Resource competition: Supporting a growing population whilst reducing greenhouse gas emissions.

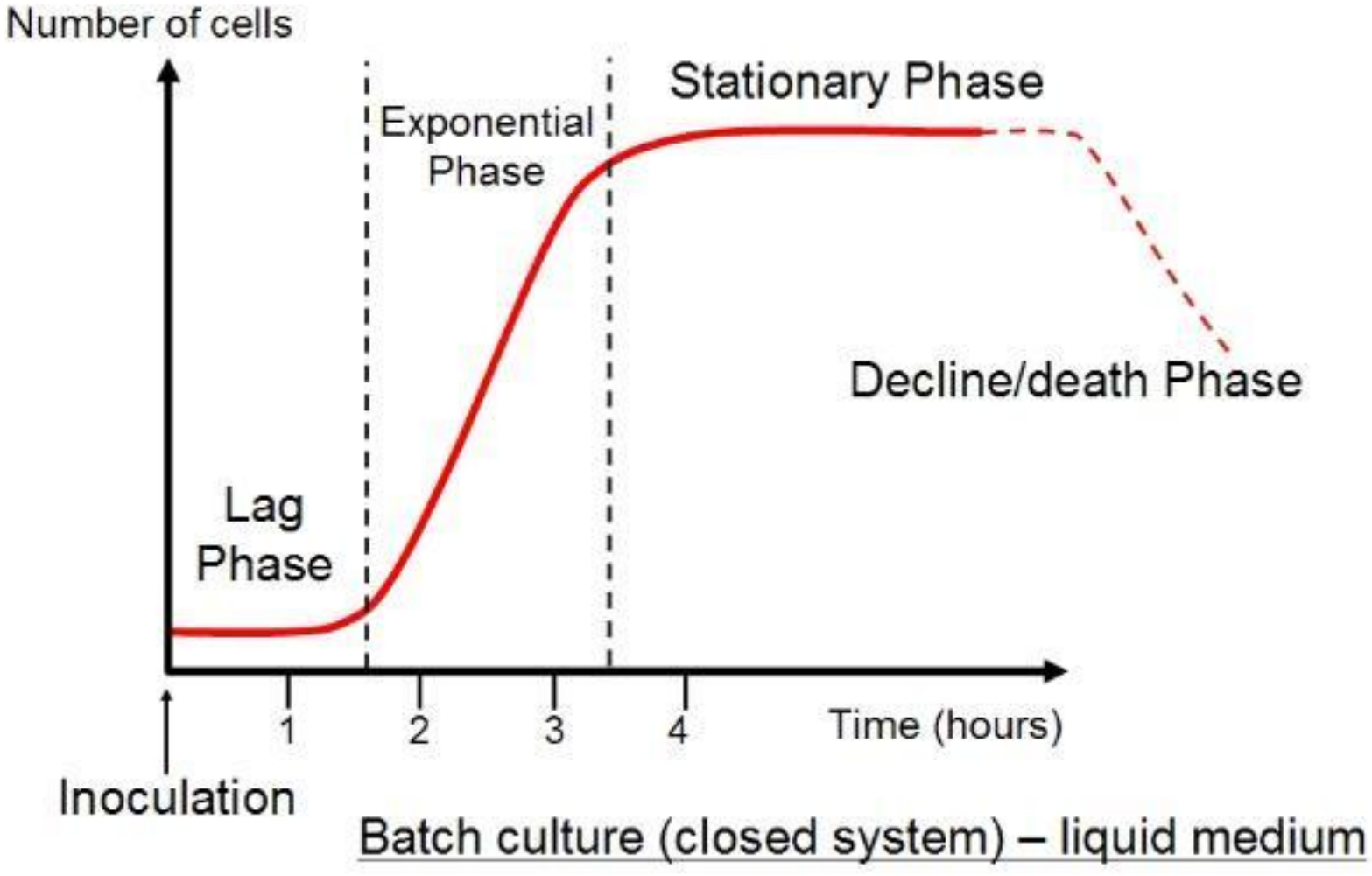
Astley Hastings

UNIVERSITY OF ABERDEEN

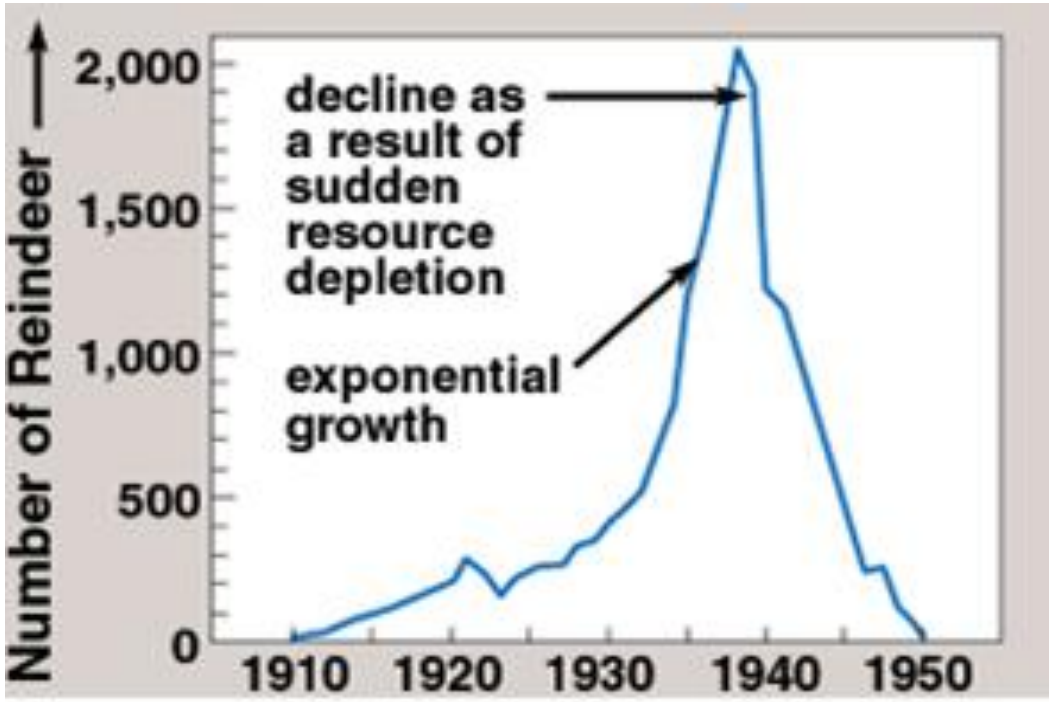
Outline

- **Population**
- Energy
- Emissions
- Resources limits
- Food
- Way forward

Population interaction with the environment

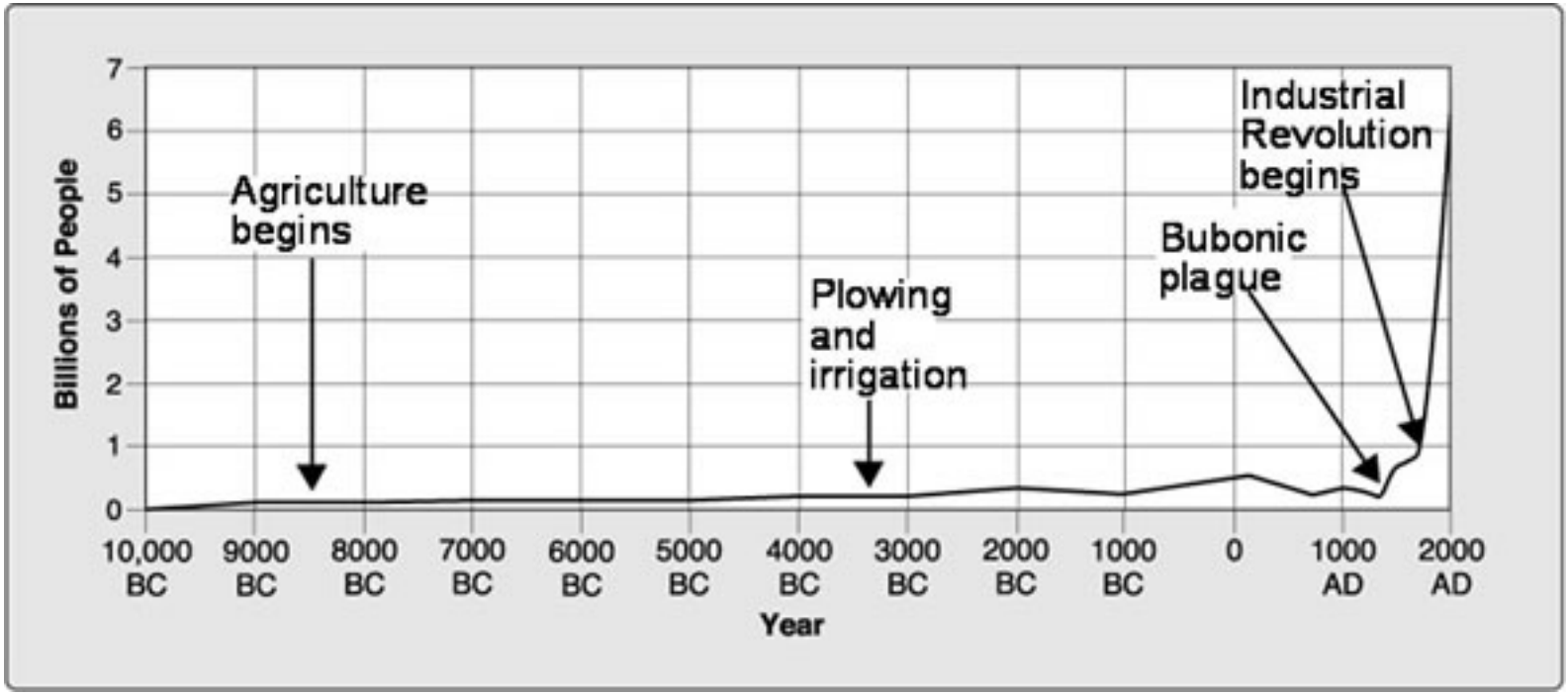


Reindeer population
St Pauls Island
Aleutian Islands



Klein 1968

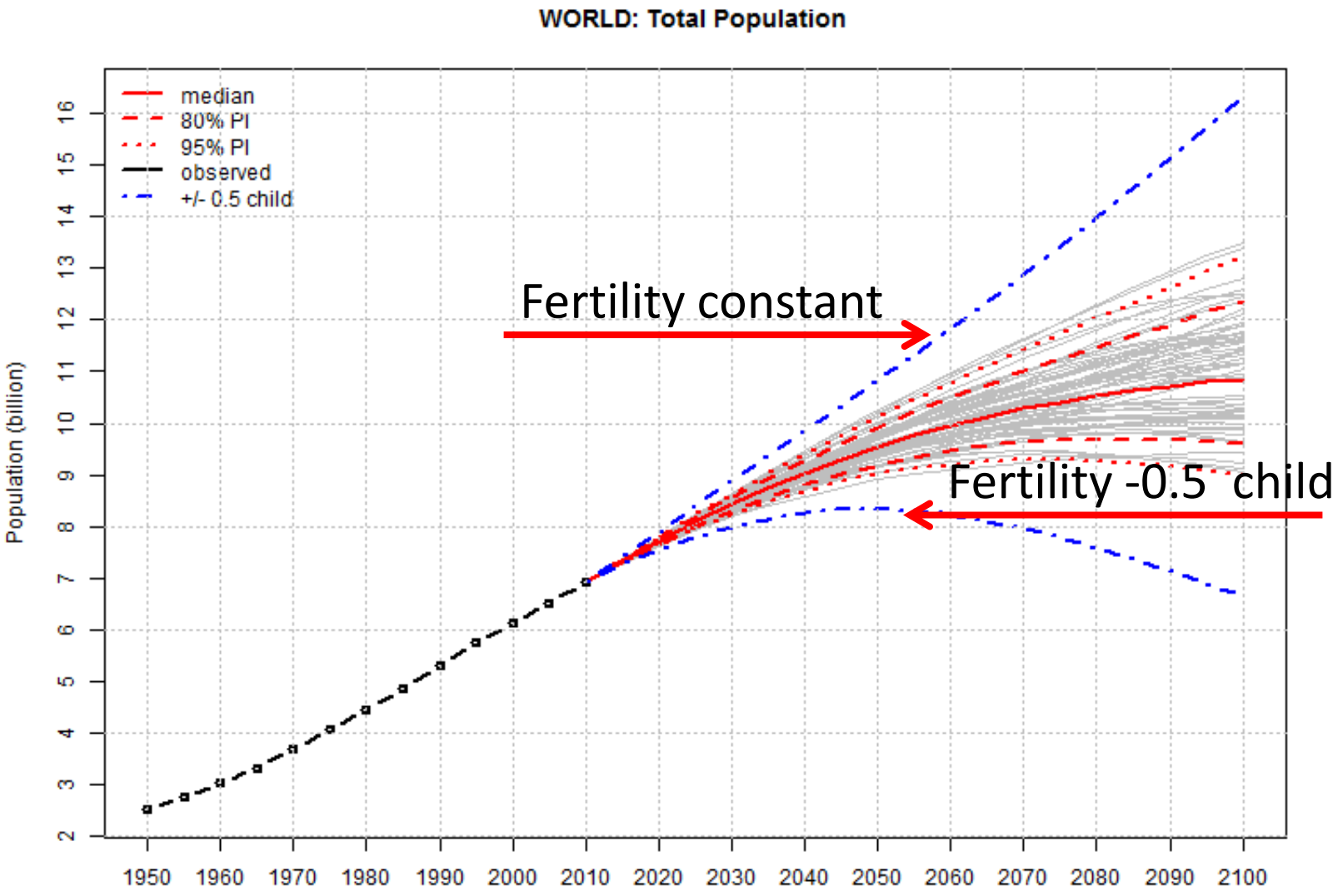
Why are humans so successful



- Collaboration
- Competition
- Dexterity
- Inquisitiveness
- Agriculture
- Engineering
- Science
- **Energy use**

