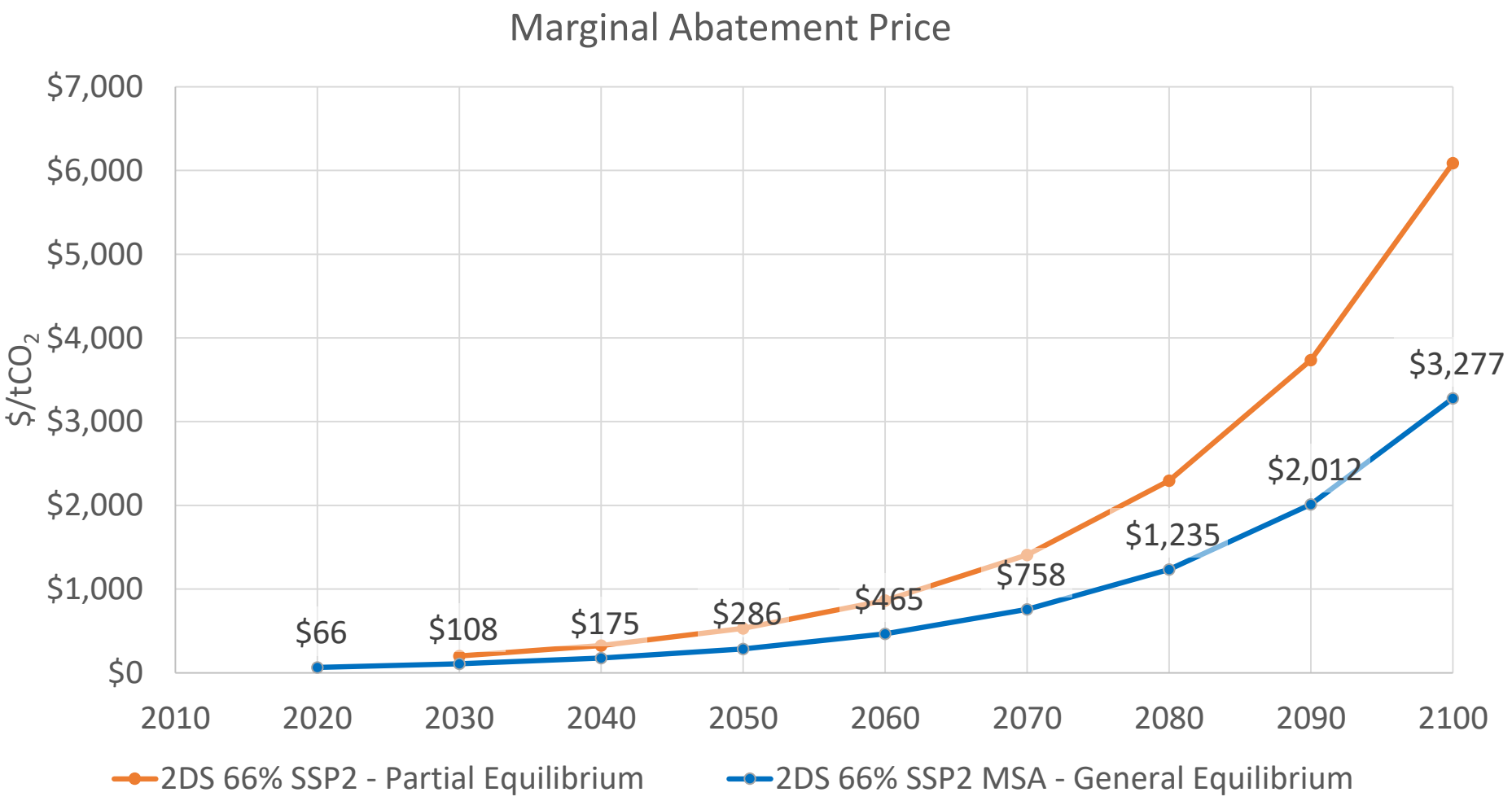
Scenarios & Effort Sharing Rules

- Scenario
  - BASE SSP2
    - Our reference case scenario with all technology options available, with sectoral growth trajectories base on OECD-SSP2 value added.
  - 2DS 66% SSP2
    - The least cost solution is fixed to the base case until 2020, whereupon a cumulative carbon budget between 2020-2100 of 1000GtCO2 is enforced while CH4 and N2O are controlled by the climate module for a 2°C 2100 temperature.
- Effort Sharing Rules
  - "Contract and Converge" Per Capita Emissions
  - *Equalise Regional GDP loss*
  - *Compensate developing countries for energy cost increases*
  - *Compensate developing countries for GDP loss*
  - Brazil rule 1– cumulative equity "past and future"
  - Brazil rule 2 – cumulative "future equity" of remaining CO2 budget.

CO_2 Budgets +SSP2 drivers



CO_2 Abatement Cost



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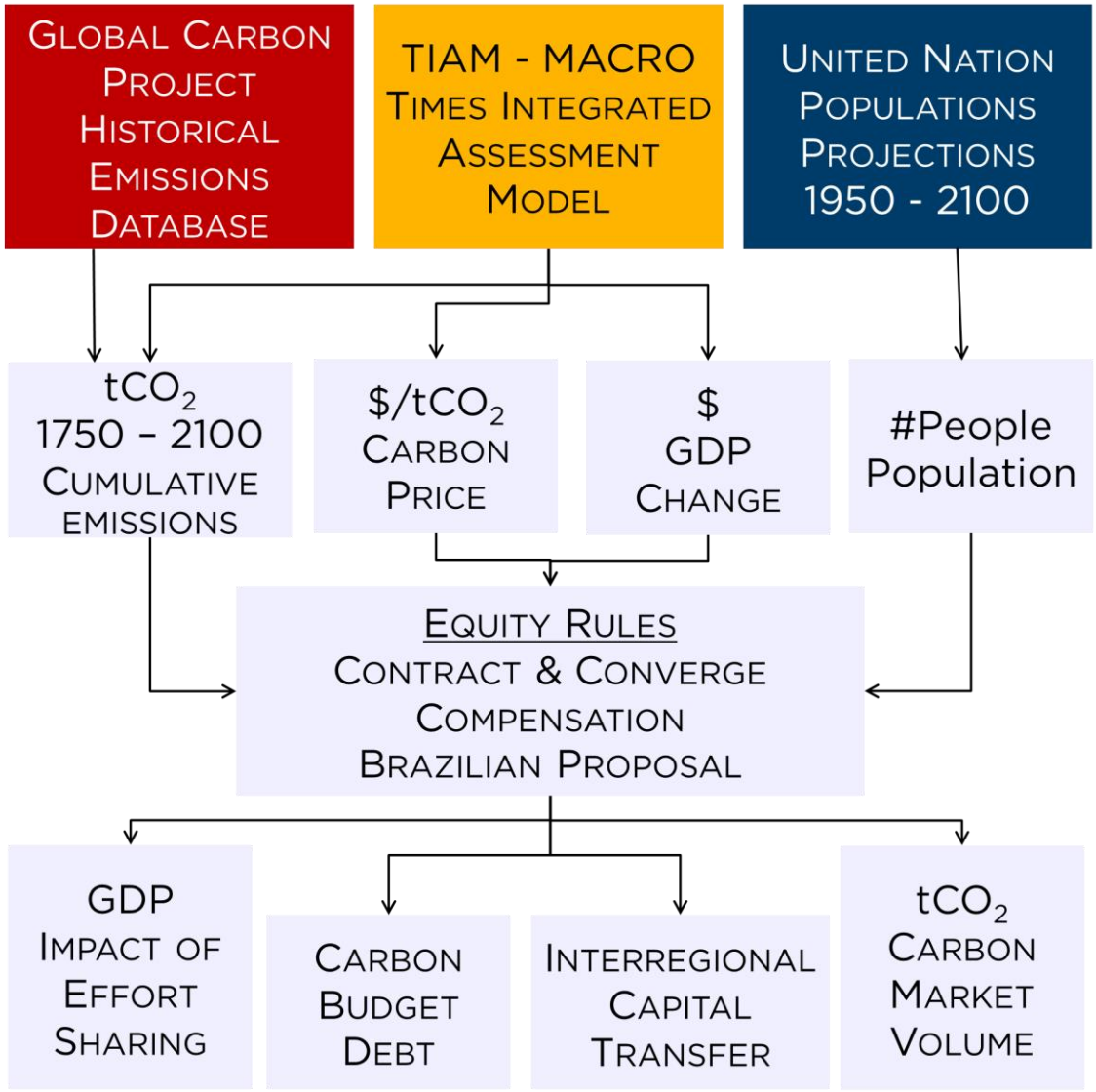
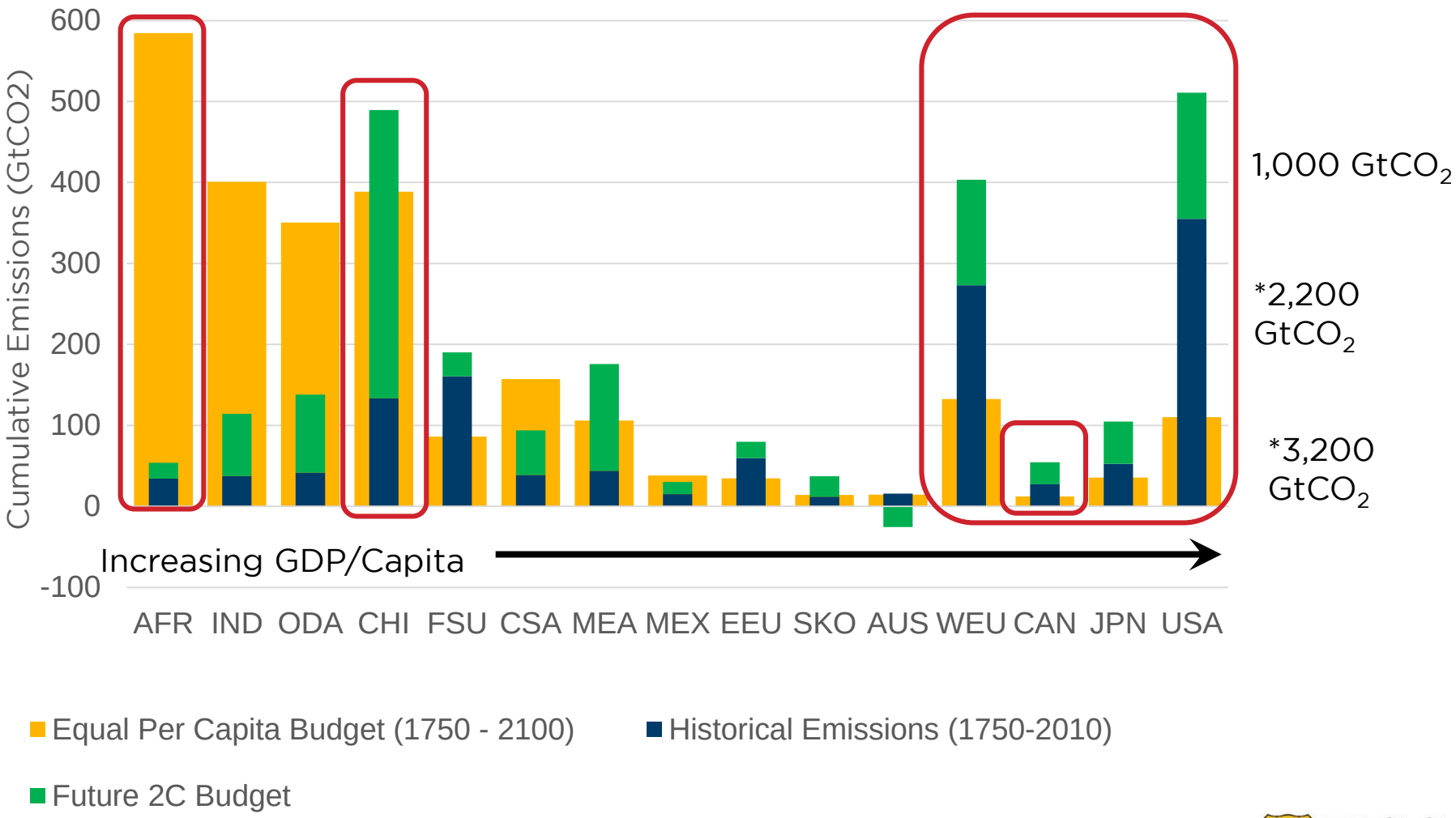
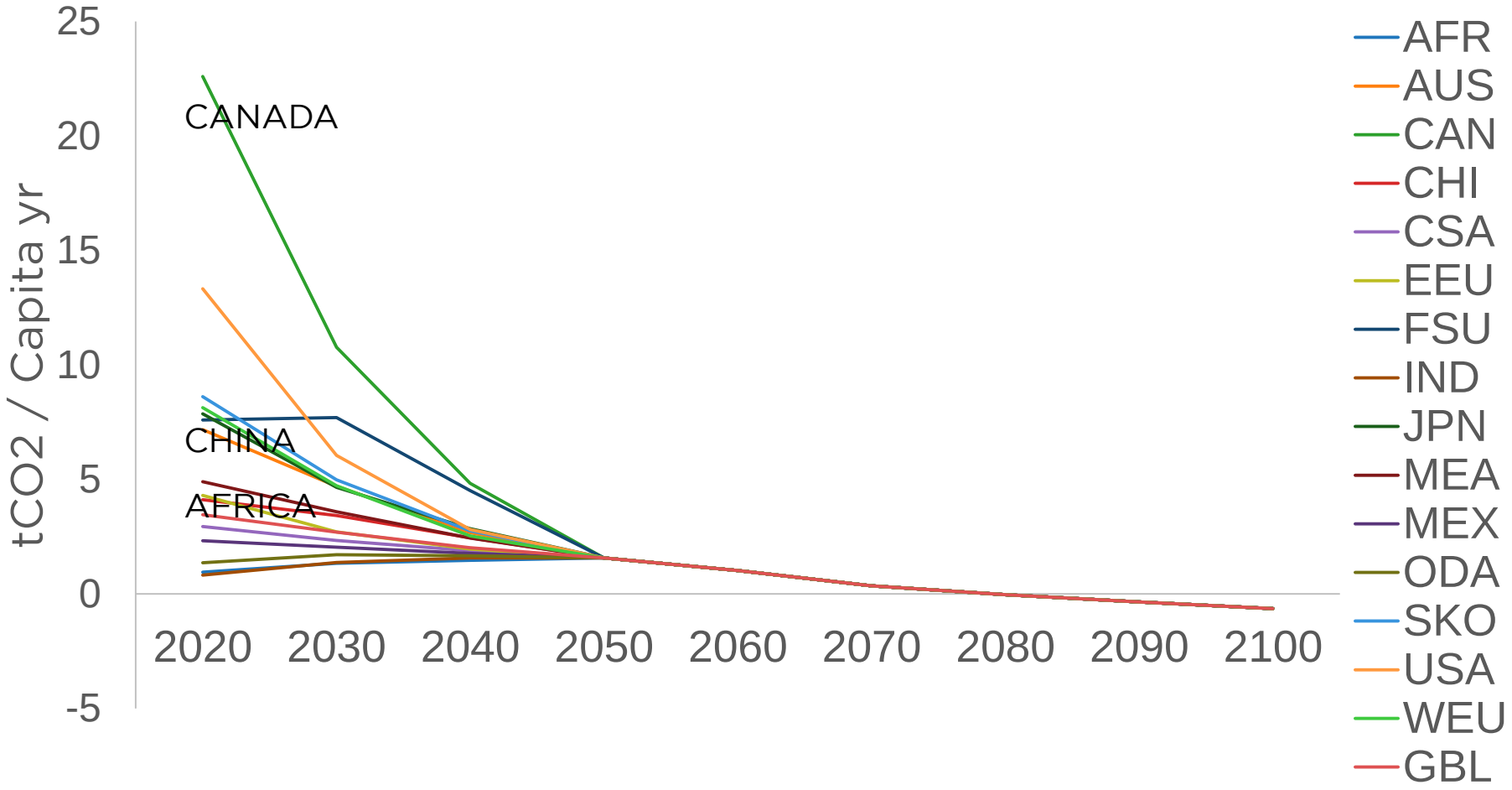
Method: Effort Sharing Process



