

Meeting Minimal Paris Agreement Emissions Targets in an Intertemporal Global Energy and Trade Model

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Where are we now?

- Weather is more variable and extreme, devastating fires burn on every continent except Antarctica. (**Black Summer**).
- The ice is melting, sea-level rise is accelerating – threatening island nations, major cities, and coastal areas. (**VMaCC**)
- Water supplies are shrinking in many parts of the world and droughts are threatening farms, livelihoods and food security (**UN**)
- The ocean is warming and becoming more acidic, destroying coral reefs and harming fish populations. (**AFMA/CSIRO**)
- Record-high temperatures are making many parts of the planet unlivable; biosecurity events more common. (**Varroa, LSD, FMD, Japanese encephalitis**)

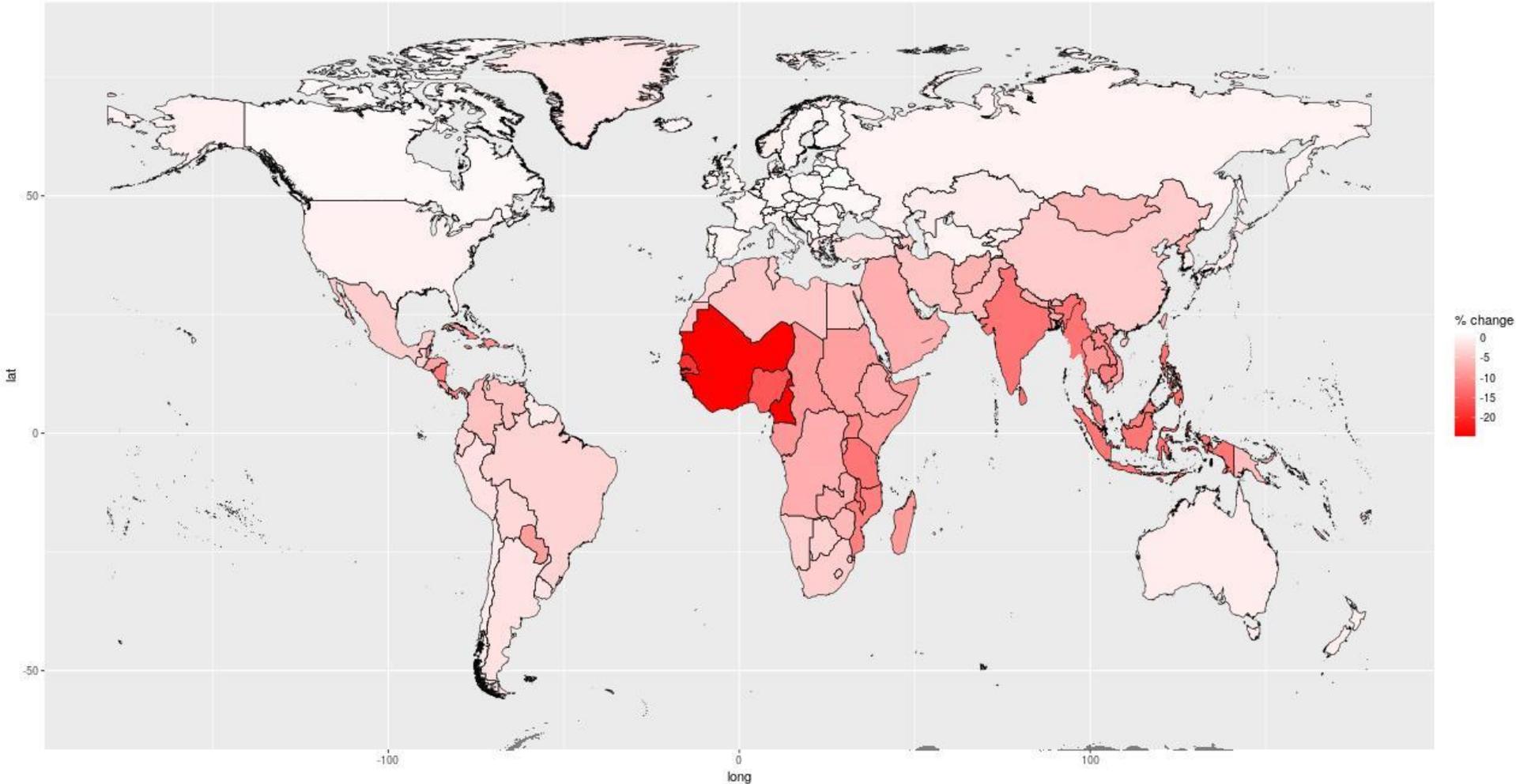
GTAP Model Settings

- Two trade and climate models (GTAP-INT & GTAP-IAM) 140 and 60 countries and up to 57+ commodity sectors to simulate the effects of temperature changes (i.e., global warming) on national income (GDP) **and** trade flows under different climate change scenarios.
- **Main** damage functions (national average effects):
 - Losses in agricultural productivity
 - Losses in labour productivity
 - Sea level rise – losses in arable land only
- Additional damages (post-GTAP model): GIS modelling on sea-level rise and storm surge, impacts on biodiversity and ecosystems, and bushfires/drought.
- Key message: Dimension matters!

Commodity Groups

57+ (with GTAP E/P): commodity groups (with trade and spatial dimension), including paddy rice, wheat, cereal grains, vegetables, fruits and nuts, bovine cattle, sugar cane, sugar beet, plant-based fibres, sheep, goats, horses, sugar cane, raw milk, wool, forestry, fishing, coal, oil, gas, meat products, vegetable oils and fats, dairy products, textiles, beverages and tobacco, wood products, paper products, chemical, rubber, leather products, plastics, metal products, electronic equipment, machinery, manufactures, air transport, motor vehicles, electricity, construction, business services, defence, public administration, dwellings, communication, financial services, construction, transport, recreational and other services, petroleum and coal products, wearing apparel, etc.