Wikipedia

Population projection

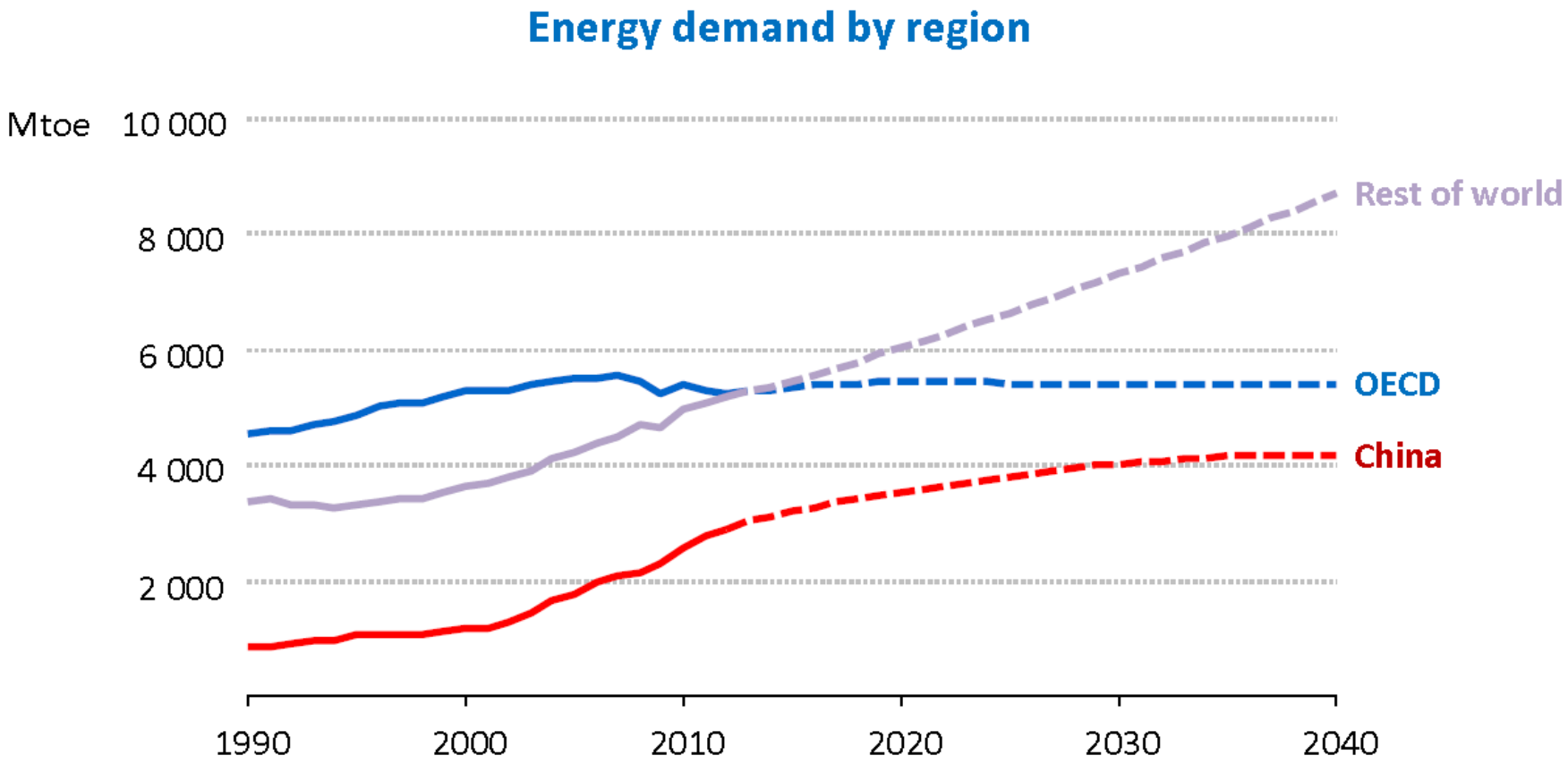


Source: United Nations (2014). *Probabilistic Population Projections based on the World Population Prospects: The 2012 Revision*. Population Division, DESA. ST/ESA/SER.A/353. http://esa.un.org/unpd/ppp/

Outline

- People
- **Energy**
- Emissions
- Resources limits
- Food
- Way forward

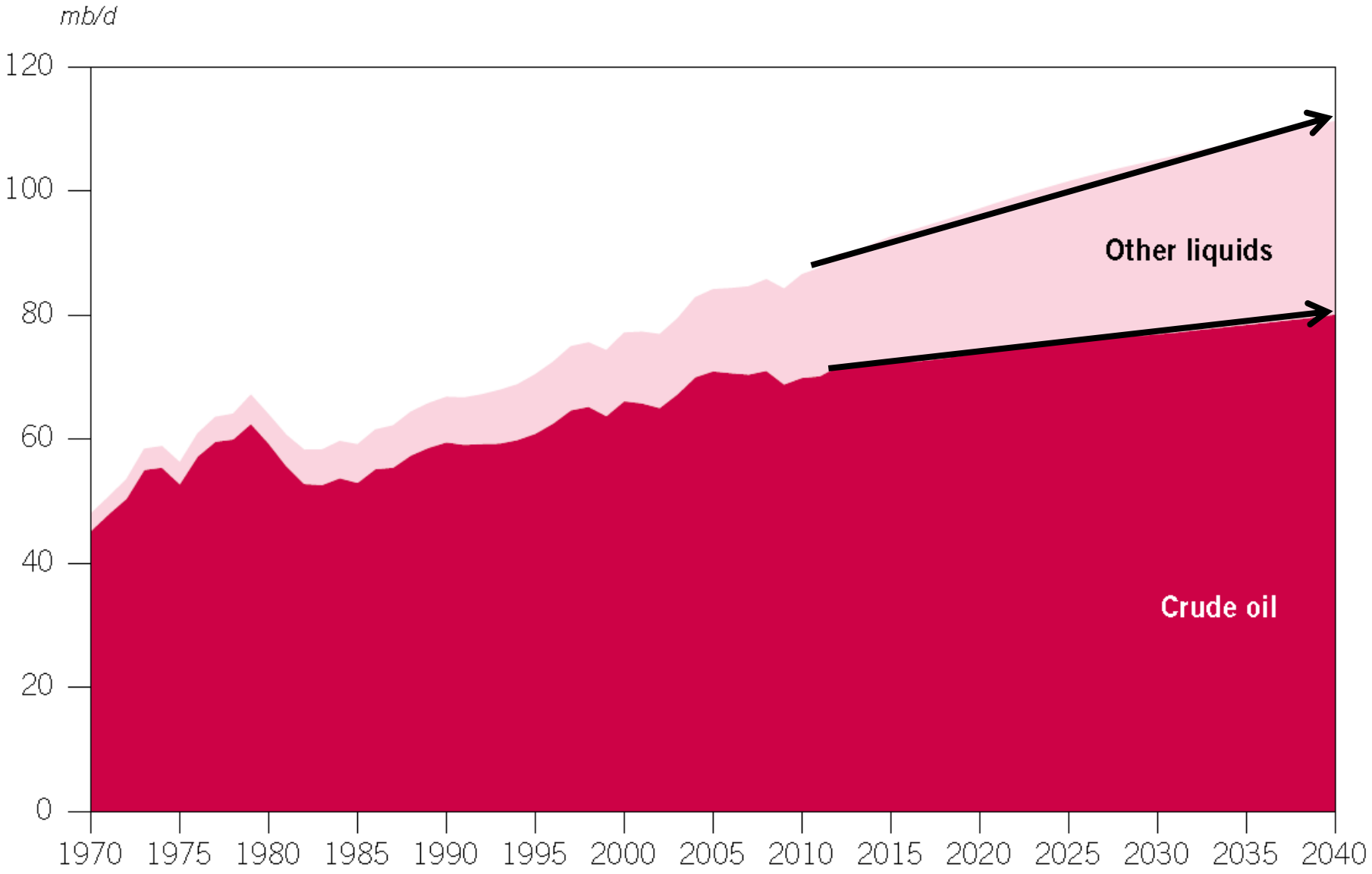
Energy demand continues to rise



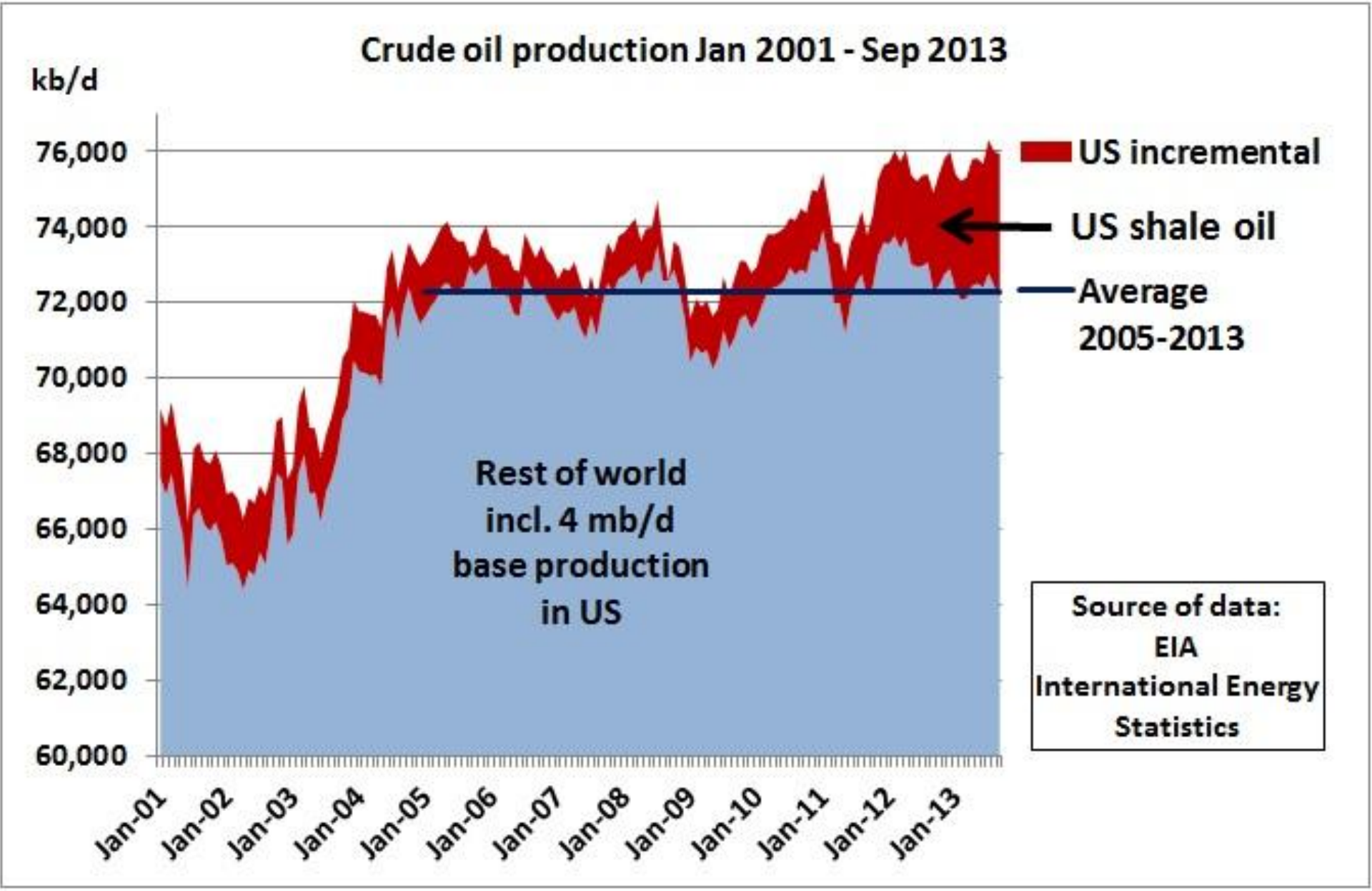
As China slows, then India, Southeast Asia, the Middle East and parts of Africa & Latin America take over as the engines of global energy demand growth.