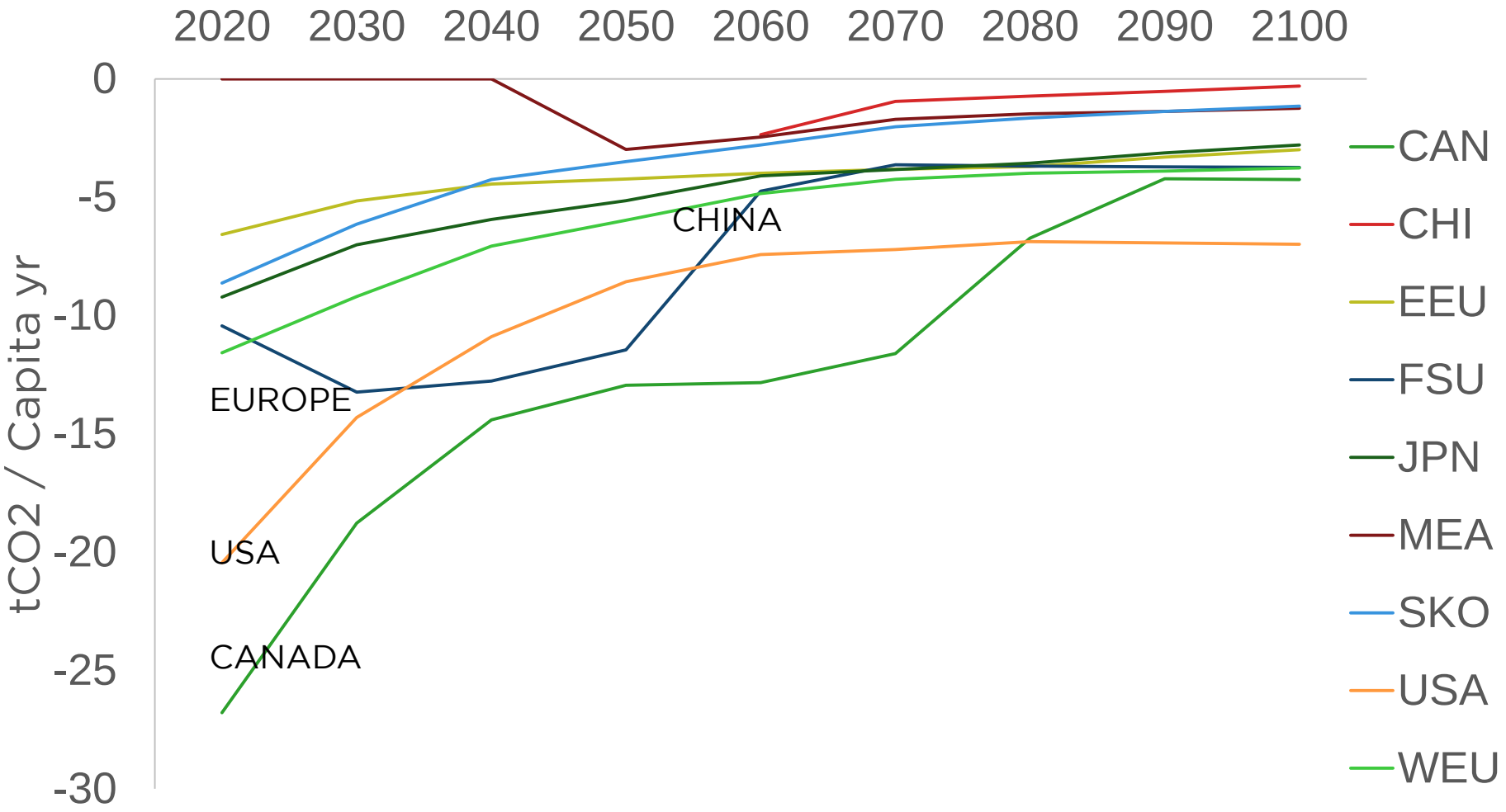
Carbon Budgets; Past and 2°C



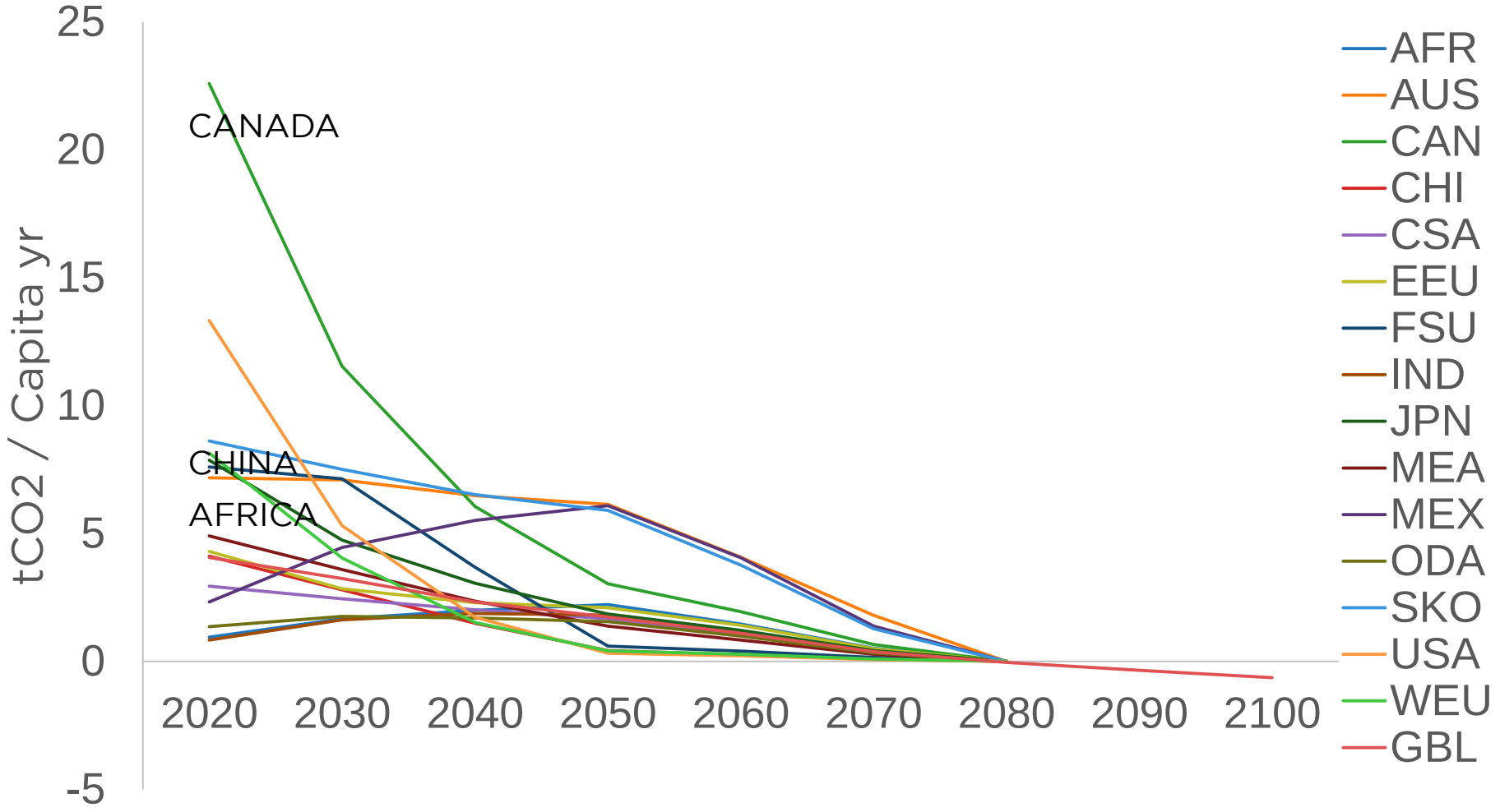
Effort Sharing Rules – (1) Contract & Converge