Global Economic Damages with 4C Warming



- Long run percentage losses in annual GDP globally: 1% to 28% depending on country; average loss in GDP *across* countries is 7%. Estimates (OECD) of falls in global GDP from COVID-19: 5-7%; for Australia: 4.1% (Treasury: 6%).

Global Economic Damages (summary)

- Even with a limited set of damage functions (losses in agricultural and labour productivity, limited human health effects and losses in arable land from sea-level rise), global cumulative damages are **\$610 trillion** USD (\$820 trillion AUD) from now to 2100.
- On average that amounts to \$7.6 trillion per year over the next 80 years.
- The projected (ADB) cost of COVID-19 is roughly \$7.3 trillion.

Economic Damages in Australia

- Using more extensive damage functions, cumulative damages to **2050 exceed \$1.89 trillion AUD**, or 4-5% of projected GDP – roughly COVID-19 equivalent on average GDP loss.
 - Losses in agricultural and labour productivity (\$261 billion); SLR/Floods (\$992 billion); bushfires (\$360 billion); biodiversity losses (\$277 billion).
- **After 2050 damages ramp-up considerably. In 2100, (RCP6.0): SLR/Storm damages alone in AUS are more than \$11 trillion or 8.4% of projected GDP.** Losses in labour and agricultural productivity range to 22% depending on state in 2100. GSP falls: QLD 17%; NSW 9%; WA 8.25%, VIC 6%

Modelling Approaches for Emissions Reduction

- GTAP-R: Dynamic Recursive Model (period-by-period solution, given a time horizon, to 2050, with adaptive expectations).
- *GTAP-DynR: Forward-looking Intertemporal Model (all periods solved at once with a fixed time horizon to 2100).
- GTAP-R/INT: Full (Optimal) Intertemporal ‘Integrated Assessment Model’ (all periods solved at once with specified terminal condition, convergence near 2300).