IEA 2014

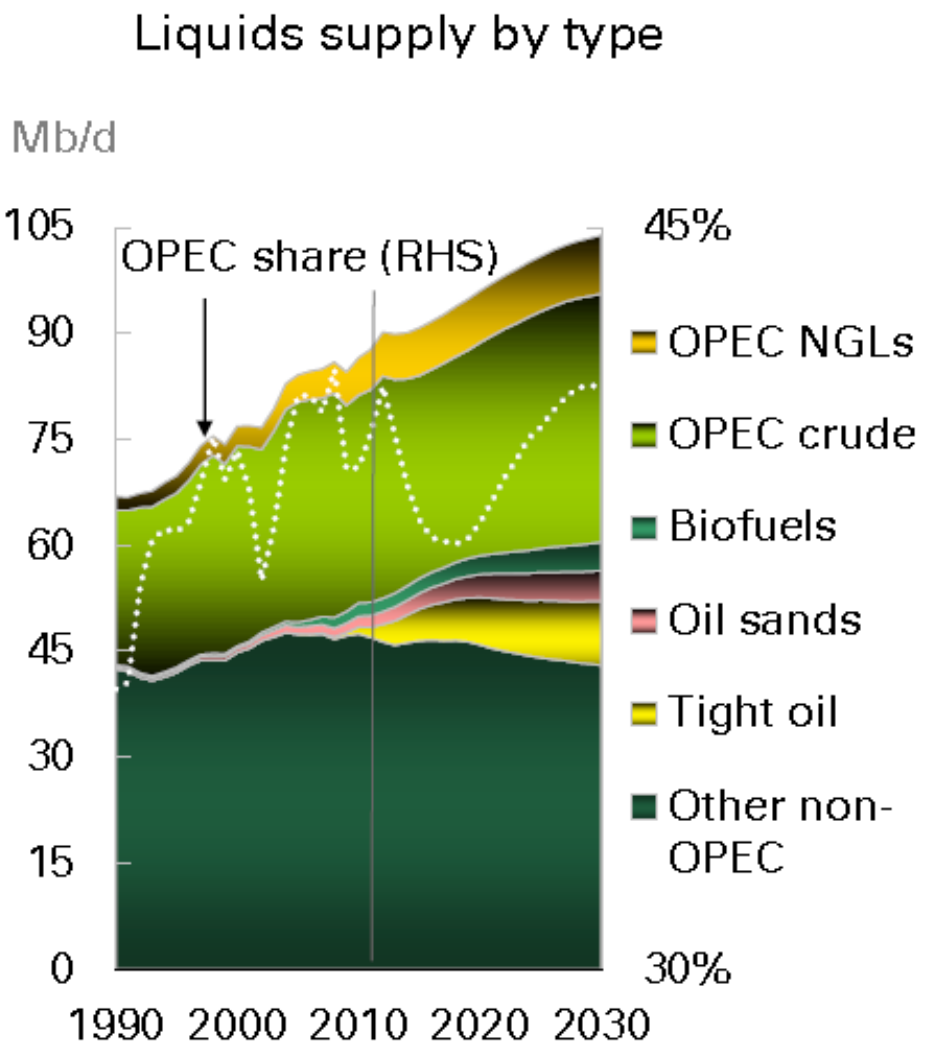
Projected crude oil demand

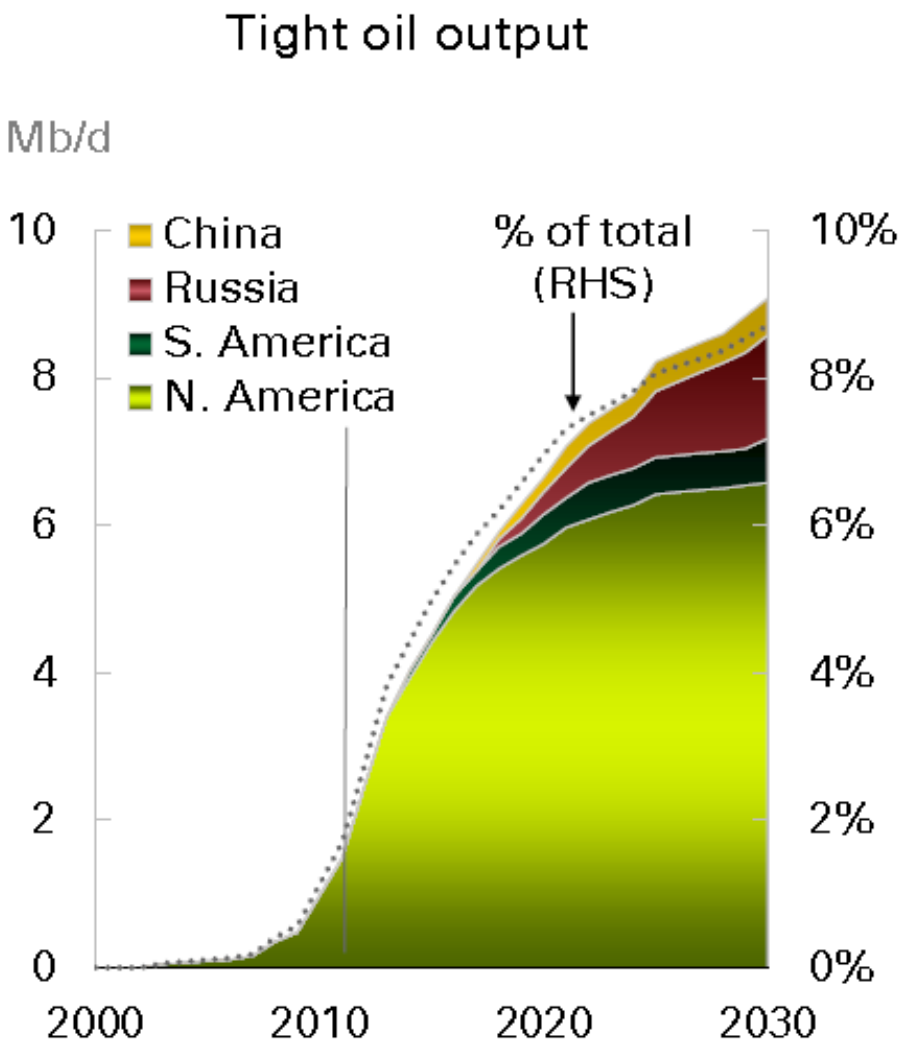


WOO 2014,OPEC

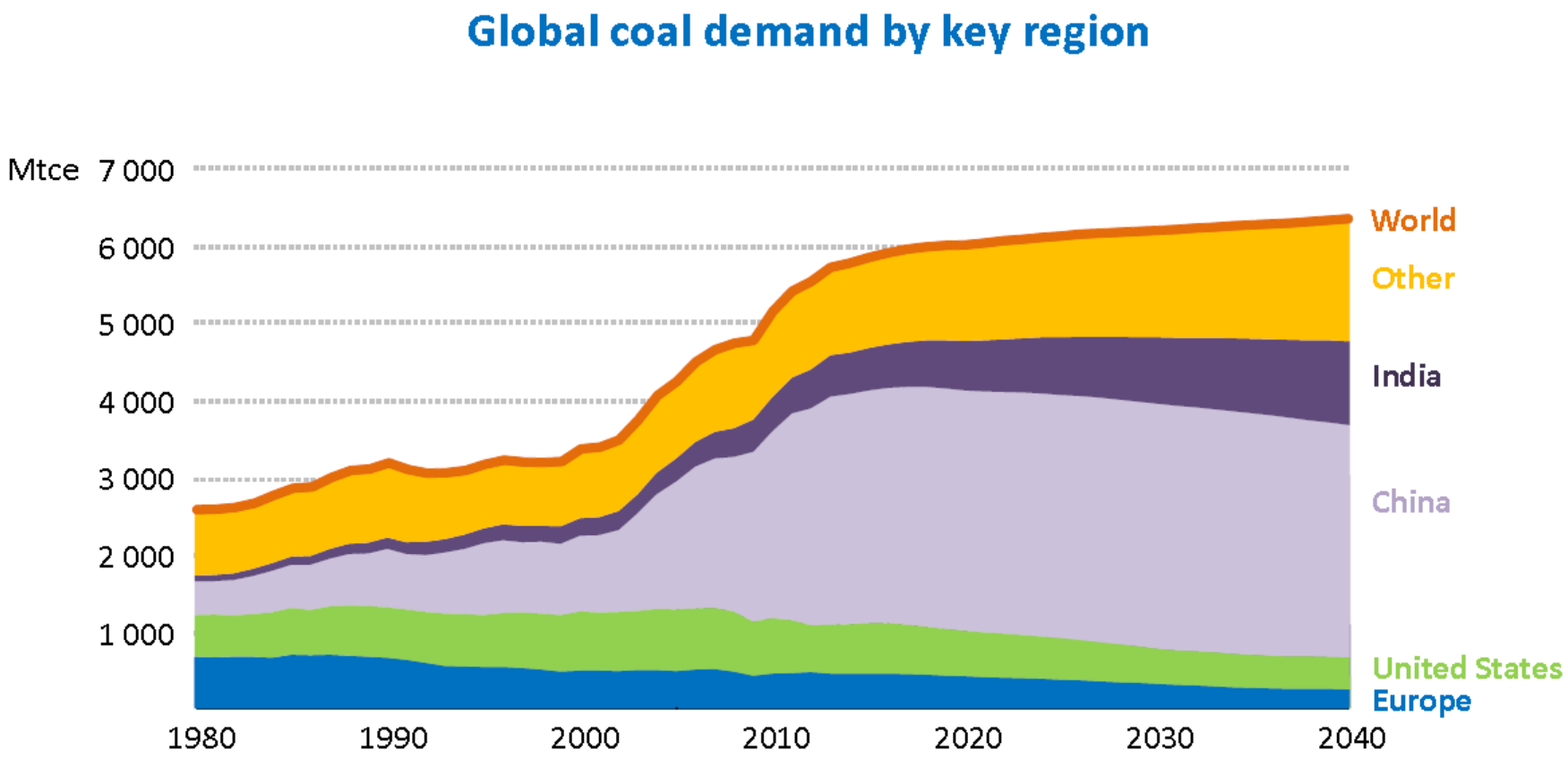

Crude oil production Jan 2001 - Sep 2013
kb/d
76,000
74,000
72,000
70,000
68,000
66,000
64,000
62,000
60,000
US incremental
US shale oil
Average 2005-2013
Rest of world incl. 4 mb/d base production in US
Source of data: EIA International Energy Statistics
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13

Oil demand satisfied by tight oil





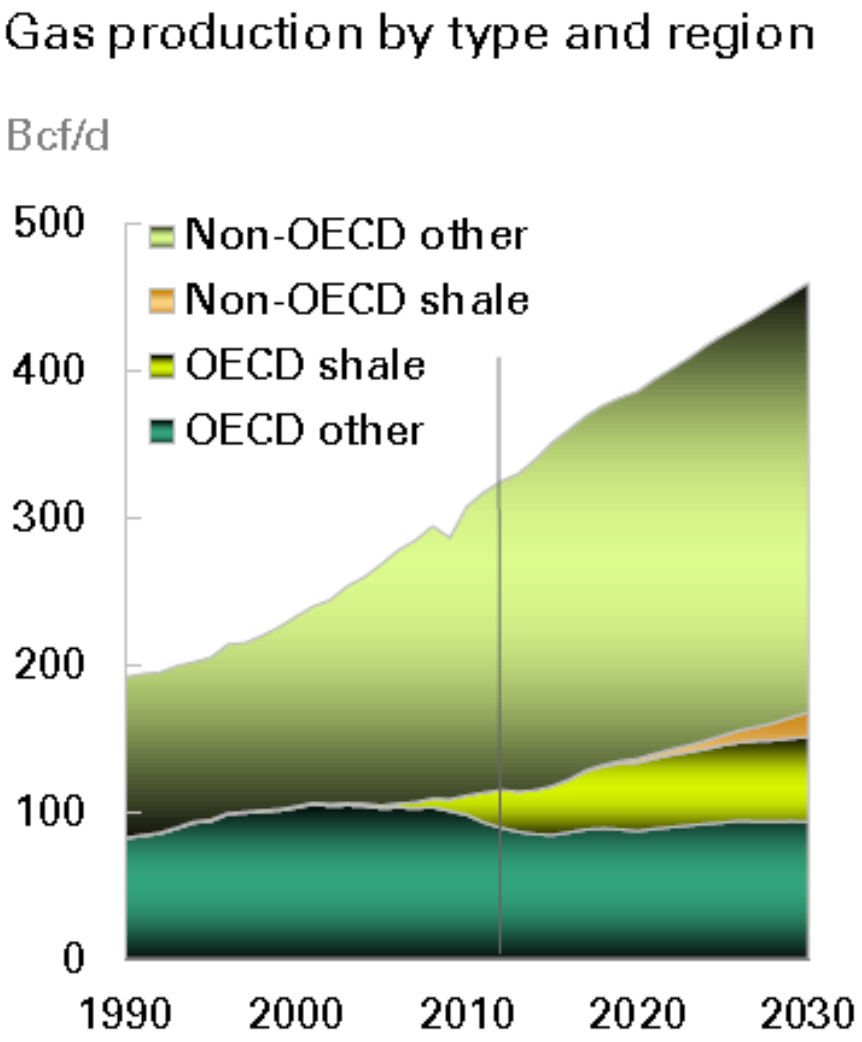
Coal use limited by GHG emissions

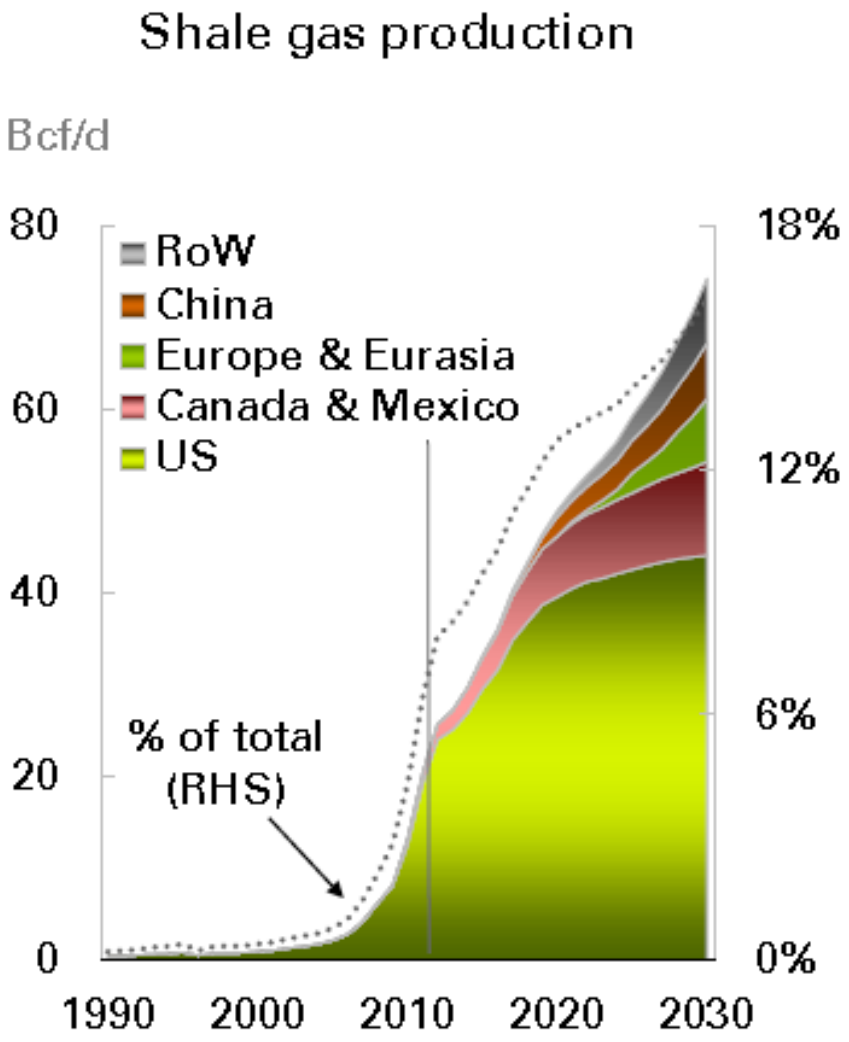


Global coal demand growth slows rapidly due to more stringent environmental policies, underlining the importance of high-efficiency plant & CCS to coal's future