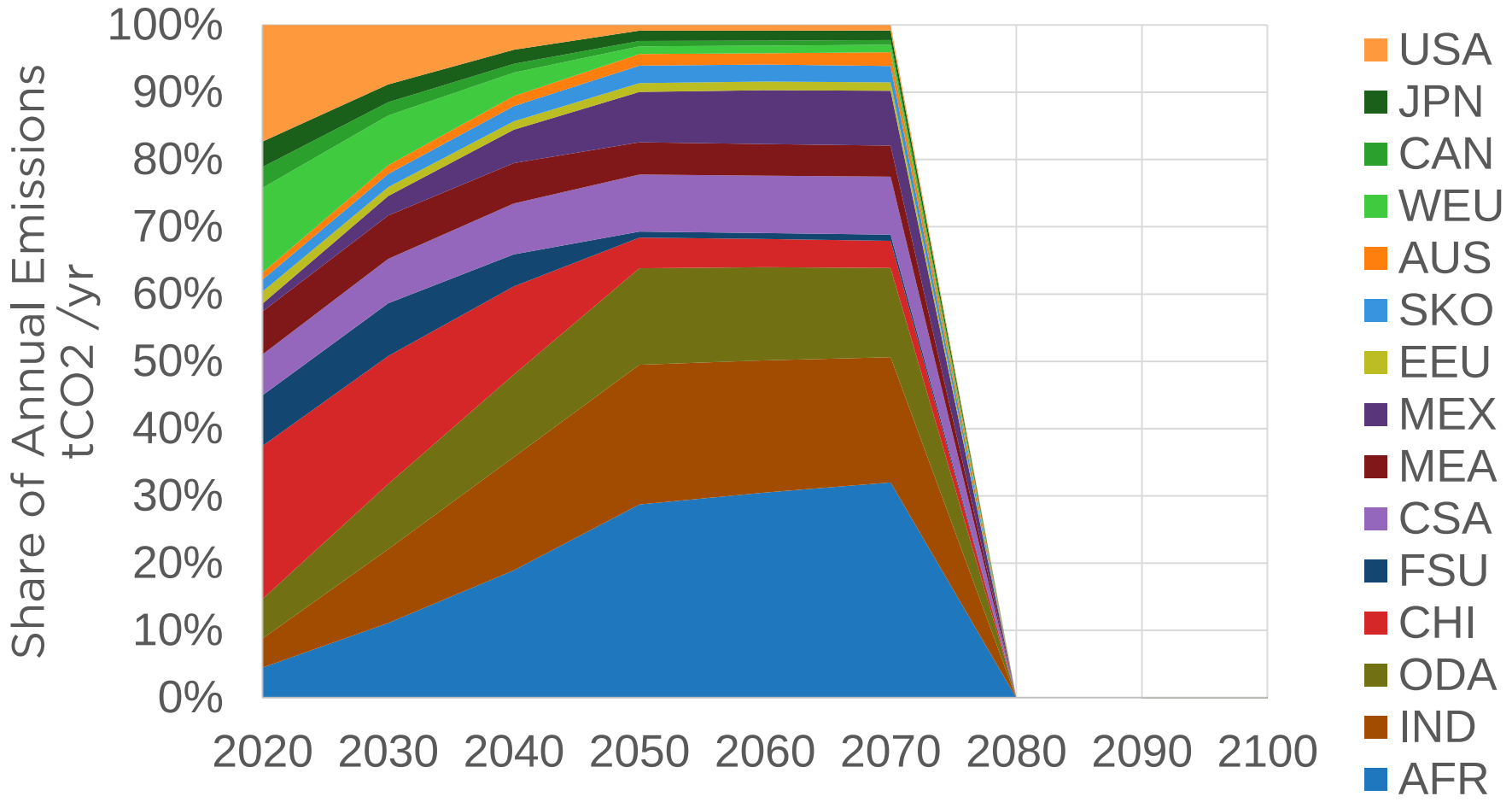
Effort Sharing Rules – (2) Past & Future Equity



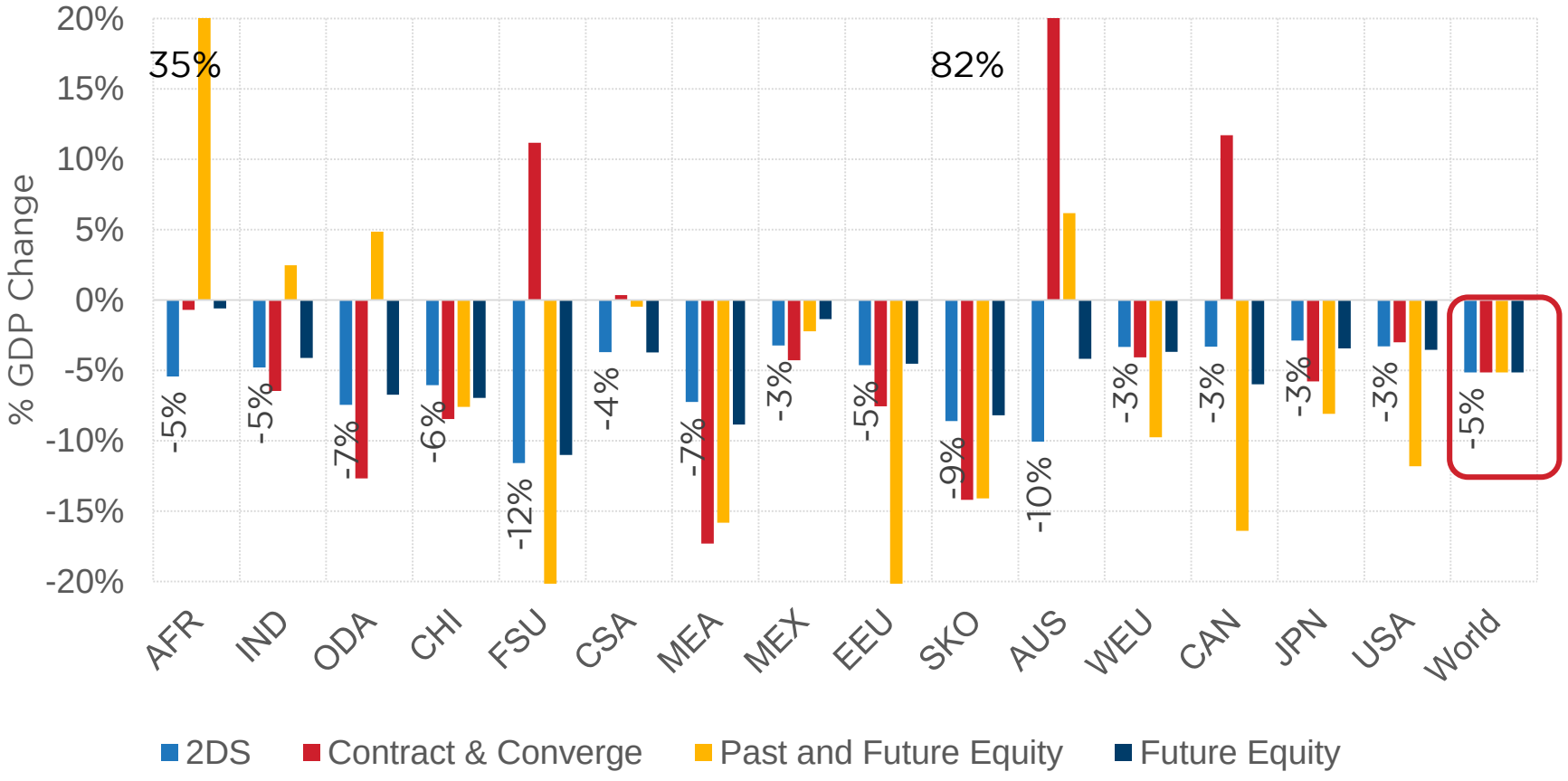
Effort Sharing Rules – (3) Future Equity



Effort Sharing Rules – (3) Future Equity



GDP Impacts by 2100



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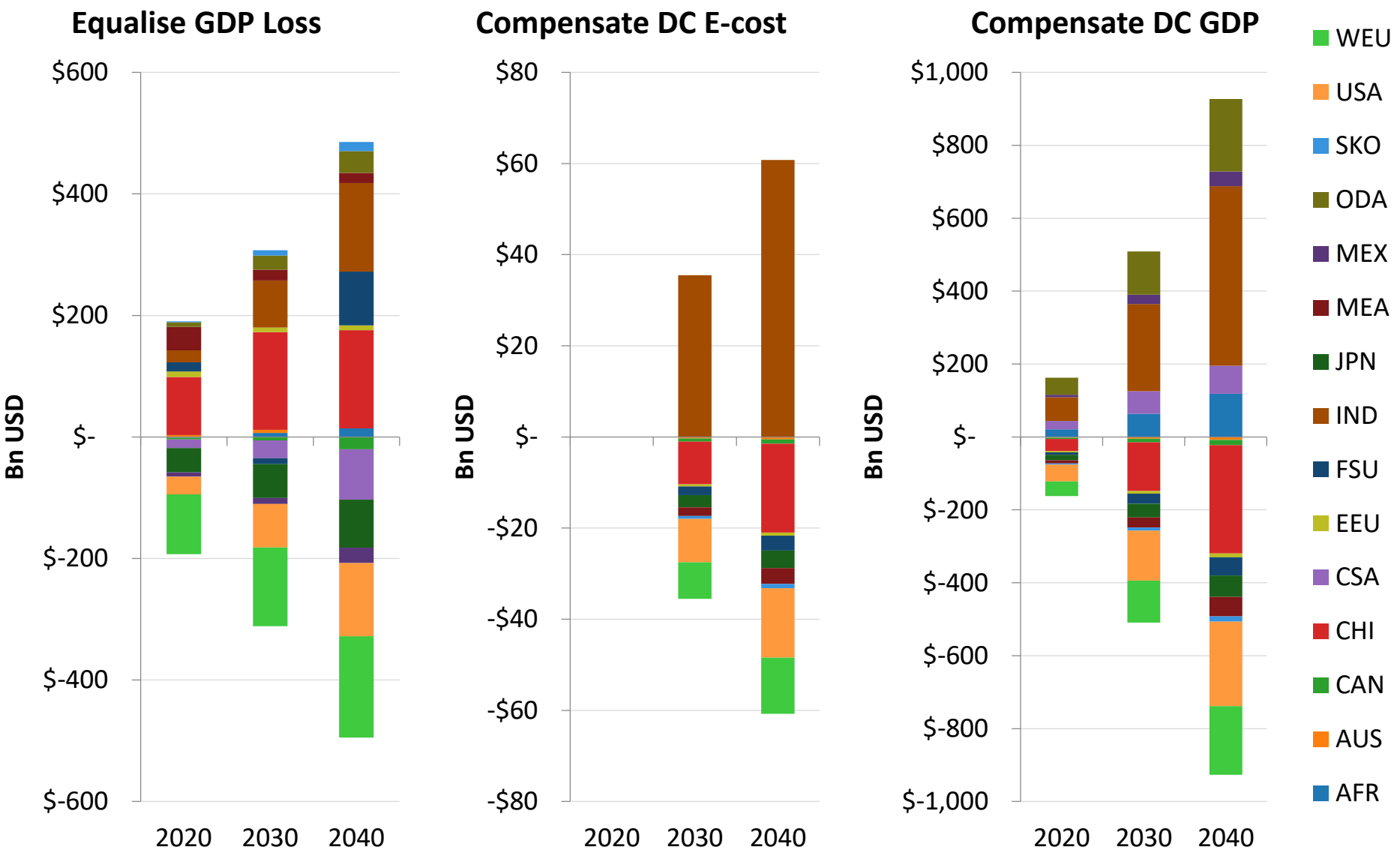
Equitable Capital Transfers
(undiscounted)