Model Settings (Data) GTAP DYN-R

- GTAP 10 Database/GTAP-Power
- 30 regions: Key Emitters (China, USA, India), ASEAN, BRICS, Brazil, Germany, France, UK, Italy, North Africa, South Africa, Russia, Australia, New Zealand, South Asia, Japan, Korea, Central Europe, Northern South America, Other Western Europe, etc.
- 28 commodity groups: Crops, Forestry, Fishing, Coal, Oil, Chemicals, Rubber and Plastics, Iron and Steel, Gas, Renewables (wind, hydro, solar, nuclear), Wood and Paper products, Services, Road Transport, Sea Transport, Manufacturing, Construction, other Minerals, etc.
- IRENA, BP, IEA supporting data (Mtoe or million tons of oil equivalent, EJ or Exajoules, etc.)

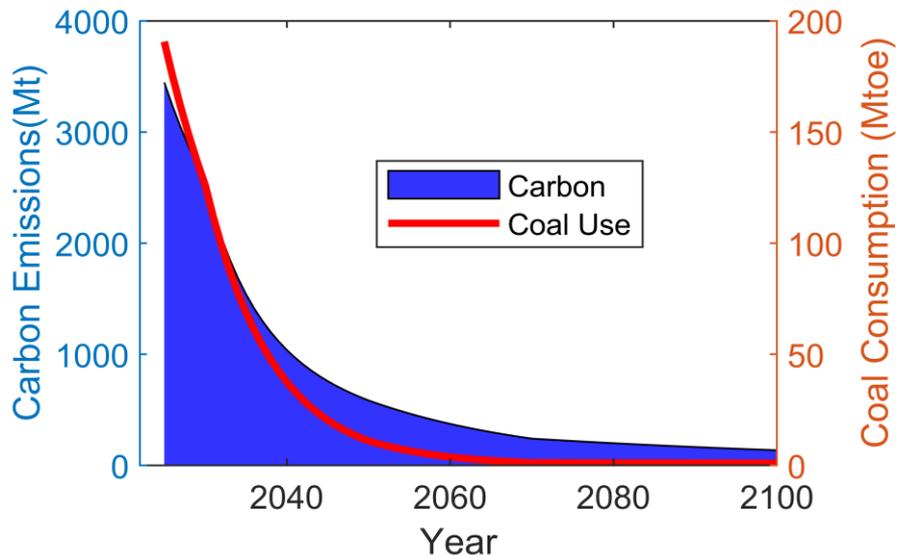
Model Settings (Shocks/Parameterization)

- Improvements in Energy Efficiency (a given level of output or service is provided with reduced amounts of energy)
- Changes in Energy Intensity (units of energy per unit of GDP)
- Fall in Renewable Costs/Prices (IRENA projections)
- Price on Carbon Emissions (vary by region/country and time period, increasing to 2050, etc.)
- Land Use Change (re-forestation, contingent on the type of tree, its location and age)
- SSP2-RCP4.5 (Base Case) vs. (better than) SSP1-RCP2.6