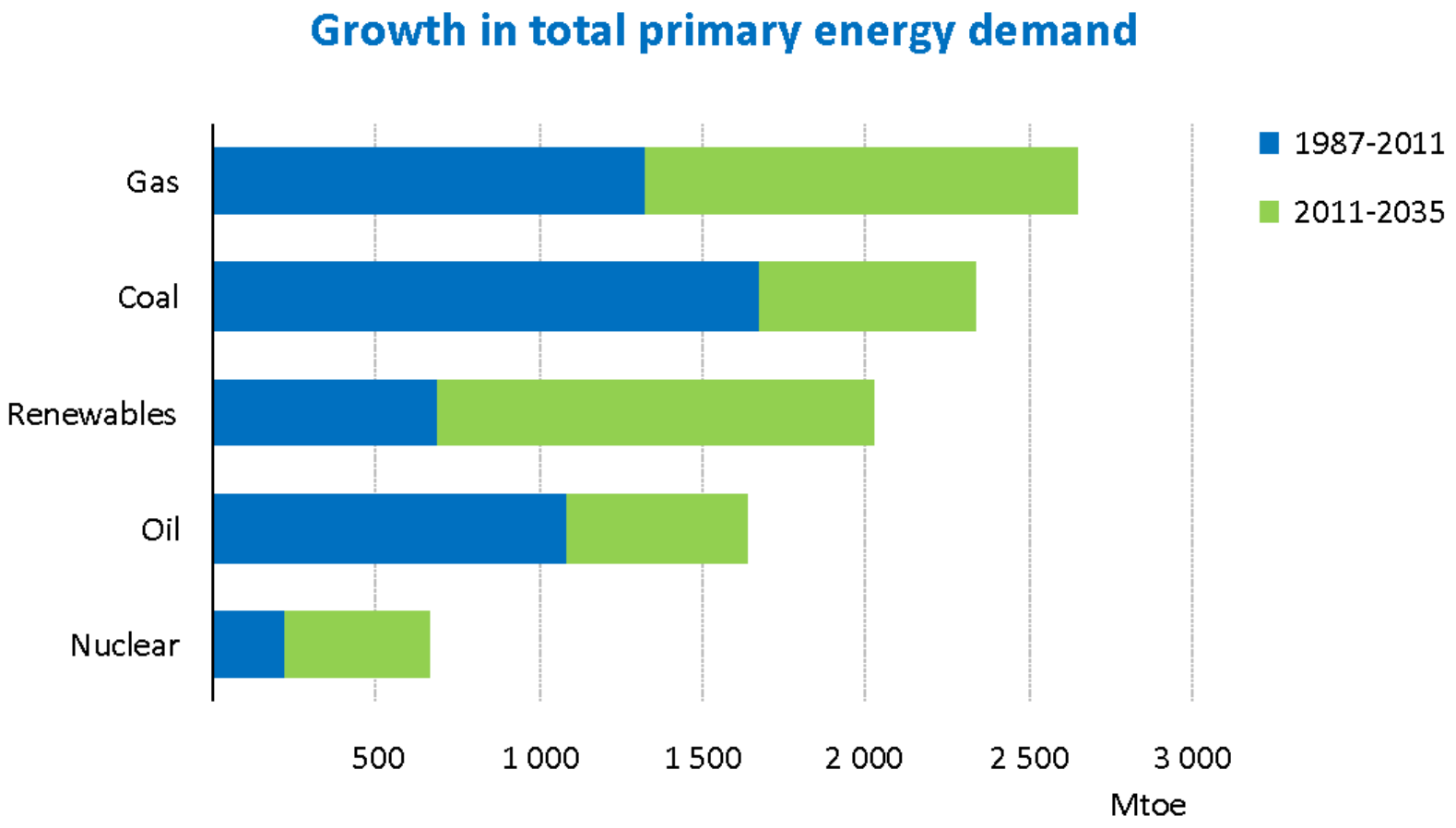
IEA 2014

Gas demand increase satisfied by LNG and shale gas





The energy mix changes slightly



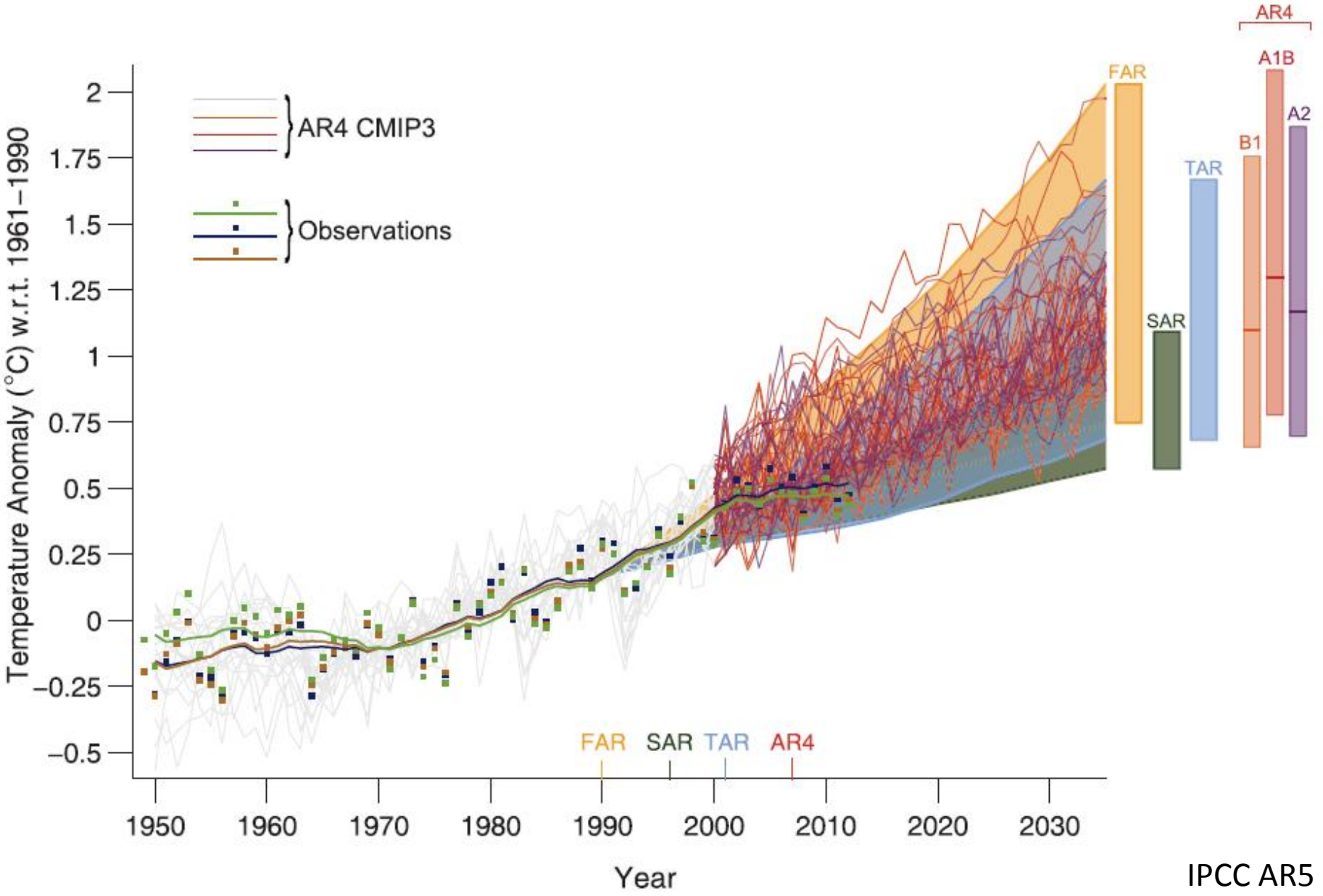
Today's share of fossil fuels in the global mix, at 82%, is the same as it was 25 years ago; the strong rise of renewables only reduces this to around 75% in 2035

IEA 2014

Outline

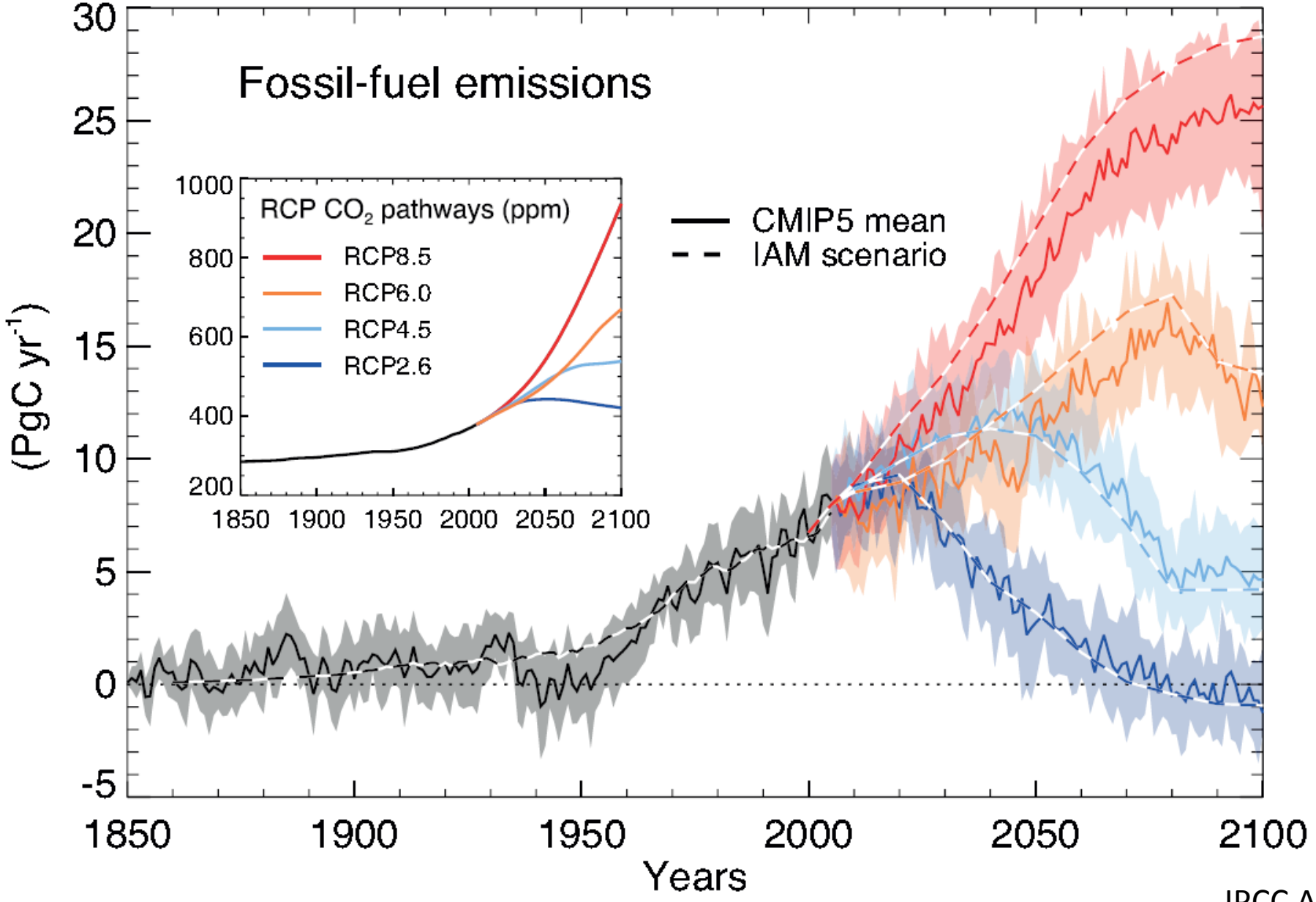
- People
- Energy
- **Emissions**
- Resources limits
- Food
- Way forward