Equitable Capital Transfers
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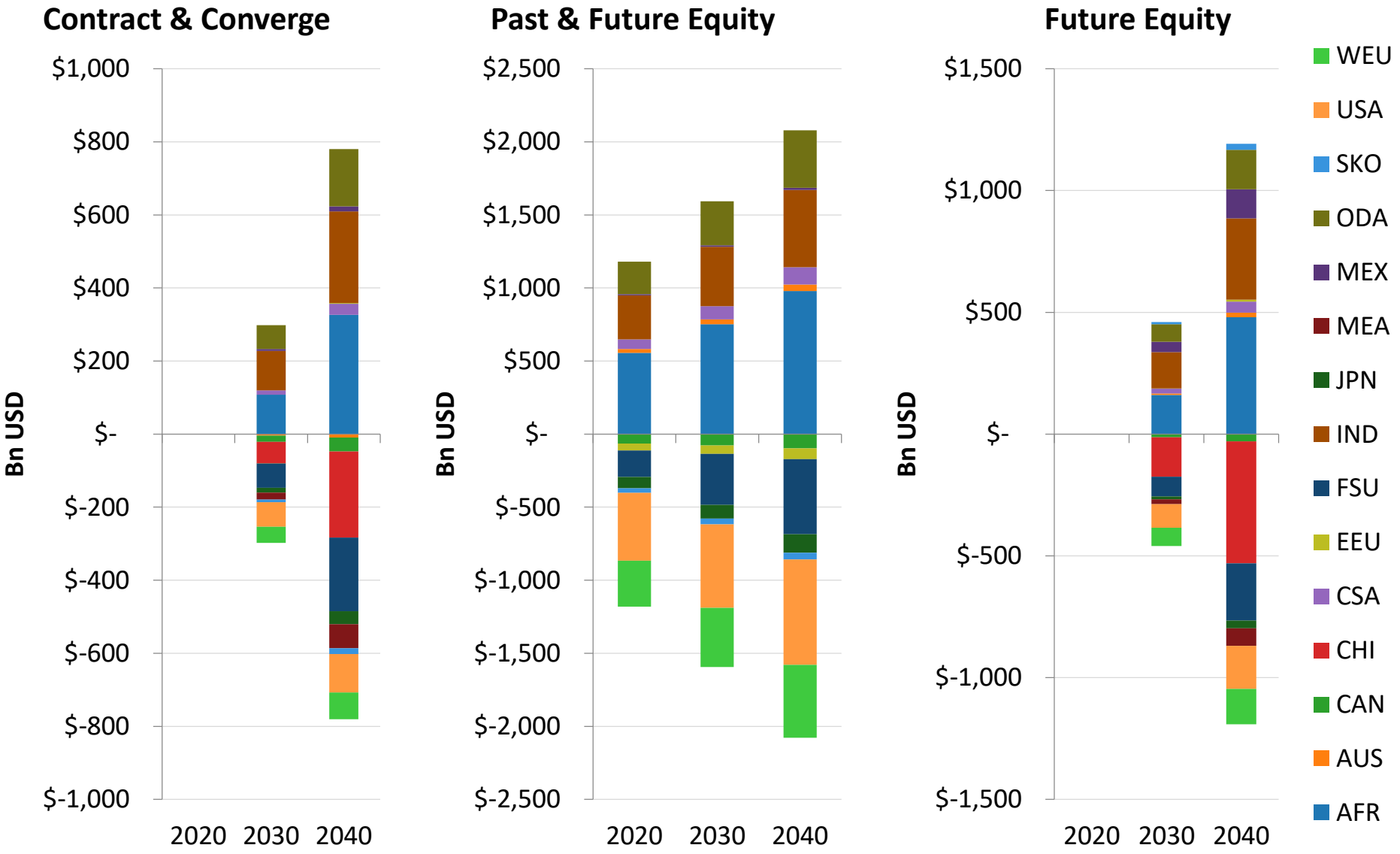
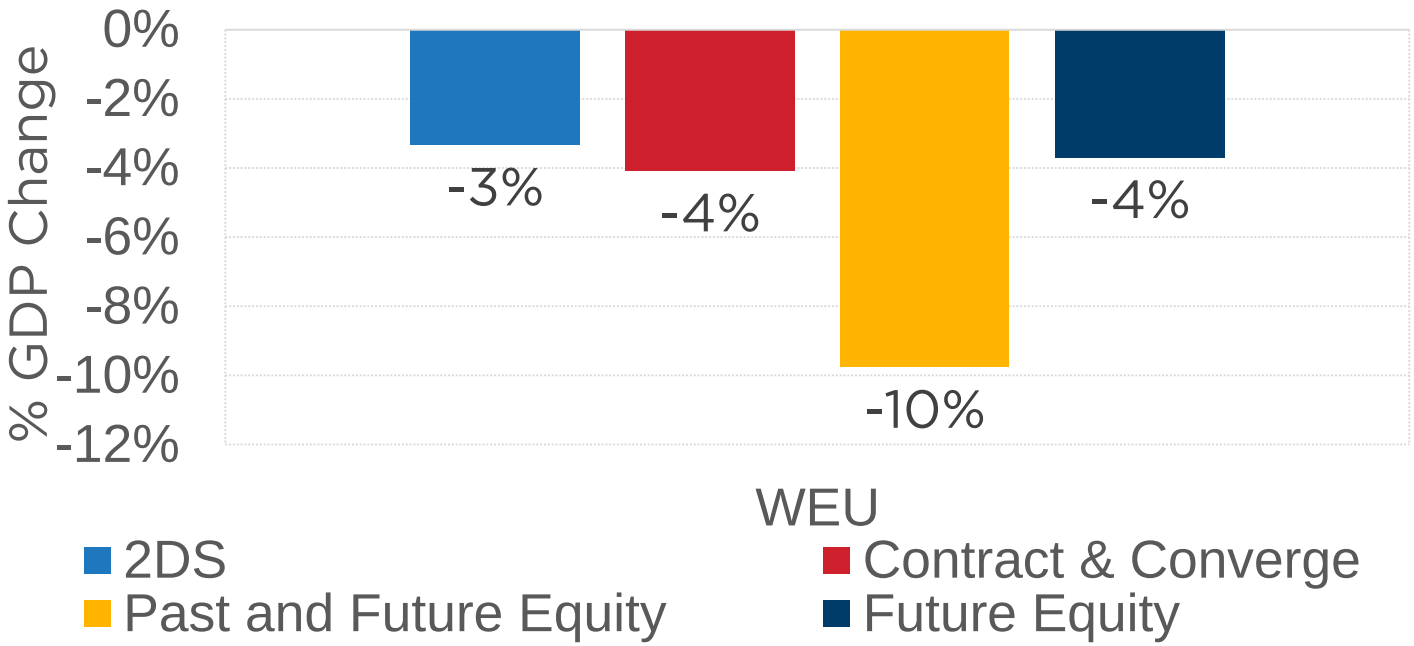


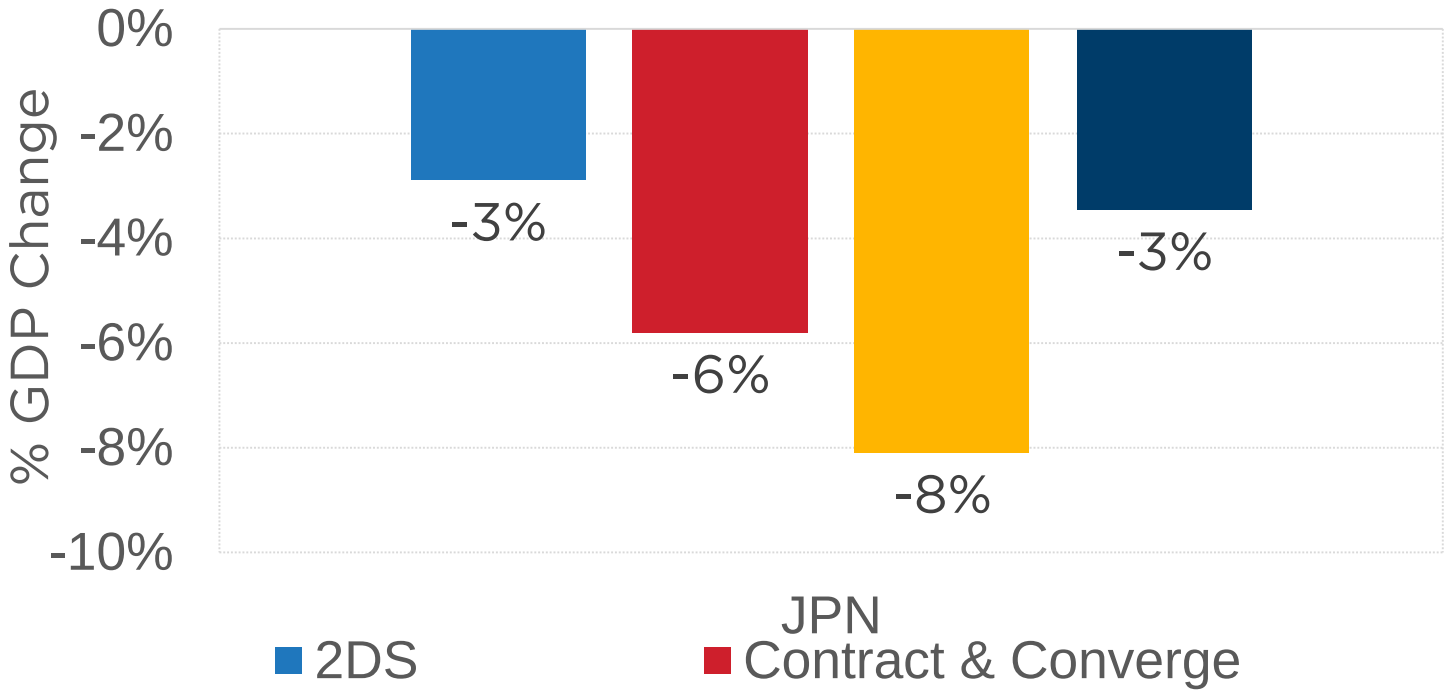
West Europe

- Europe's cumulative GDP loss in the least cost 2DS solution is 3.3%. Europe has already emitted it's equitable share of emissions and so trades accordingly causing GDP losses of 3% - 10% GDP depending upon the share of future emissions allowed to be emitted
- Capital Transfer range: -$1.2 Tn to -$14.2Tn (discounted at 5%)
  - -$7.6 Tn to -$134 Tn (undiscounted 2020 - 2100)