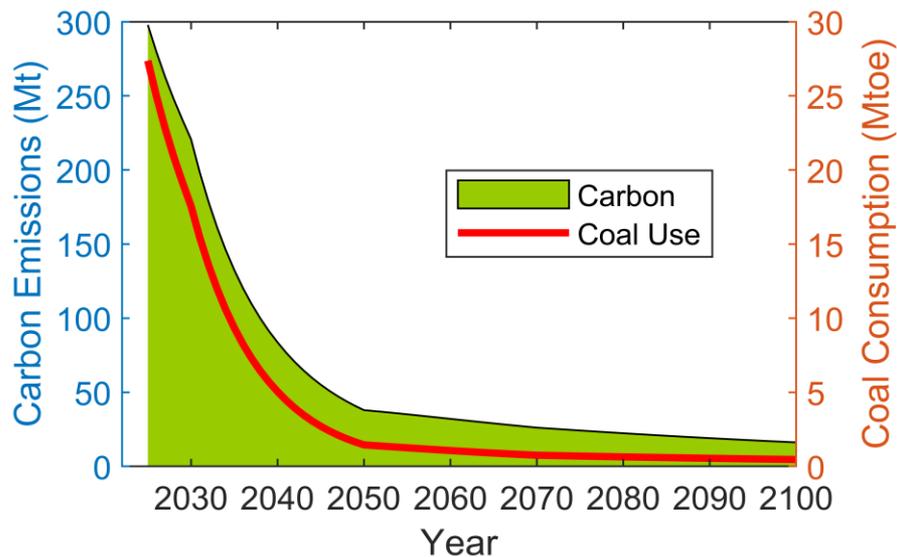
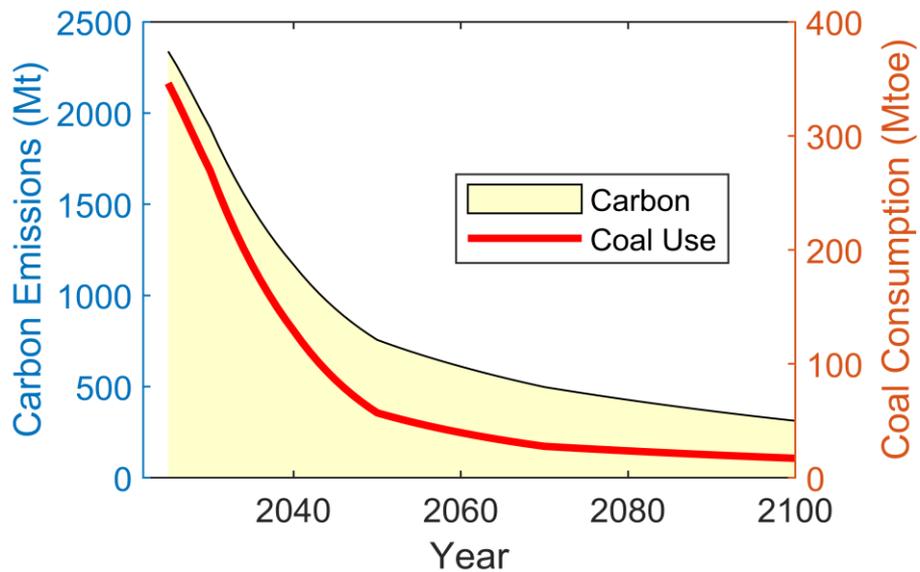
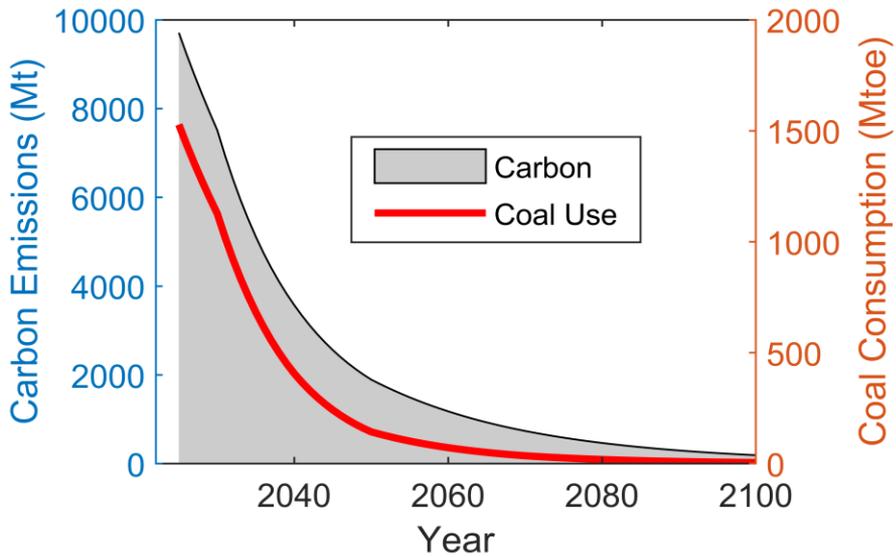
Model Results (GTAP-R/GTAP-DynR)

- Results show that the use of fossil fuels needs to be reduced substantially by 2050, for coal alone by over 90% in India, China and the USA, compared to 2019, with a sustained transition to renewable energy.
- Globally, model results show reductions in fossil fuel carbon emissions overall must decrease by at least 4% per year, on average, to meet a minimal Paris Agreement target of less than 2oC warming and domestic coal consumption must fall continuously from 2022 forward.
- Limited carbon sequestration from forestry and land use change can help generate a near global net zero model outcome in 2050, albeit with marked uncertainty.