Climate change and model predictions



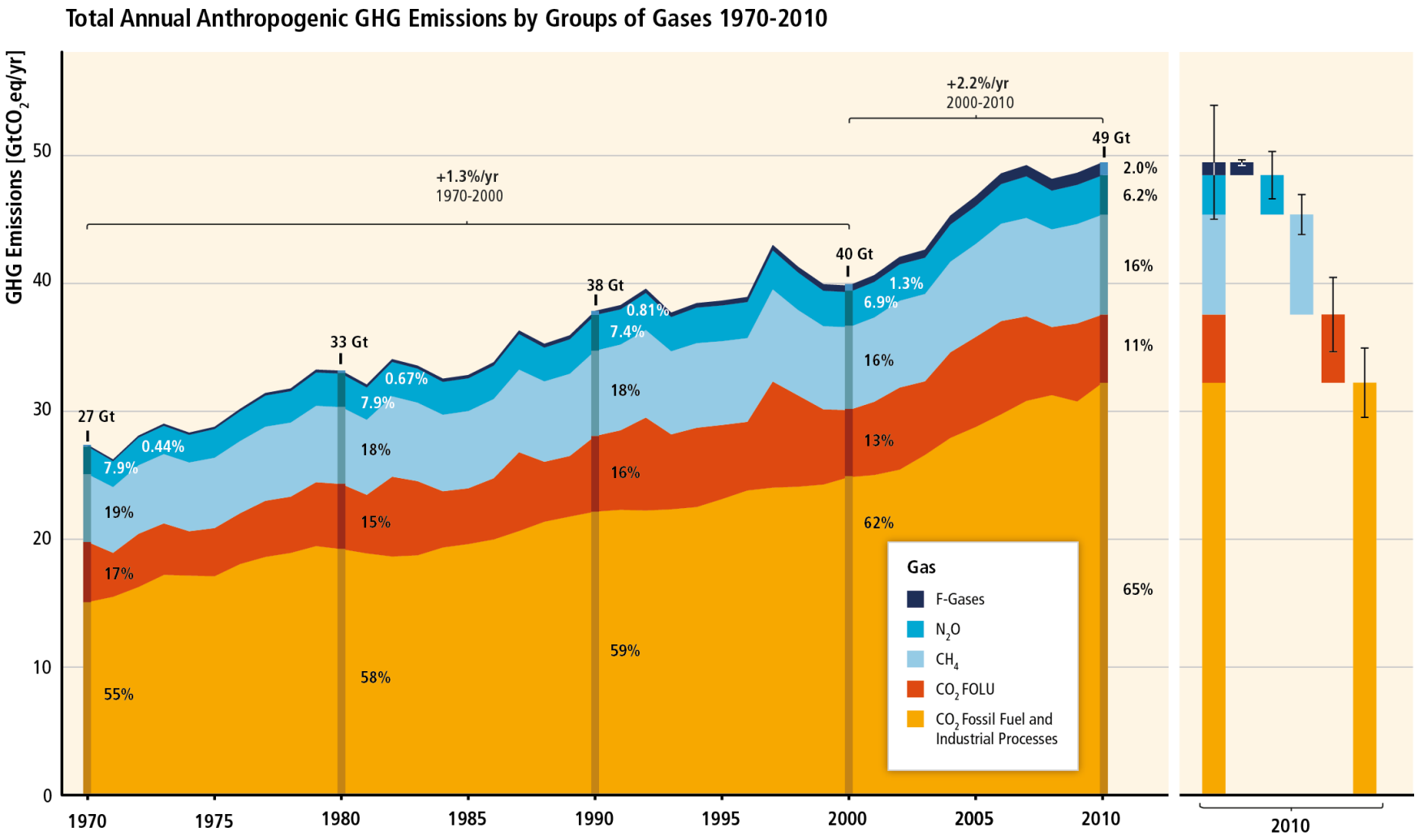
IPCC AR5

Emissions driving the models



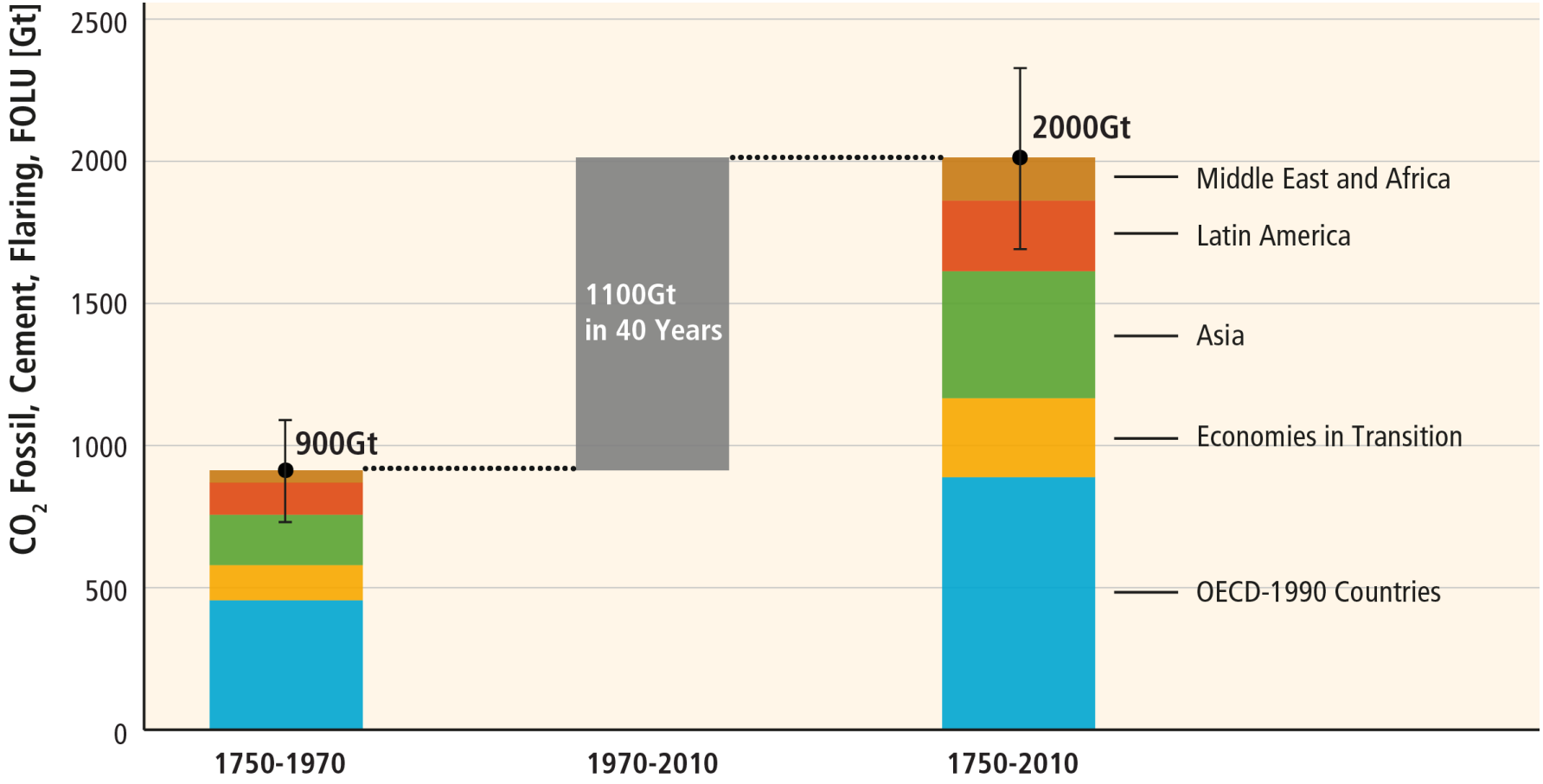
IPCC AR5

GHG emissions growth has continued to increase despite policies.



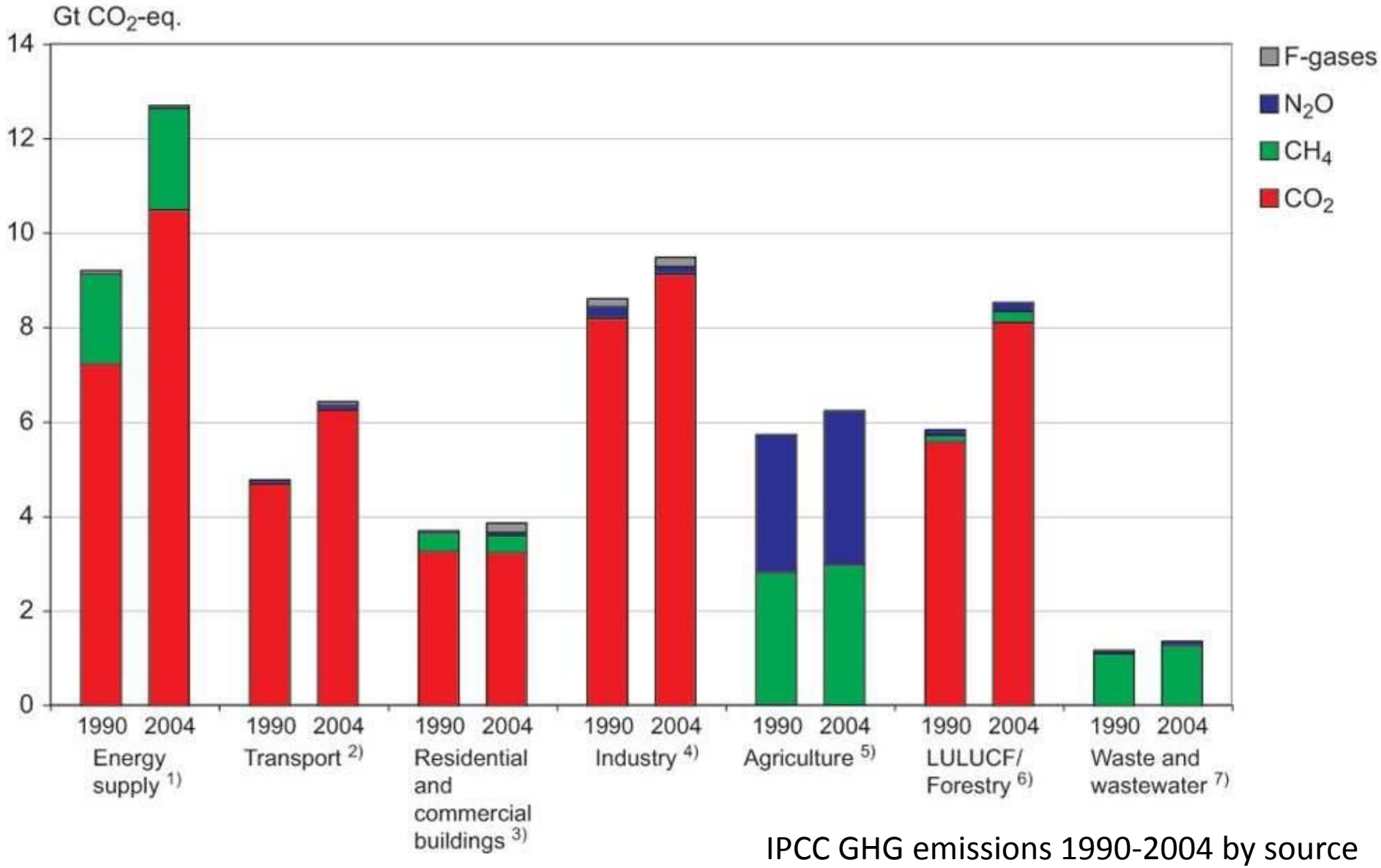
IPCC AR5

About half of cumulative anthropogenic CO_2 emissions between 1750 and 2010 have occurred in the last 40 years.