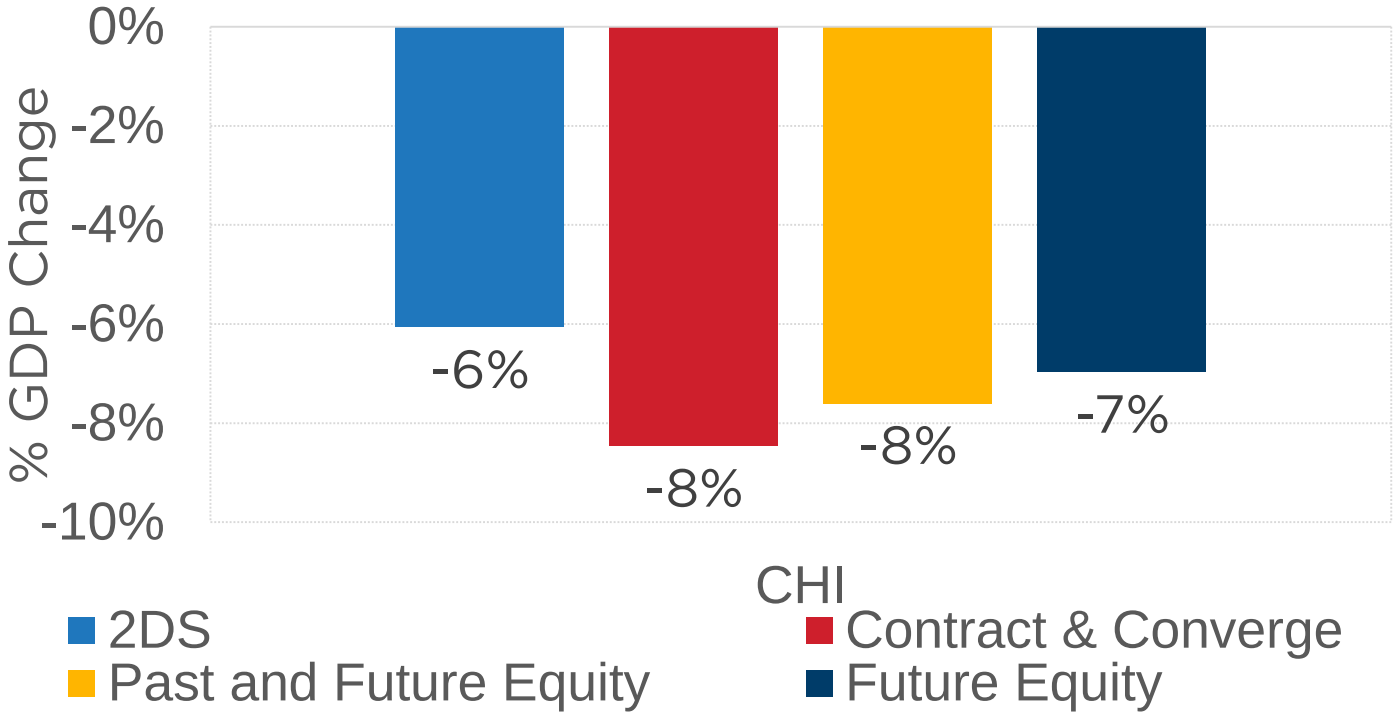
Japan

- Japans's cumulative GDP loss in the least cost 2DS solution is 2.9%. Japan has already emitted it's equitable share of emissions and so trades accordingly causing GDP losses of 3% - 8% GDP depending upon the share of future emissions allowed to be emitted
- Capital Transfer range: -$600 Bn to -$3.5Tn (discounted at 5%)
  - -$3.5 Tn to -$33 Tn (undiscounted 2020 - 2100)



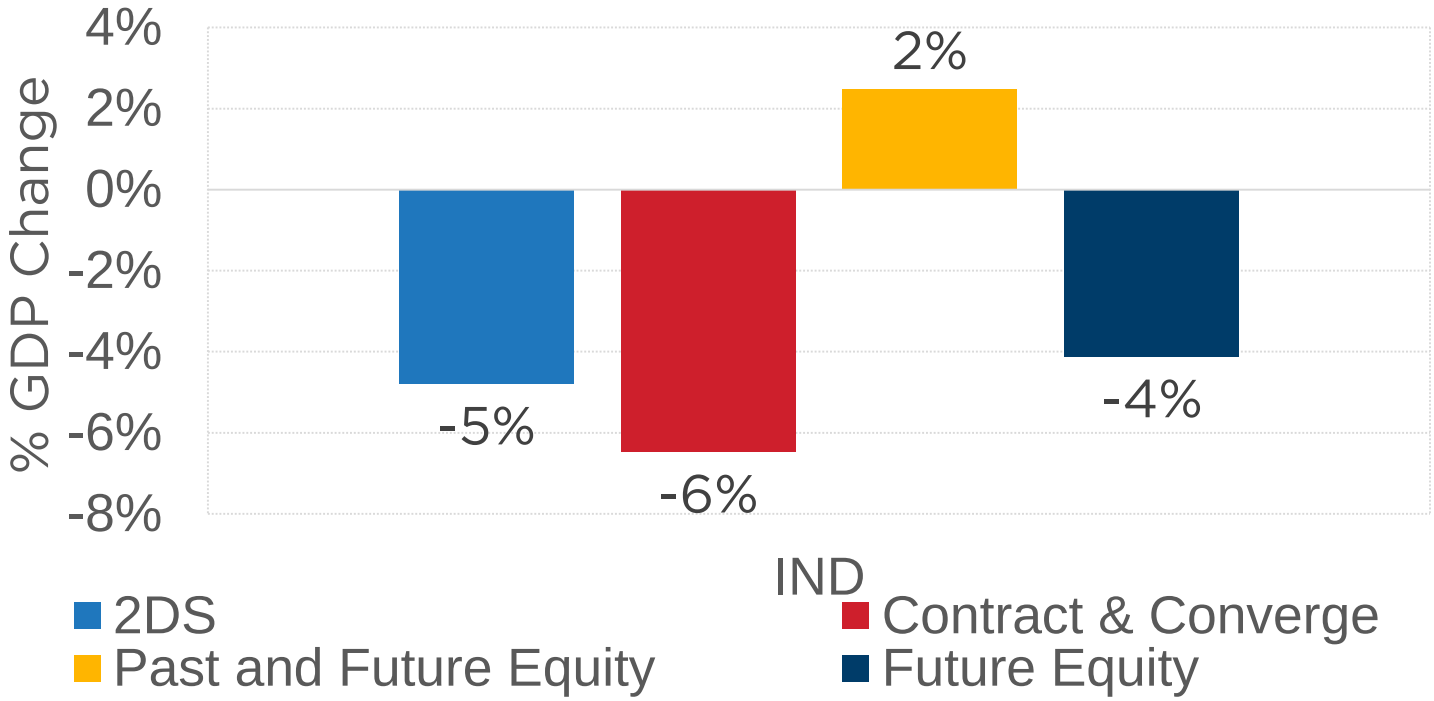
China

- China's cumulative GDP loss in the least cost 2DS solution is 6.1%. The "Future Equity" effort sharing rule (3) causes relative GDP losses of 7% but less than the other effort sharing rules presented
- Capital Transfer range: -$4.9 Tn to -$8.5Tn (discounted at 5%)
  - -$43 Tn to -$114 Tn (undiscounted 2020 - 2100)



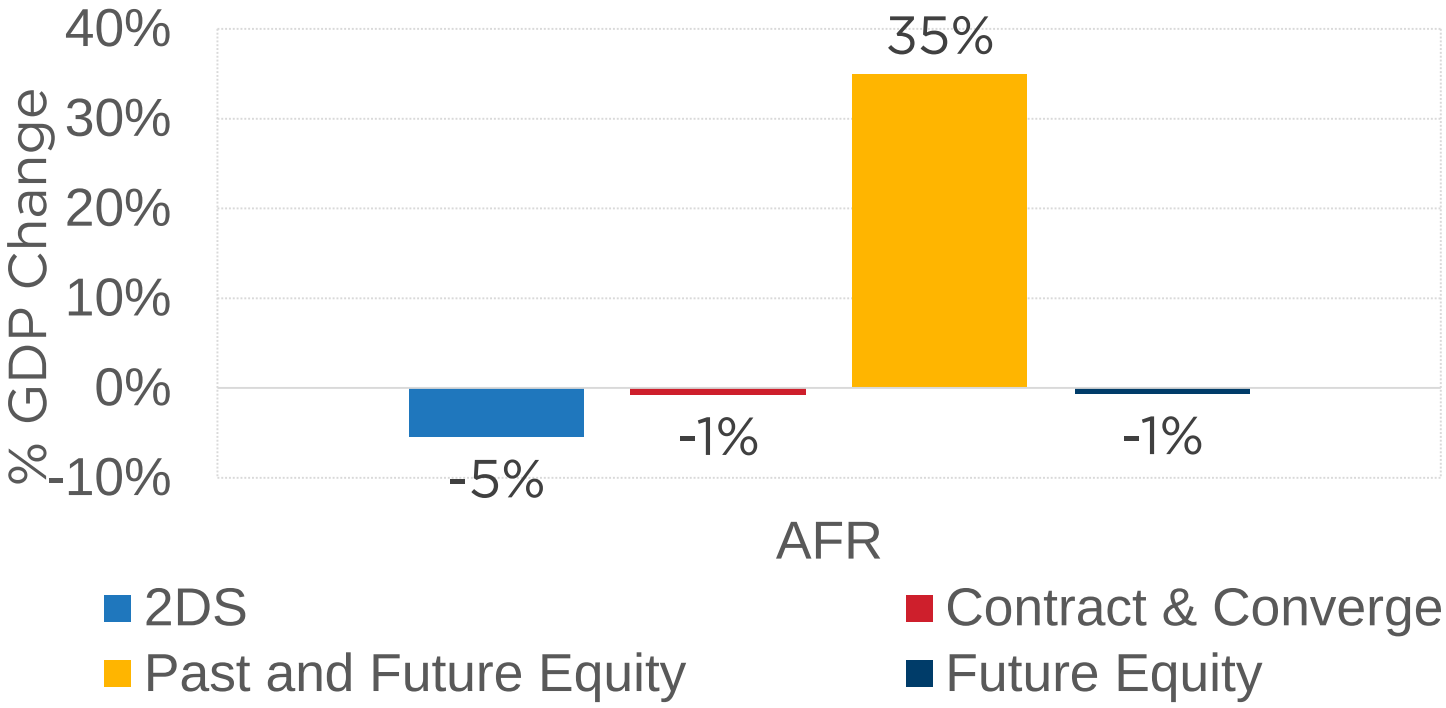
India

- India's cumulative GDP loss in in the least cost 2DS solution is 4.8%. Again the "Past & Future Equity" effort sharing rule (2) causes relative GDP growth of 2.5%.
- Capital Transfer range: +$1.7 Tn to +$16.5Tn (discounted at 5%)
  - -$38.9 Tn to +$168 Tn (undiscounted 2020 - 2100)



Africa

- Africa's cumulative GDP loss in in the least cost 2DS solution is 5.4%. The "Past & Future Equity" effort sharing rule (2) causes relative GDP growth of 34% given the continents lack of responsibility and population growth.
- Capital Transfer range: +$5.6 Tn to +$30.6Tn (discounted at 5%)
  - -$36 Tn to +$311 Tn (undiscounted 2020 - 2100)



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Conclusions

- Equitable effort sharing is critical for success of the Paris Agreement.
- GDP losses in the utility maximising least cost scenario for delayed action to 2020 is regionally varied and inequitable
- Equitable Capital Transfers should not become wealth redistribution.
- Equitable capital transfers do not negate the requirement to also decarbonise developed regions internal energy systems