USA



China

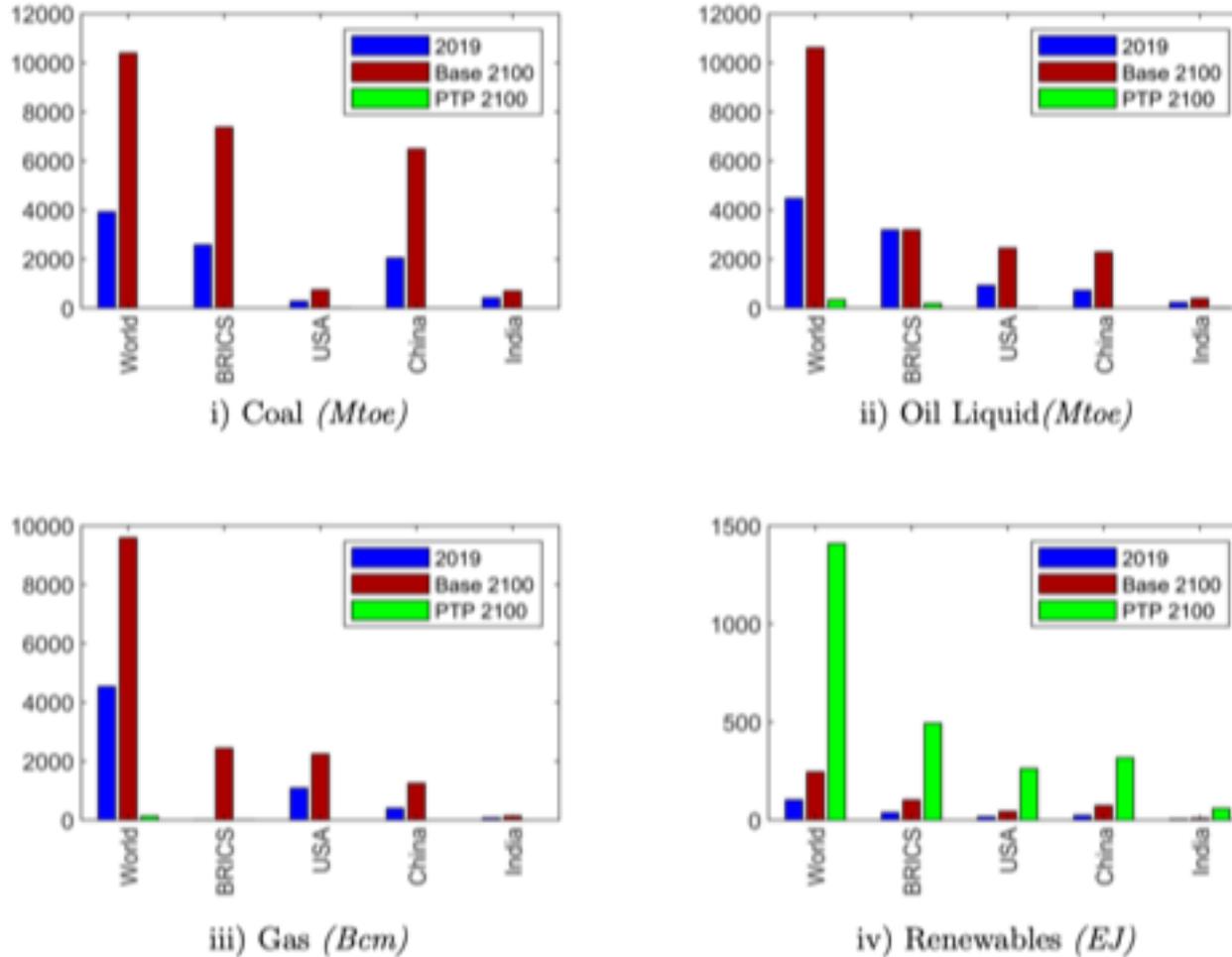


GTAP-DynR

India

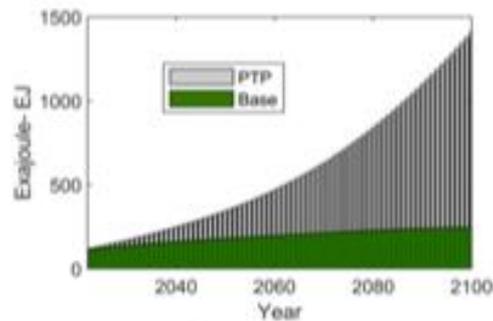
AUS

Figure 3: Fuel Consumption by Scenario in 2100

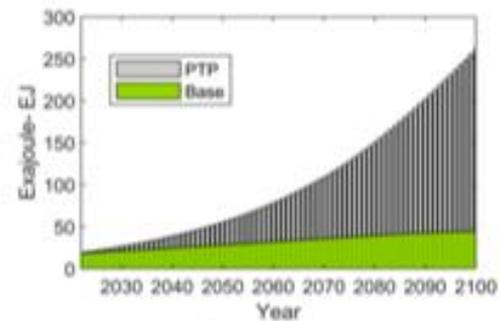


Note: Reference year is 2019 (BP, 2020; IEA, 2021c). Base 2100 is fuel consumption for the Base Case. PTP 2100 is the Paris (Agreement) Transition Path (for the vicinity of SSP1-RCP1.9). Mtoe: Million Tons of Oil Equivalent; Bcm: Billion Cubic Meters; EJ: Exajoule.