IPCC AR5

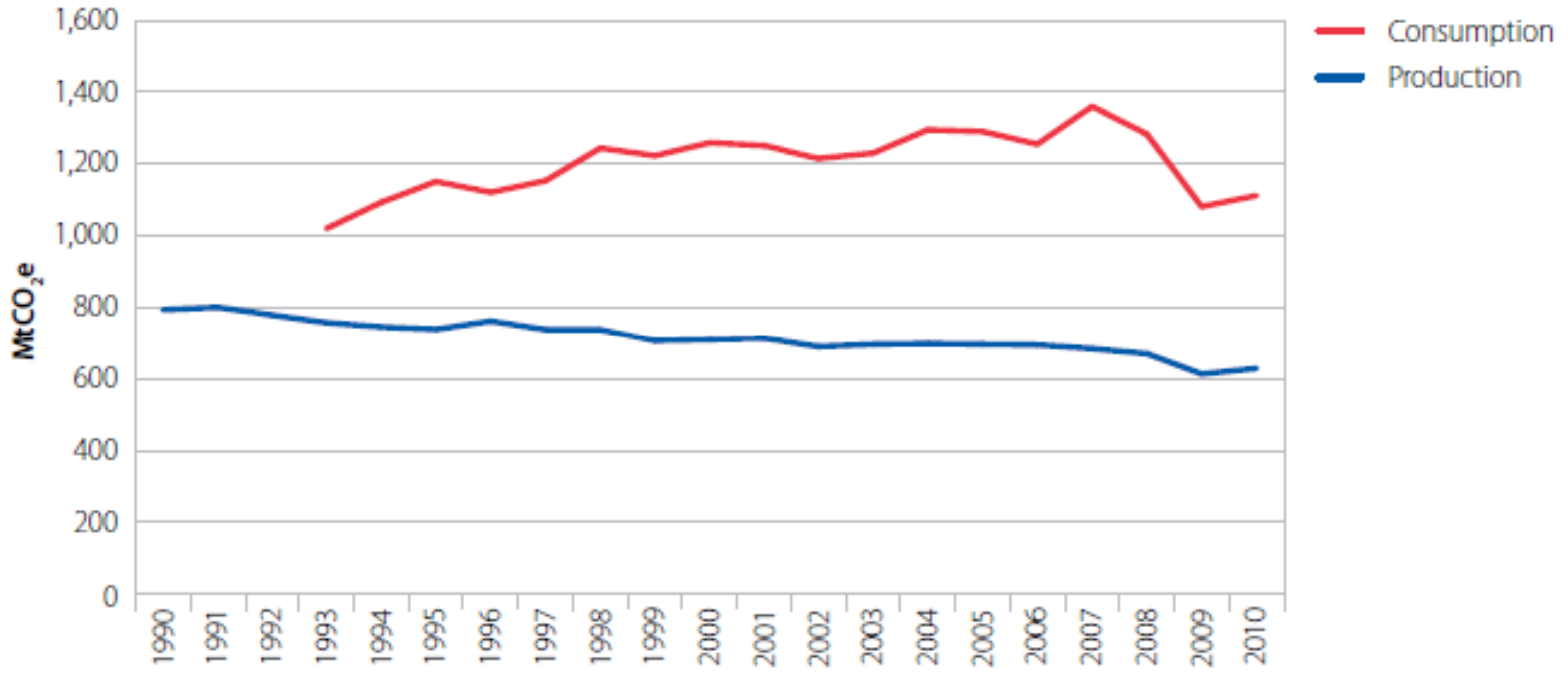
World changes in emissions 1990-2004 by source and GHG



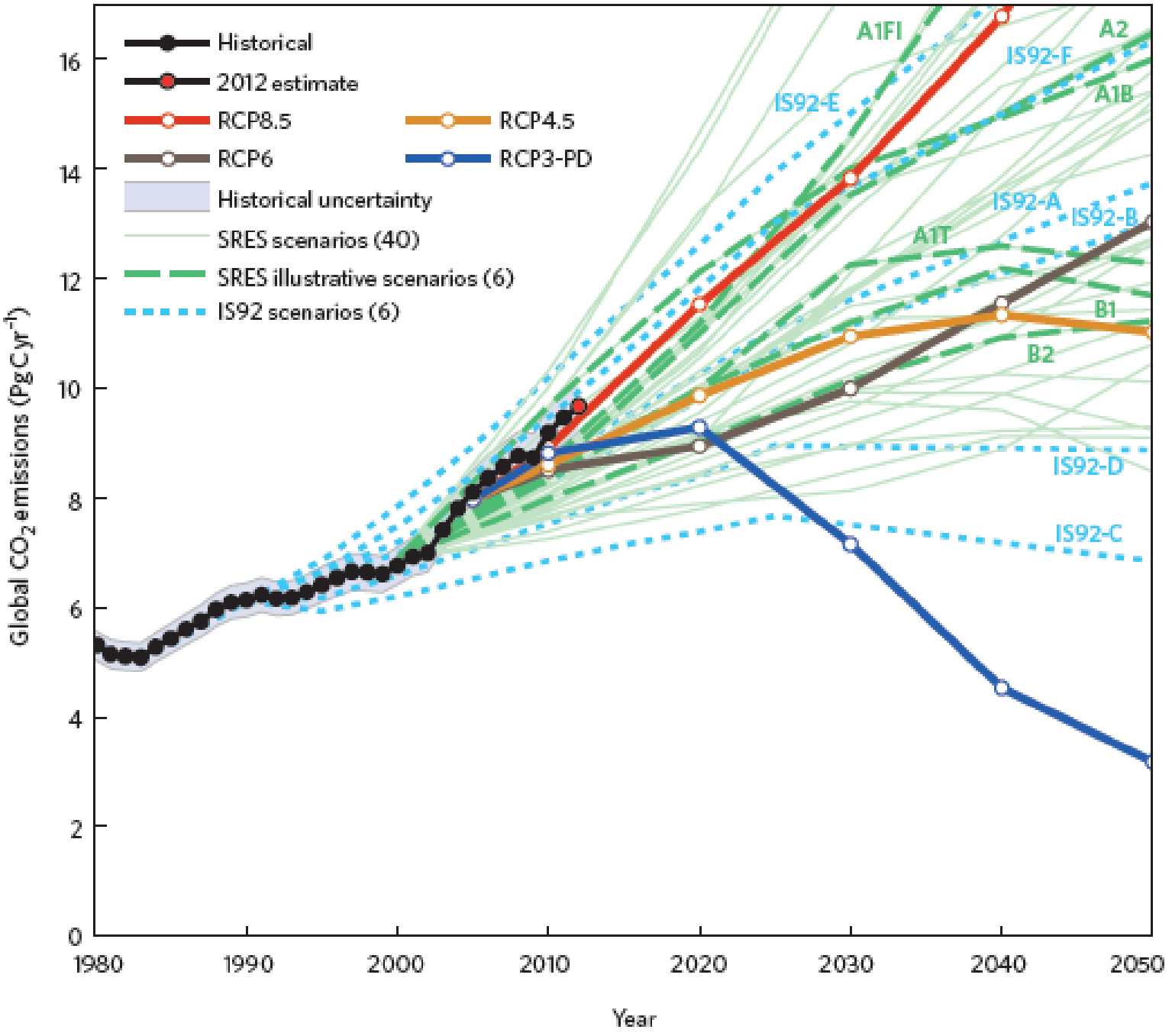
IPCC GHG emissions 1990-2004 by source

UK Greenhouse gas production & consumption

Figure 1.2: Greenhouse gas emissions associated with UK production and consumption (1990-2010)



Source: CCC consumption estimates developed by the University of Leeds (2013); NAEI (2012).
Notes: Production emissions include emissions from international aviation and shipping. Due to data limitations, consumption emissions estimates are not available pre-1993.

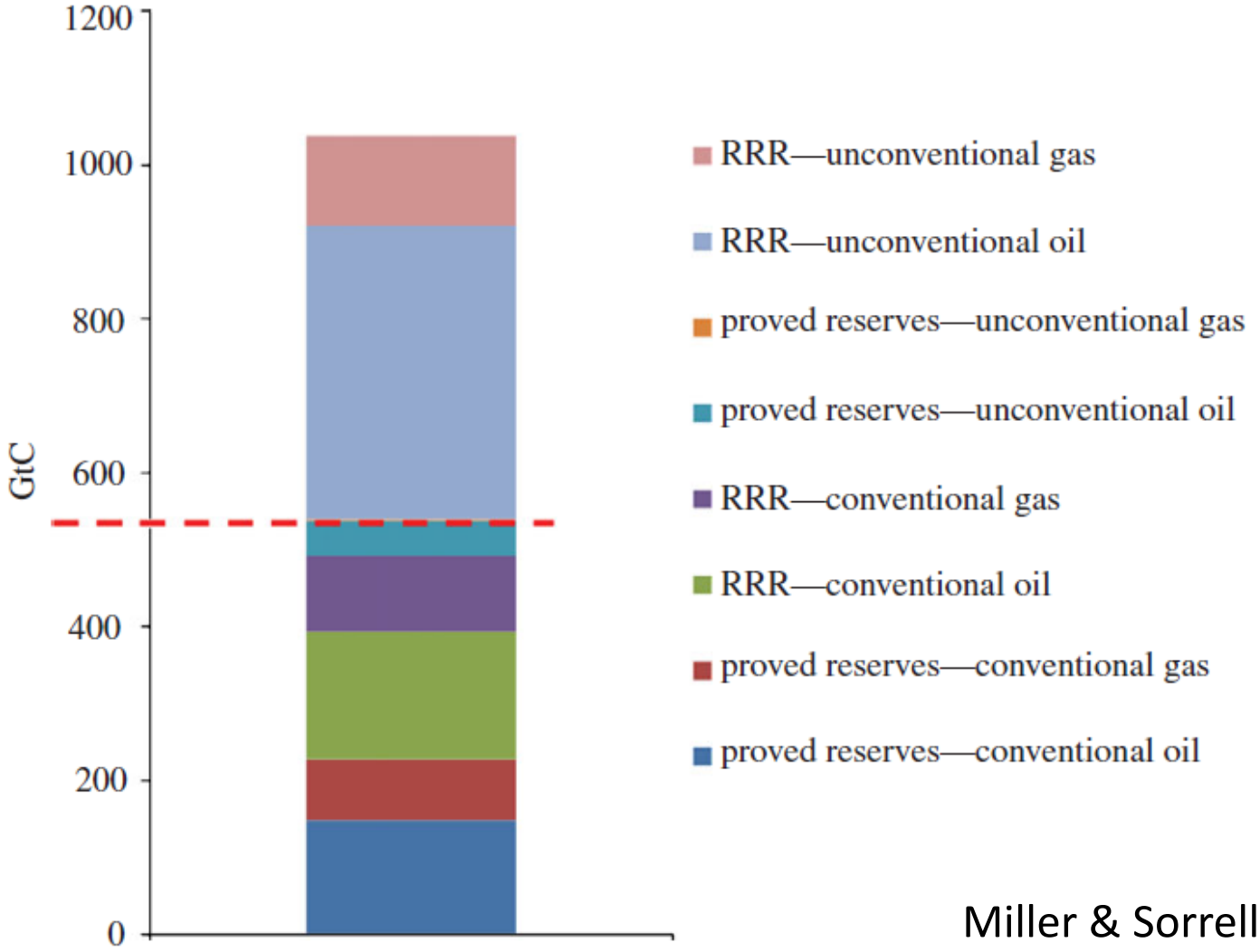

Historical
2012 estimate
RCP8.5
RCP4.5
RCP6
RCP3-PD
Historical uncertainty
SRES scenarios (40)
SRES illustrative scenarios (6)
IS92 scenarios (6)
A1FI
A2
IS92-F
IS92-E
A1B
IS92-A
IS92-B
A1T
B1
B2
IS92-D
IS92-C
Global CO_2 emissions ($Pg\,C\,yr^{-1}$)
Year
0
2
4
6
8
10
12
14
16
1980
1990
2000
2010
2020
2030
2040
2050

IPCC AR5

Outline

- People
- Energy
- Emissions
- **Resources limits**
- Food
- Way forward

From a climate perspective, we should not chase unconventional fossil fuels - and we need to wean ourselves off conventional fossil fuels

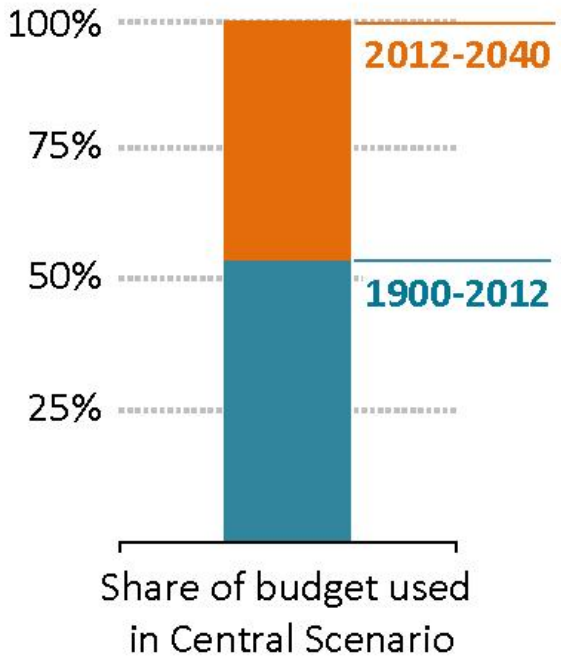


Miller & Sorrell (2013)

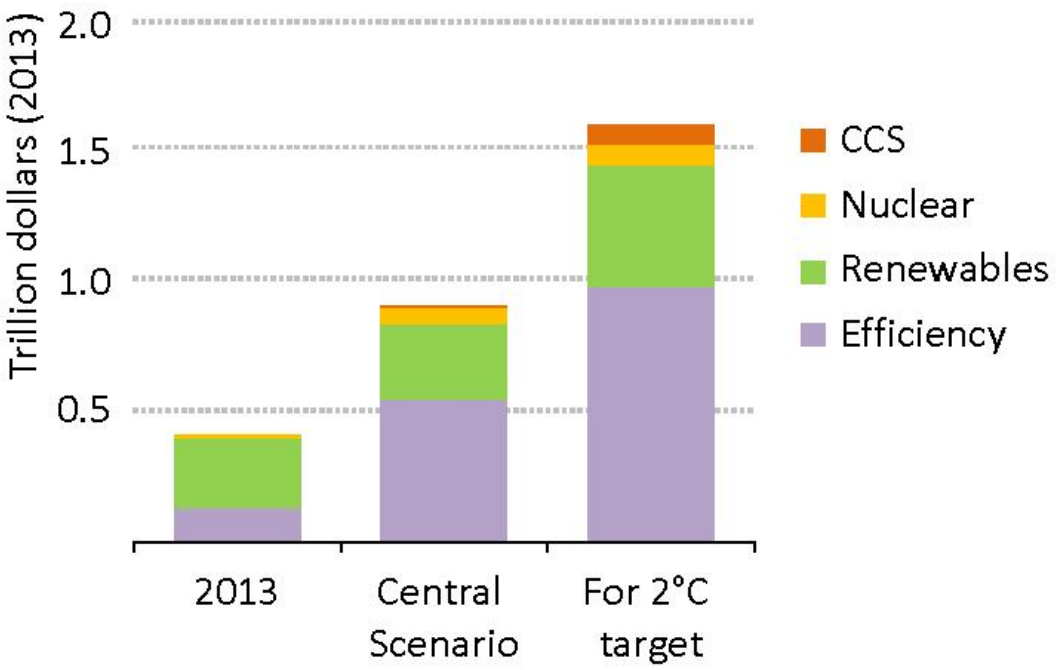
Capital Investment

World Energy Outlook 2014

World CO_2 budget for 2 °C ~2300 Gt



Average annual low-carbon investment, 2014-2040



The entire global CO_2 budget to 2100 is used up by 2040 – Paris must send a strong signal for increasing low-carbon investment four times beyond current levels