- Some future effort sharing scenarios are more equitable than others.
  - 2DS – **-2.9% GDP to -11.6% GDP**
  - 1 – Contract & Convergence **82% GDP to -17.3% GDP**
  - 2 – Past and Future Equity – **+32.6% GDP to -25.5% GDP**
  - 3 – Future Equity – **+42% GDP to -85% GDP**
- Annual equitable capital transfers can be delayed by the burden sharing rules,
- Some rules are considerably higher than the €100bn from the Paris Agreement.
  - 1 – Contract & Convergence **~$300Bn/yr by 2030**
  - 2 – Past and Future Equity ~ **>$1Tn/yr by 2020**
  - 3 – Future Equity – **>$450Bn/yr by 2030**
- Equitable burden sharing rules require high capital transfers of trillions US $ between 2020 – 2100 (*Discounted at 5%/yr)
  - 1 – Contract & Convergence – **$Tn 15 ($Tn 342 – undiscounted)**
  - 2 – Past and Future Equity – **$Tn 65 ($Tn 660 – undiscounted)**
  - 3 – Future Equity – **$Tn 17 ($Tn 78.4 – undiscounted)**

Energy Policy & Modelling Collaborators and Funders

Roinn Cumarsáide,
Fuinnimh & Acmhainní Nádúrtha
Department of Communications,
Energy & Natural Resources

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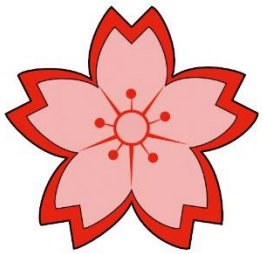
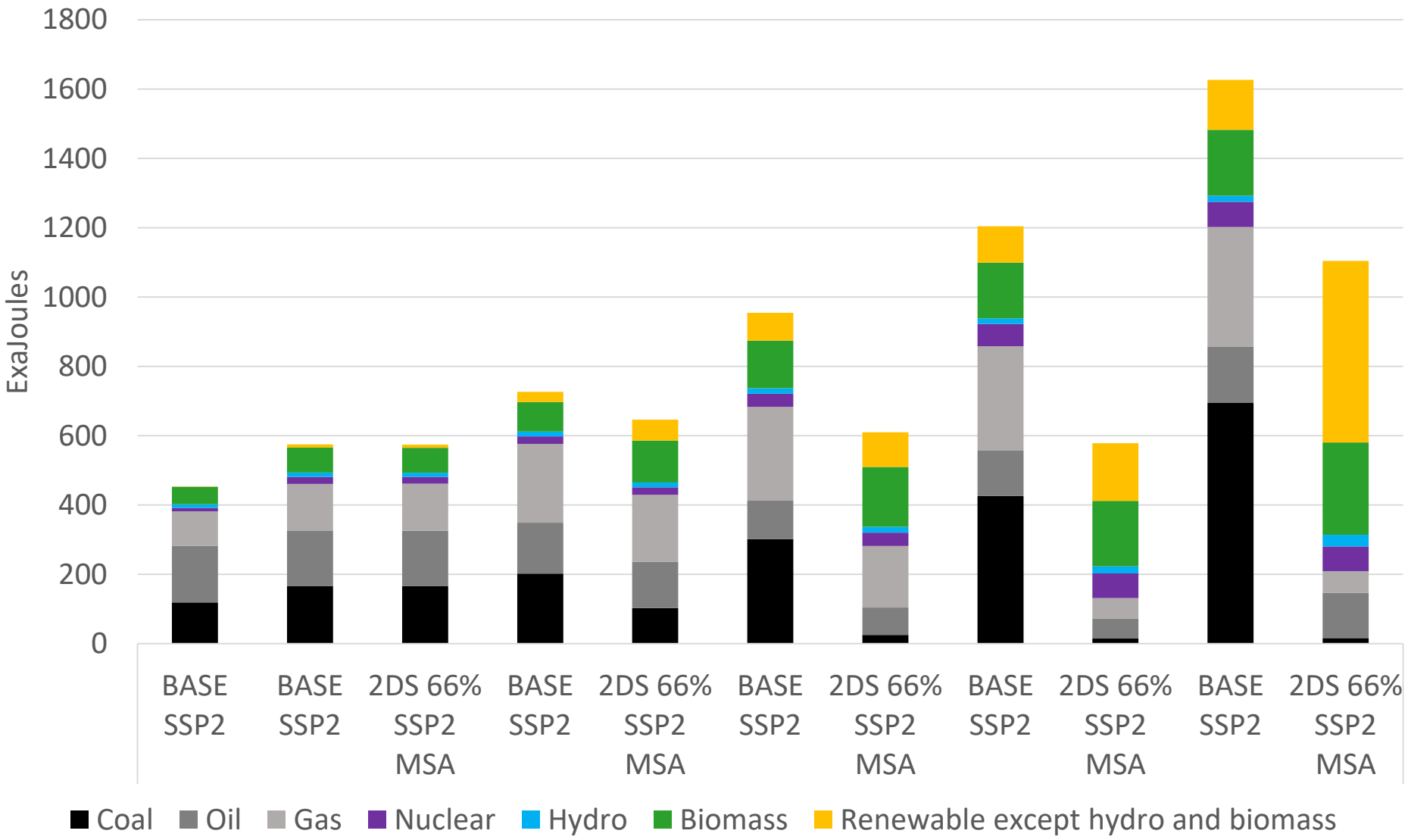