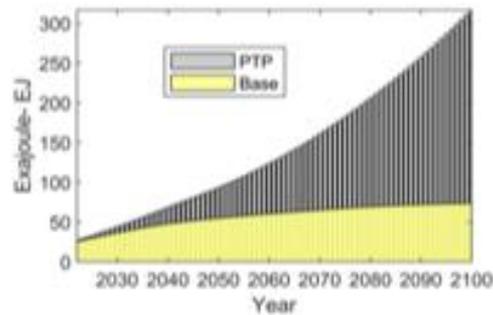
Figure 2: Annual Renewables Consumption of the World and Selected Regions



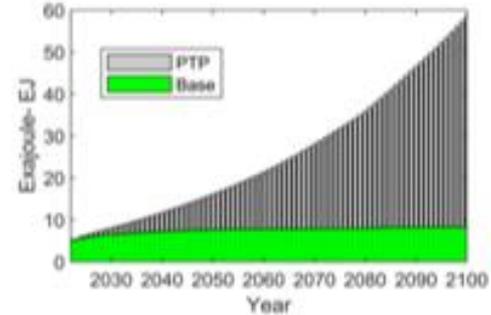
i) The World



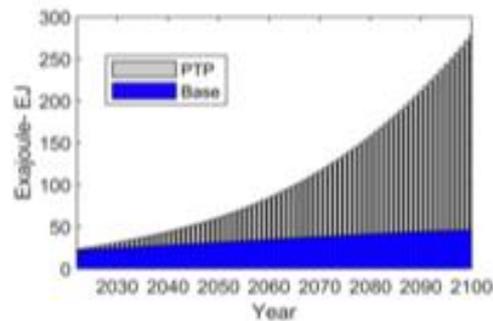
ii) The USA



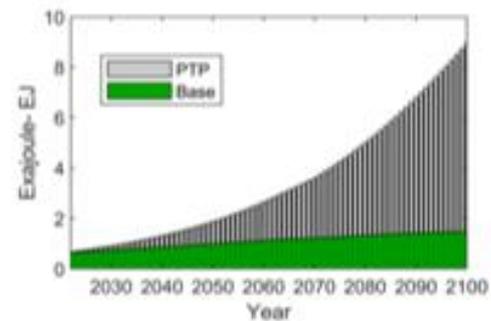
iii) China



iv) India



v) Western Europe



vi) Australia

Thanks for listening!