IEA 2014

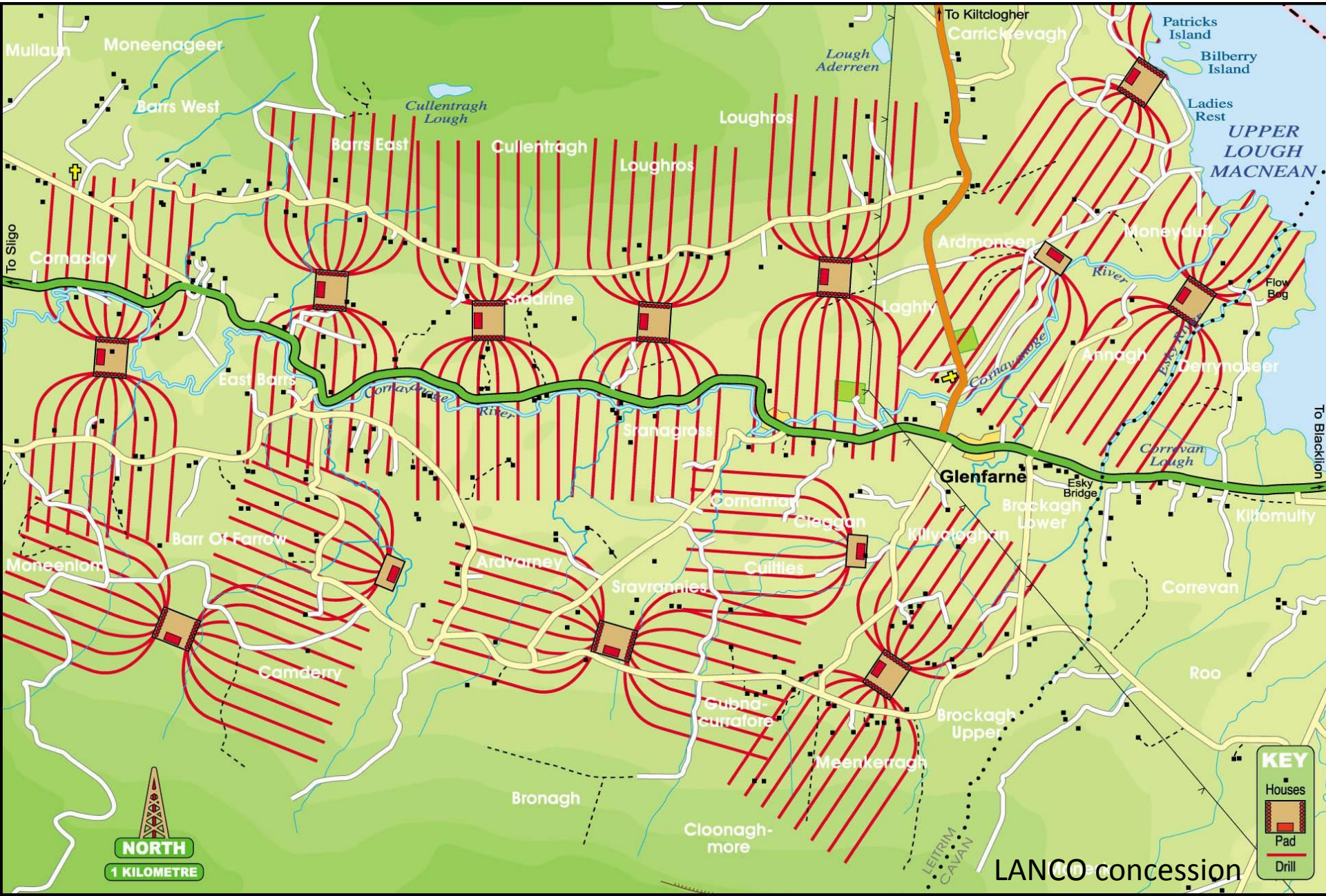
Sustainability metrics for a low carbon future

- Perpetual
- High energy efficiency
- Low GHG emissions per unit of energy
- High net energy per hectare