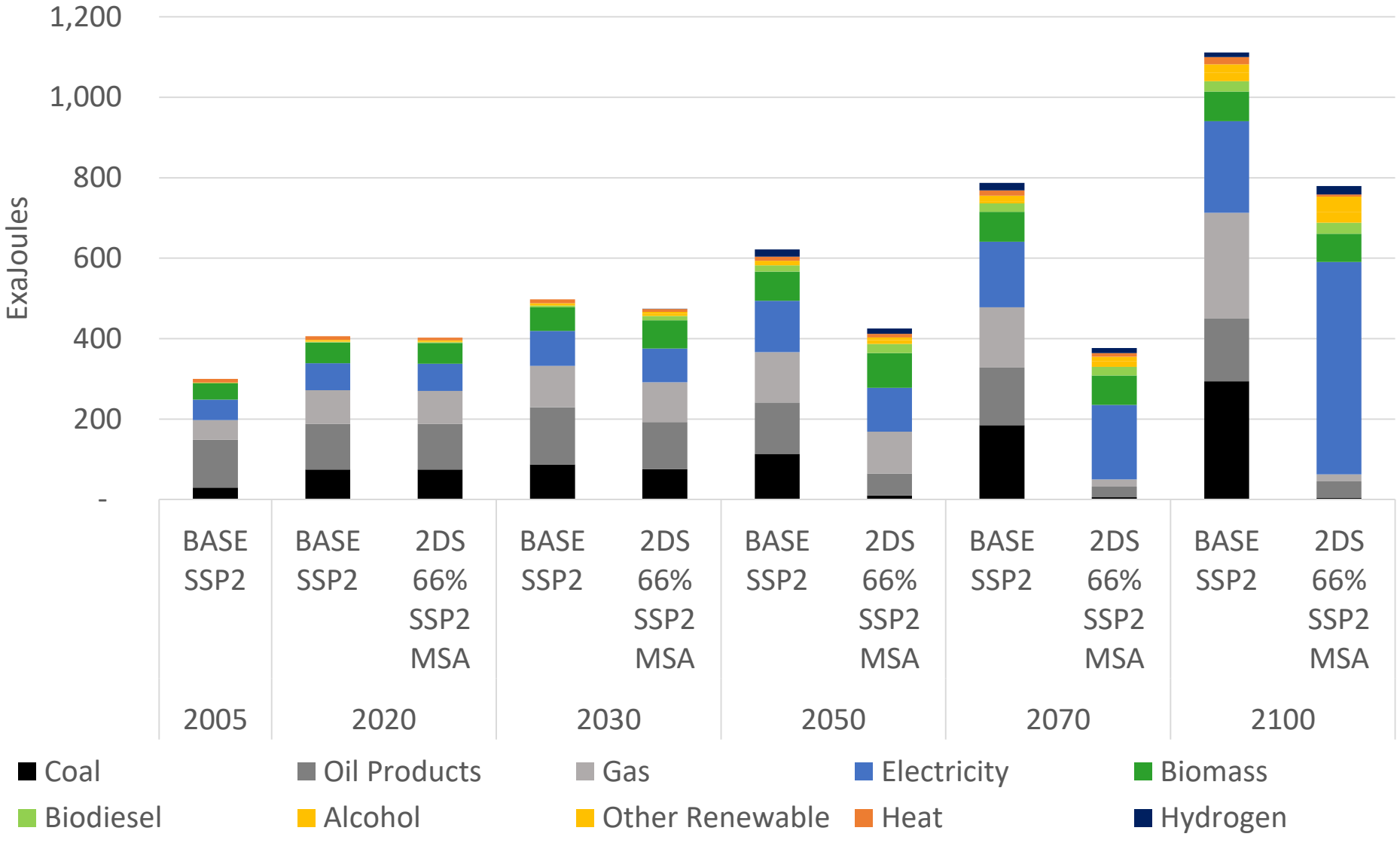
ISCA Japan

International Strategic
Cooperation Award

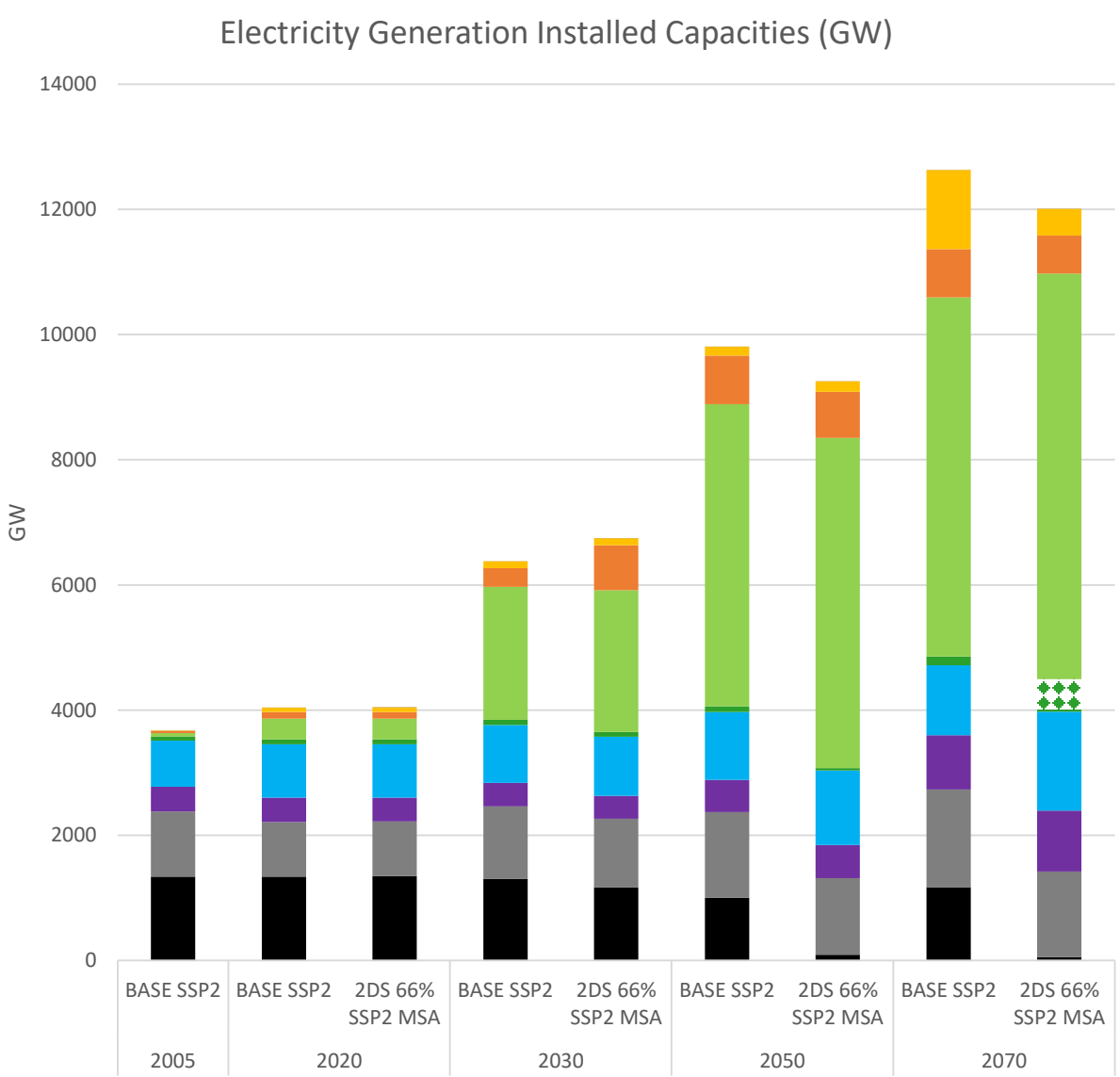
Primary Energy Requirement

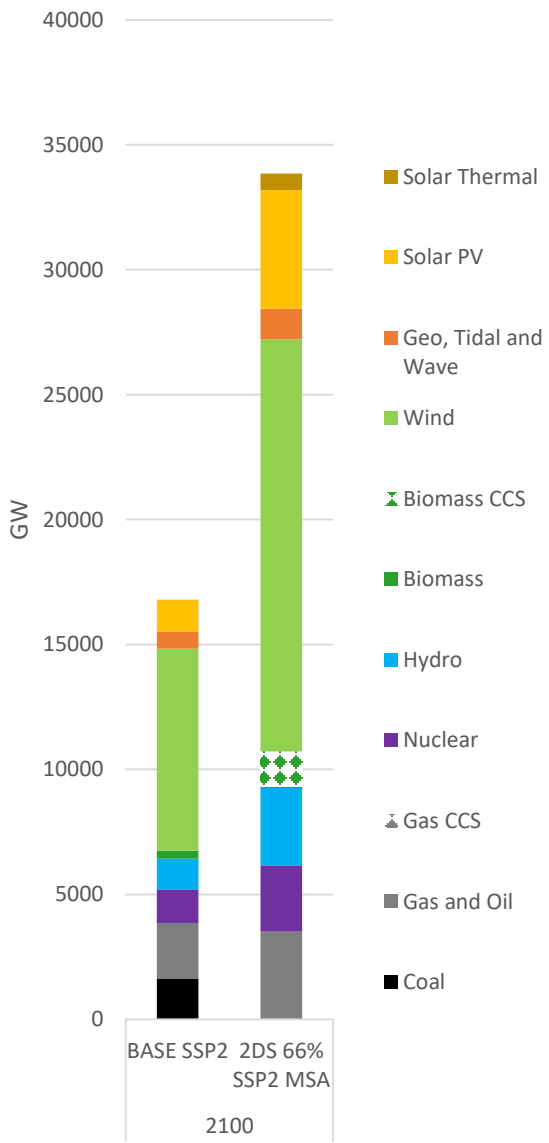


Final Energy Consumption

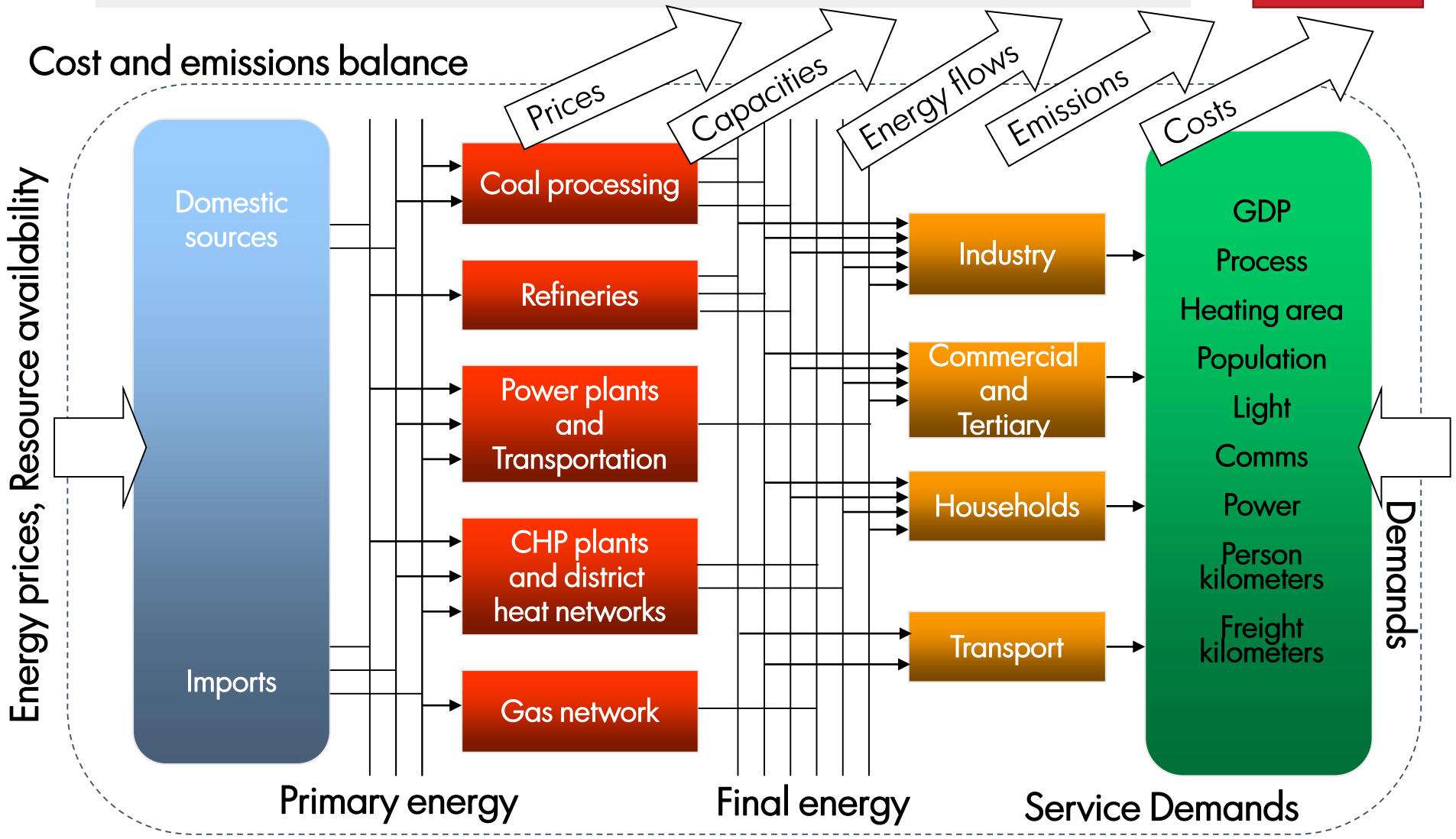


Electricity Installed Capacity

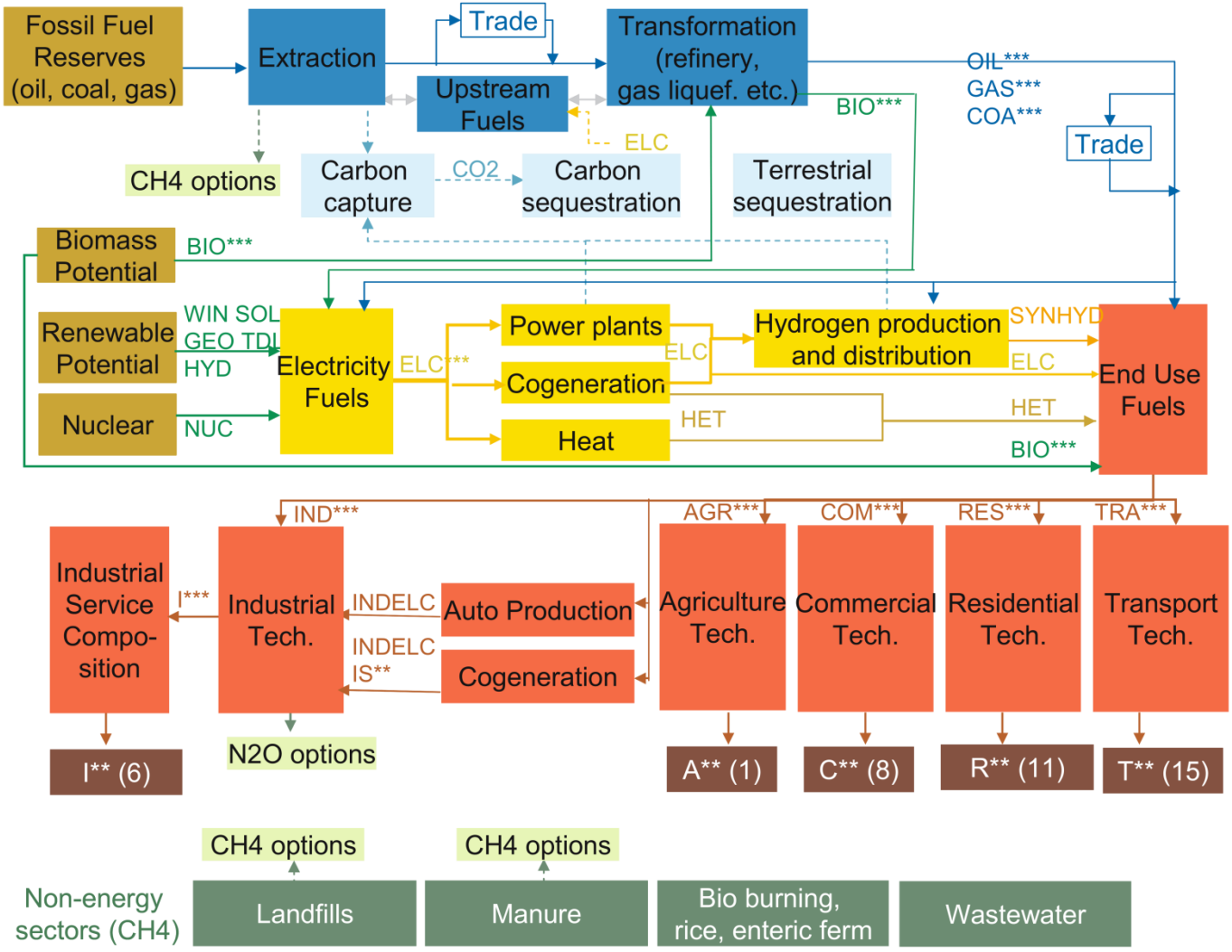




TIMES Energy System Model



ETSAP-TIAM
Reference Energy System



Source: Loulou, R., Labriet, M., 2008. ETSAP-TIAM: the TIMES integrated assessment model Part I: Model structure. Comput. Manag. Sci. 5, 7–40. doi:10.1007/s10287-007-0046-z

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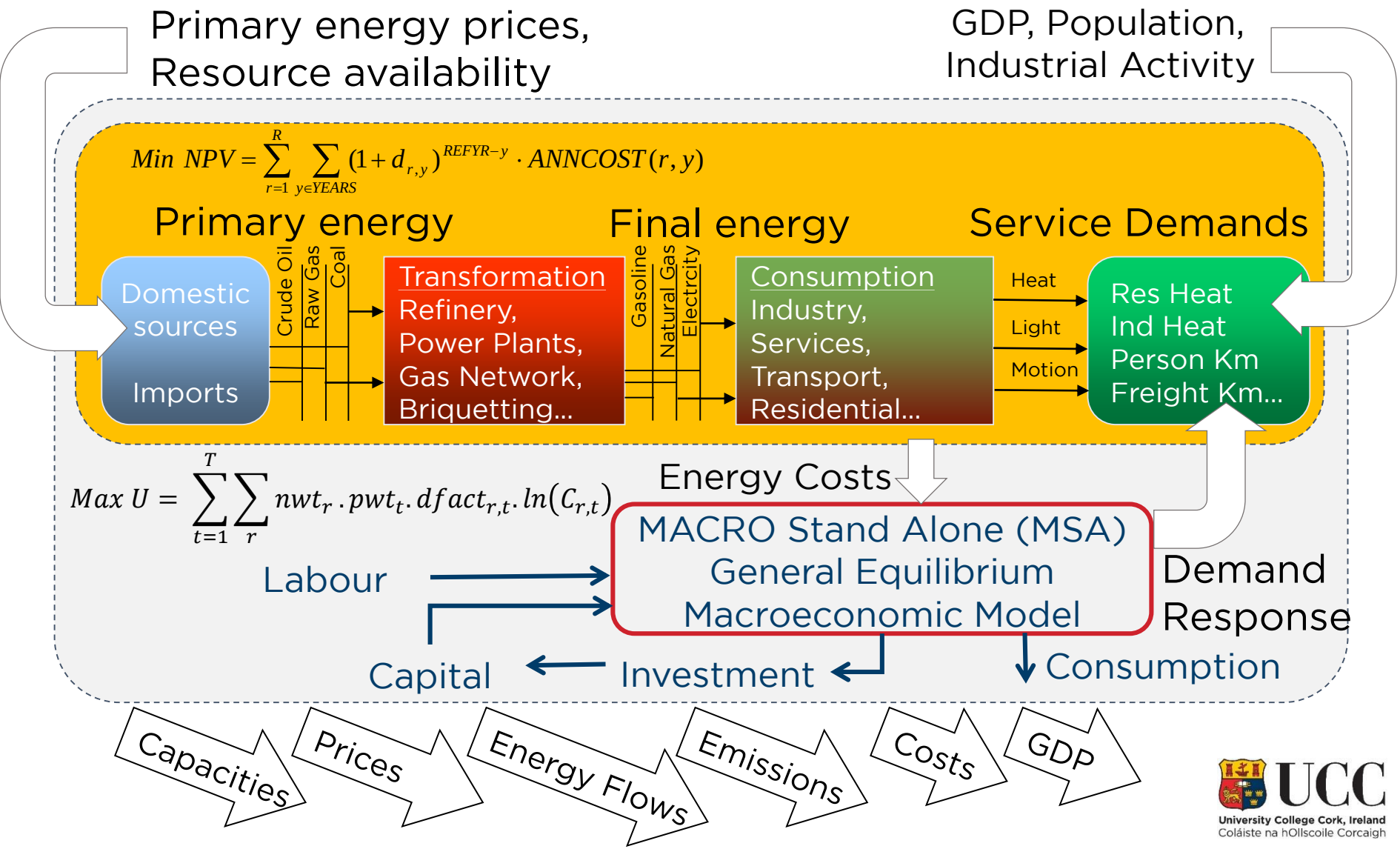
TIMES & MACRO Stand Alone



ETSAP-TIAM MSA (TMSA)
Macro Stand Alone

$$Min\ NPV = \sum_{r=1}^{R} \sum_{y \in YEARS} (1+d_{r,y})^{REFYR-y} \cdot ANNCOST(r,y) \qquad \text{(TIAM OBJ}_z\text{)}$$

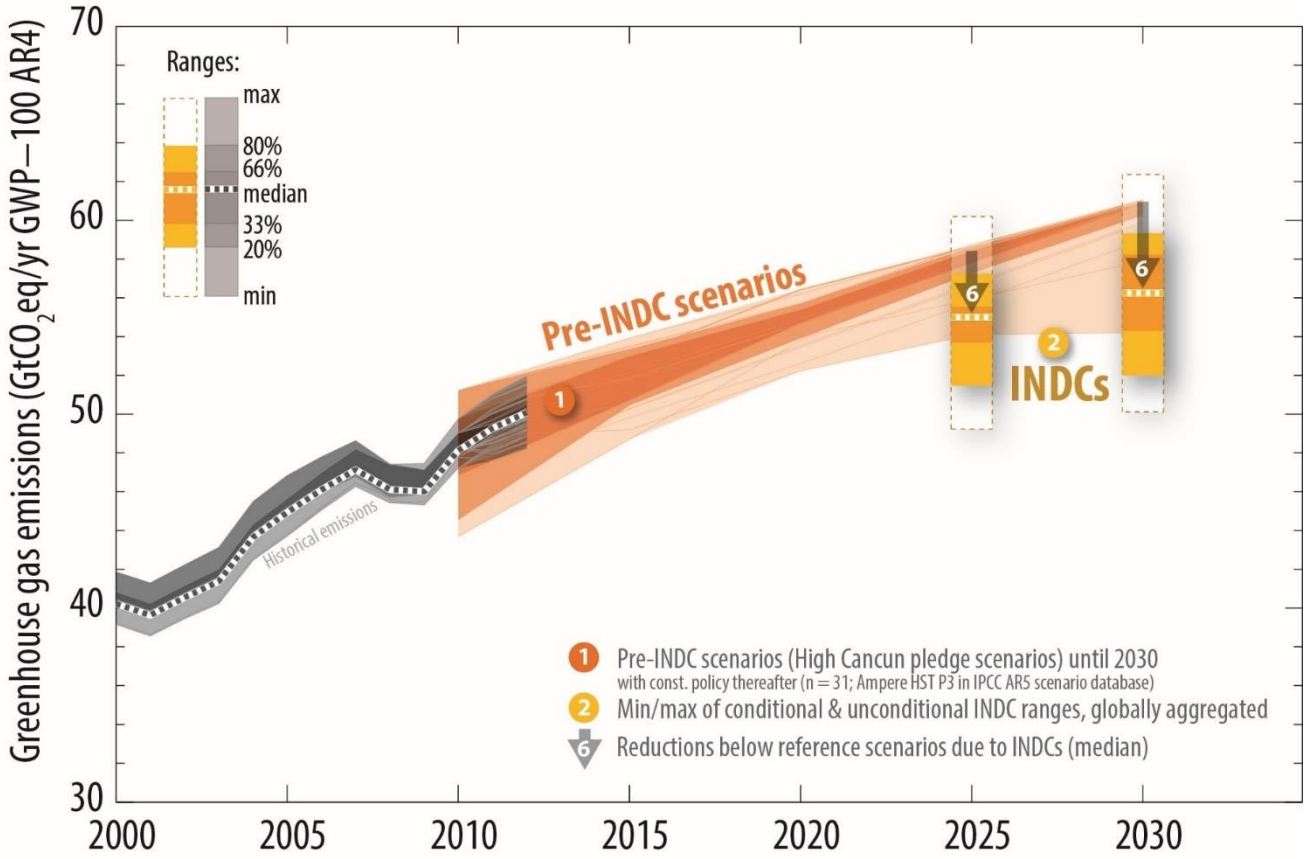
$$Max\ U = \sum_{t=1}^{T} \sum_{r} nwt_r \,.\, pwt_t \,.\, dfact_{r,t} \,.\, ln(C_{r,t}) \qquad \text{(1) (MSA OBJ}_z\text{)}$$

$$Y_{r,t} = C_{r,t} + INV_{r,t} + EC_{r,t} + NTX(nmr)_{r,t} \qquad (2)$$

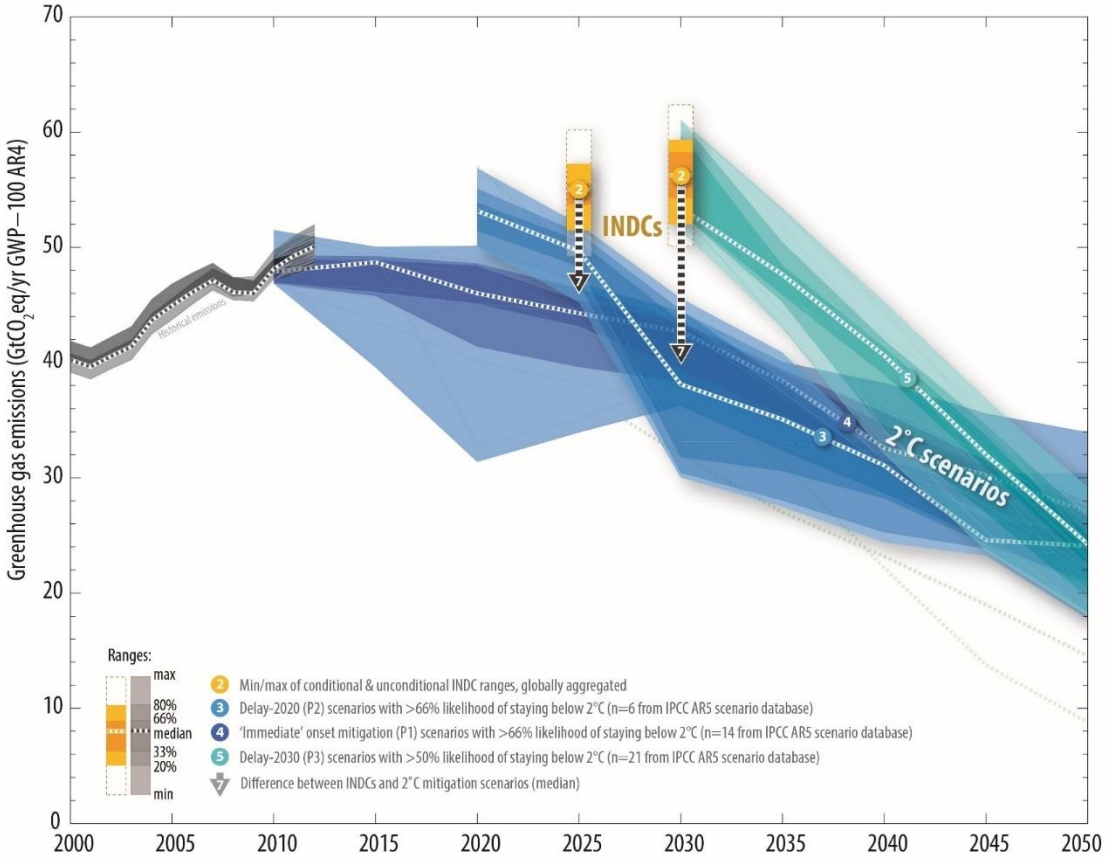
$$Y_{r,t} = \left(akl_r \cdot K_{r,t}^{kpvs_r \cdot \rho_r} \cdot l_{r,t}^{(1-kpvs_r)\rho_r} + \sum_{k} b_{r,k} \cdot DEM_{r,t,k}^{\rho_r} \right)^{\frac{1}{\rho_r}} \qquad (3)$$

- *nwt* – Negishi Weights
- pwt – weight Multiplier
- dfact – utility discount factor
- C – Consumption
- *Y* – Production
- INV – Investment
- EC – Energy Cost
- NTX – Net exports
- akl – production fn constant
- K – Capital
- kpvs – capital value share
- l – Labour annual growth
- b – Demand coefficient
- p – elasticity of substitution
- DEM – Energy Demands

National Determined Contributions and resultant GHG Global Pathways



2C Pathways, and delayed action to 2030



1.5C scenarios with Delayed Action