Land use is a limiting factor


Shale gas wells in Wyoming
Ecoflight 2014

Land Use from oil/shale gas development 7ha pads



Wytch Farm oil field requires only 4 pads


Small and well
Camouflaged facilities

Mojave desert California solar thermal

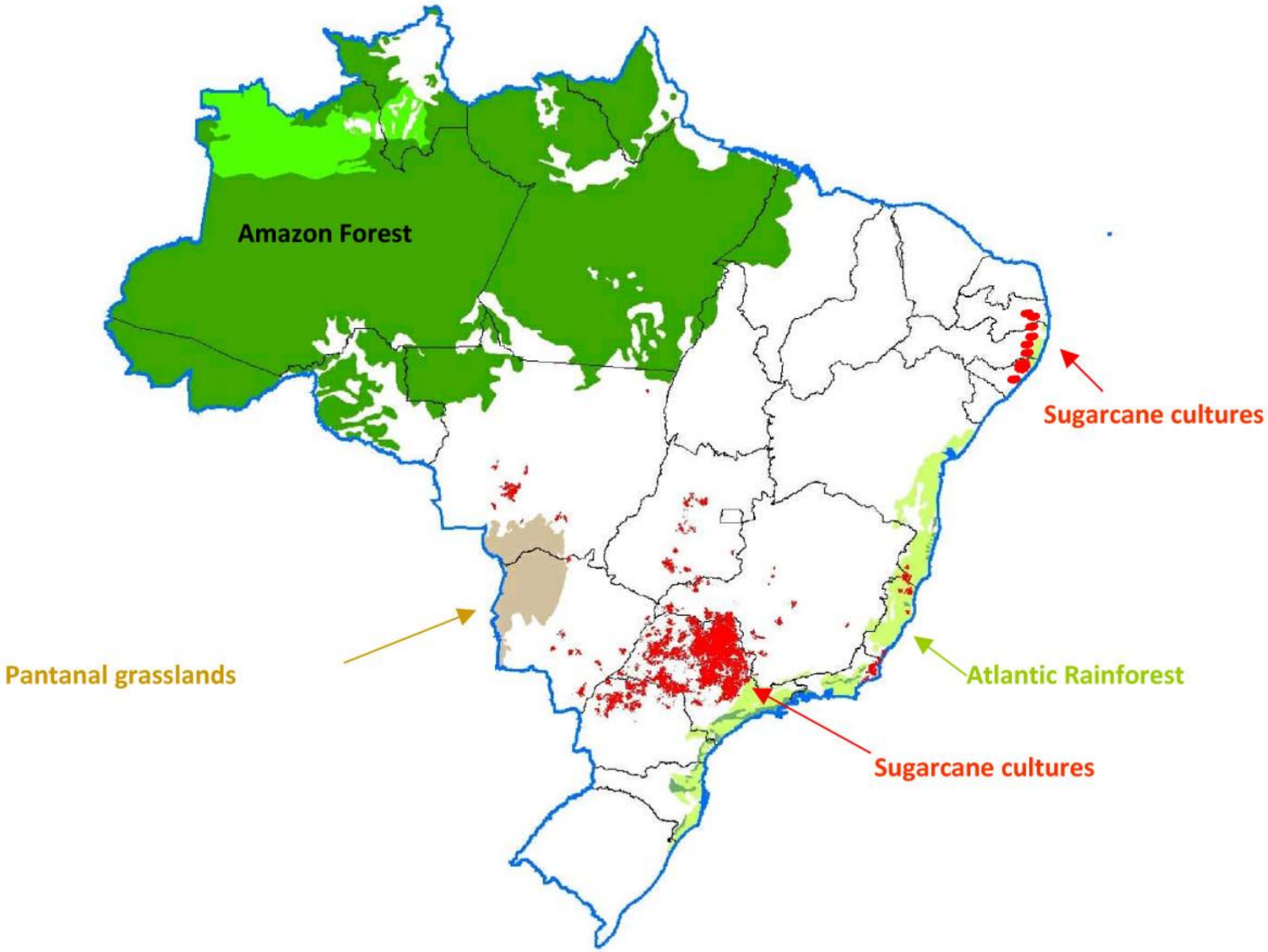
Hampshire solar PV

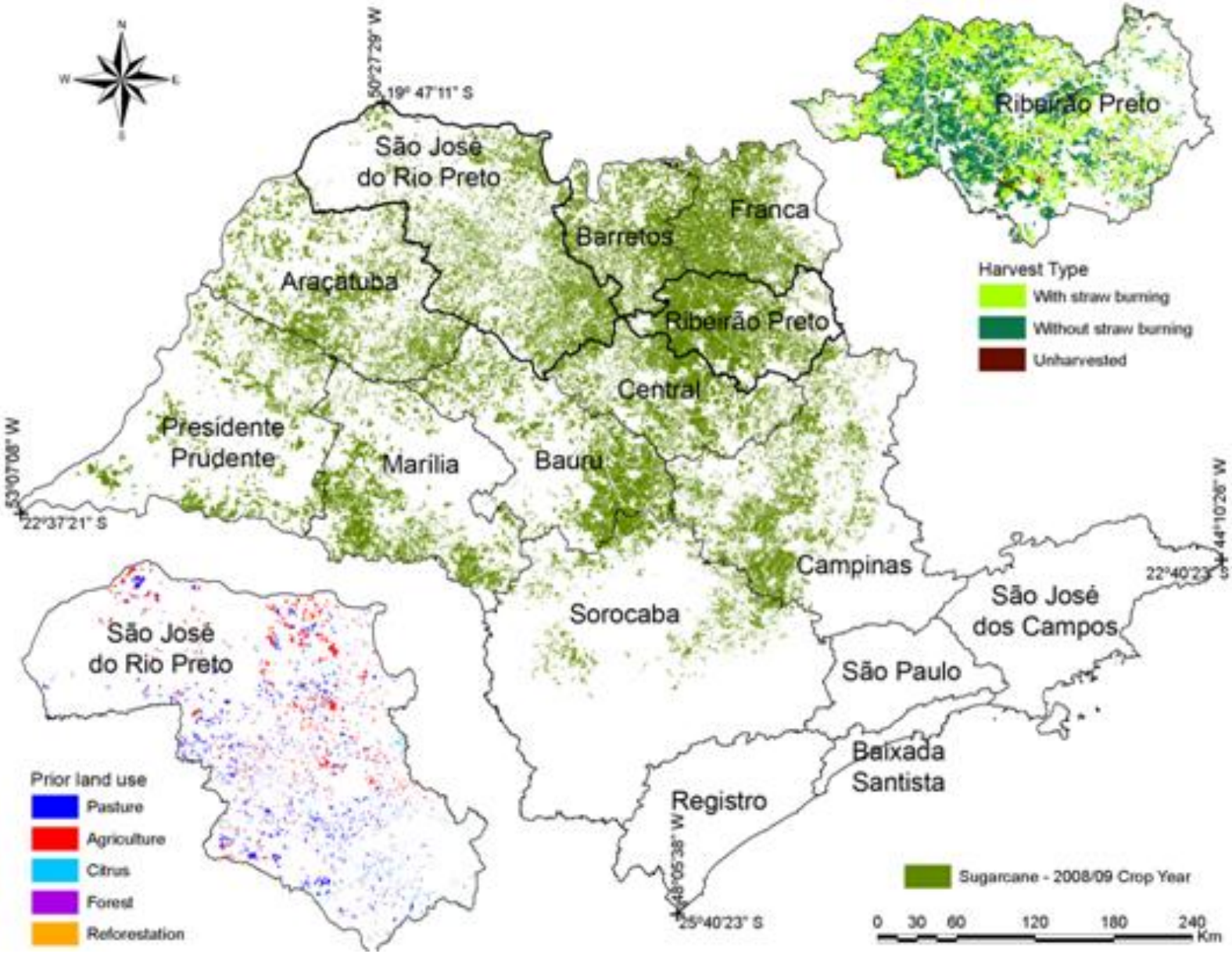
Wind farms in “pristine” landscapes

Dual land use wind and crop farms

Extreme wind development

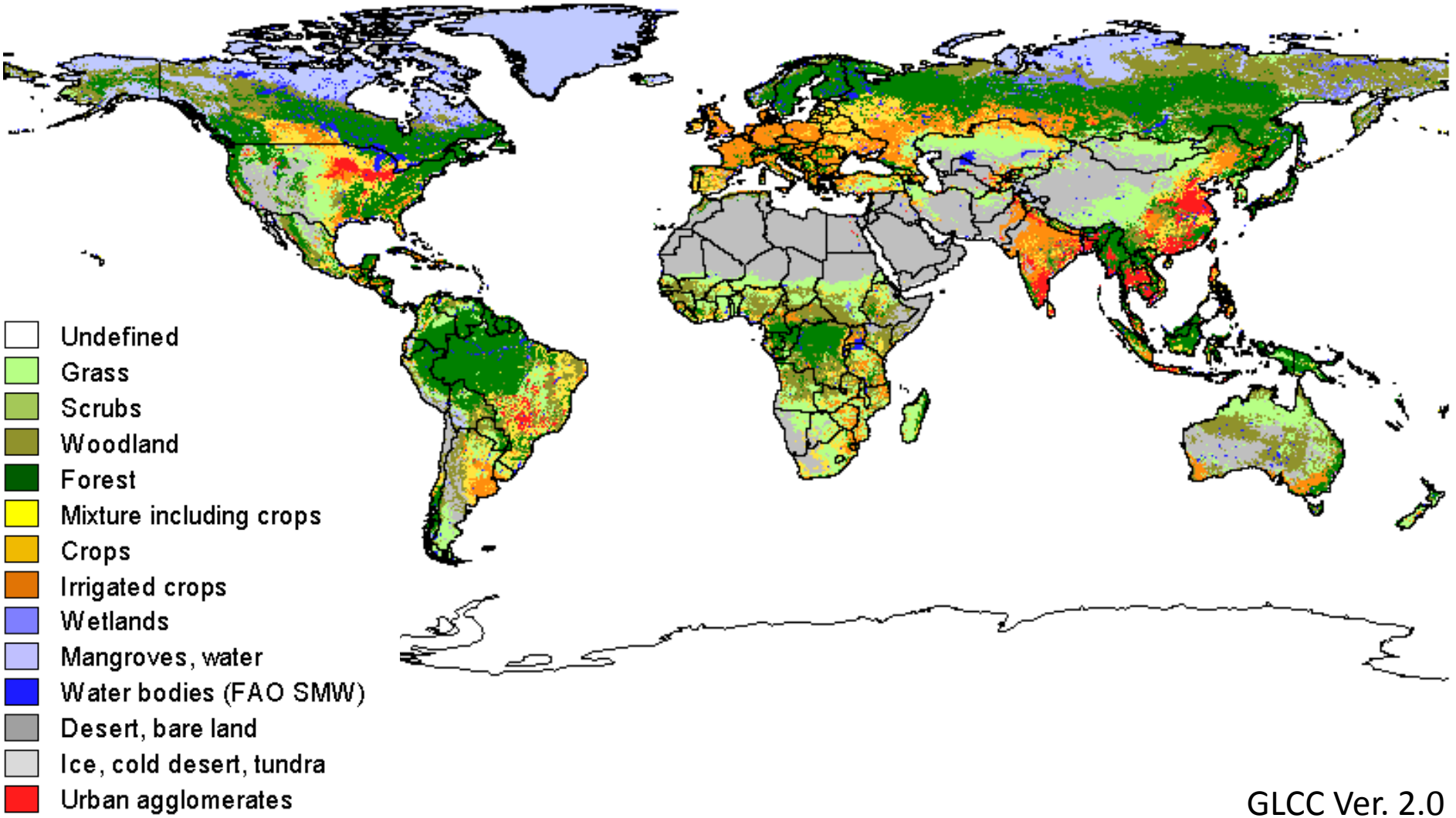
Sugar cane plantations on Maui Hawaii


Amazon Forest
Sugarcane cultures
Pantanal grasslands
Atlantic Rainforest
Sugarcane cultures

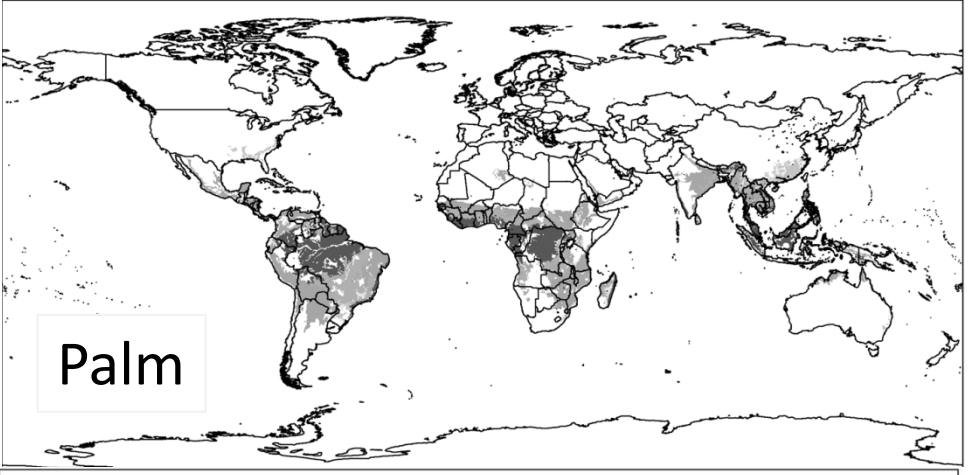


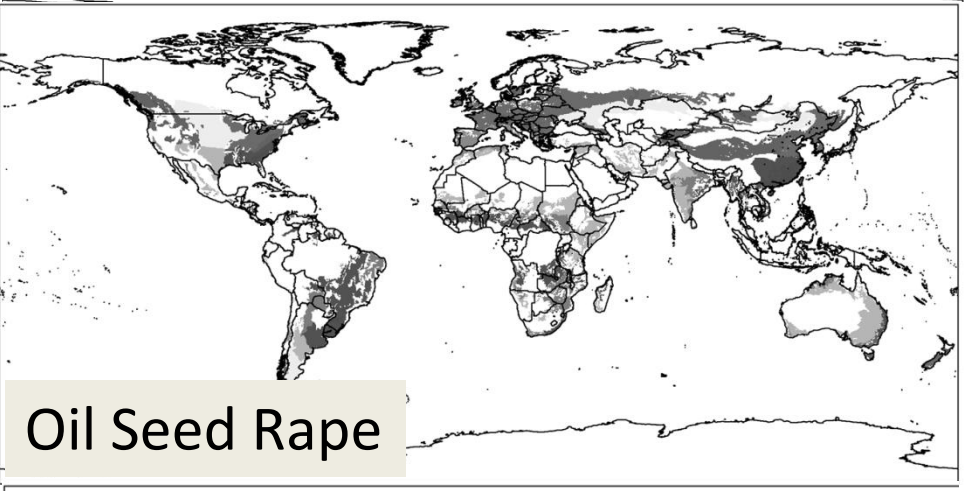
Rudolff et al 2014

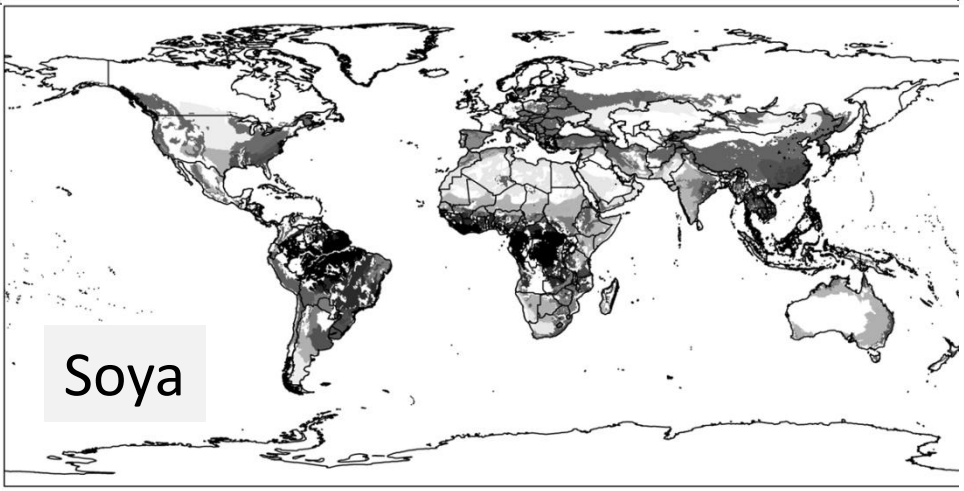
Balancing Land Use between: eco-system services – food and energy



GLCC Ver. 2.0



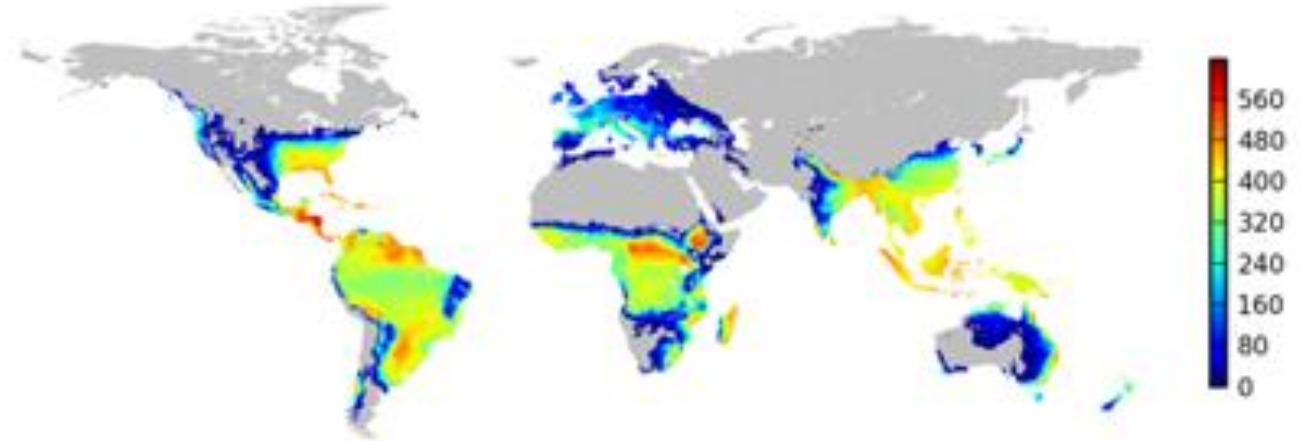




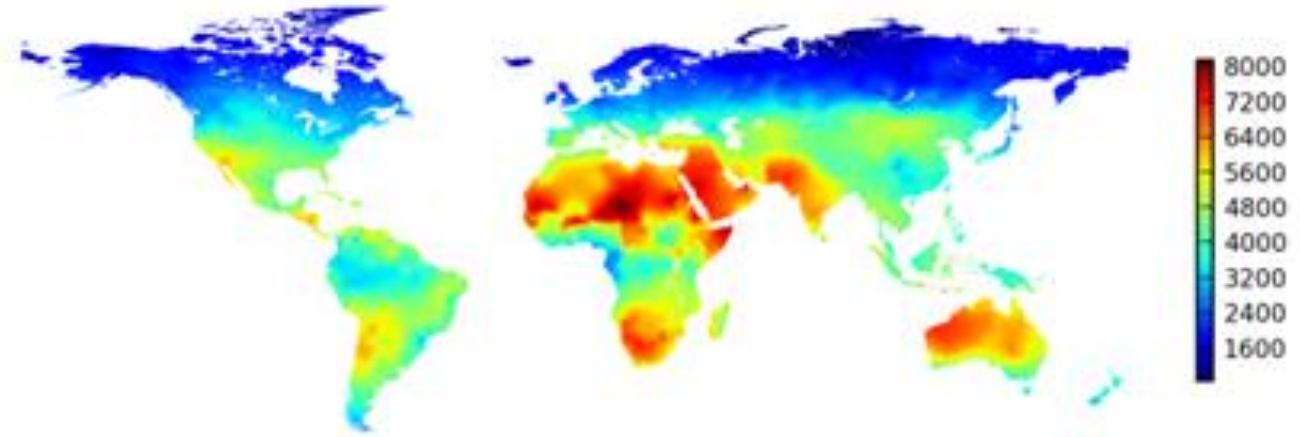
Carbon emissions Mg C ha-1 y-1
From natural vegetation
to
bioenergy crops
Including soil carbon and vegetation
For the first 20 years

White area crop does not grow
Light grey =2
Black >42

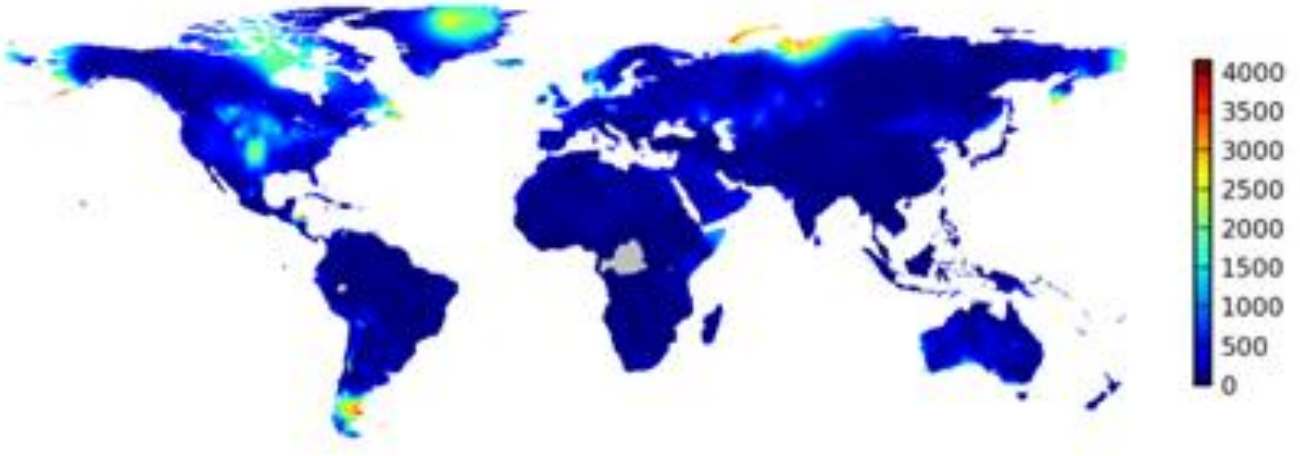
Flynn et al. 2011



Bioenergy

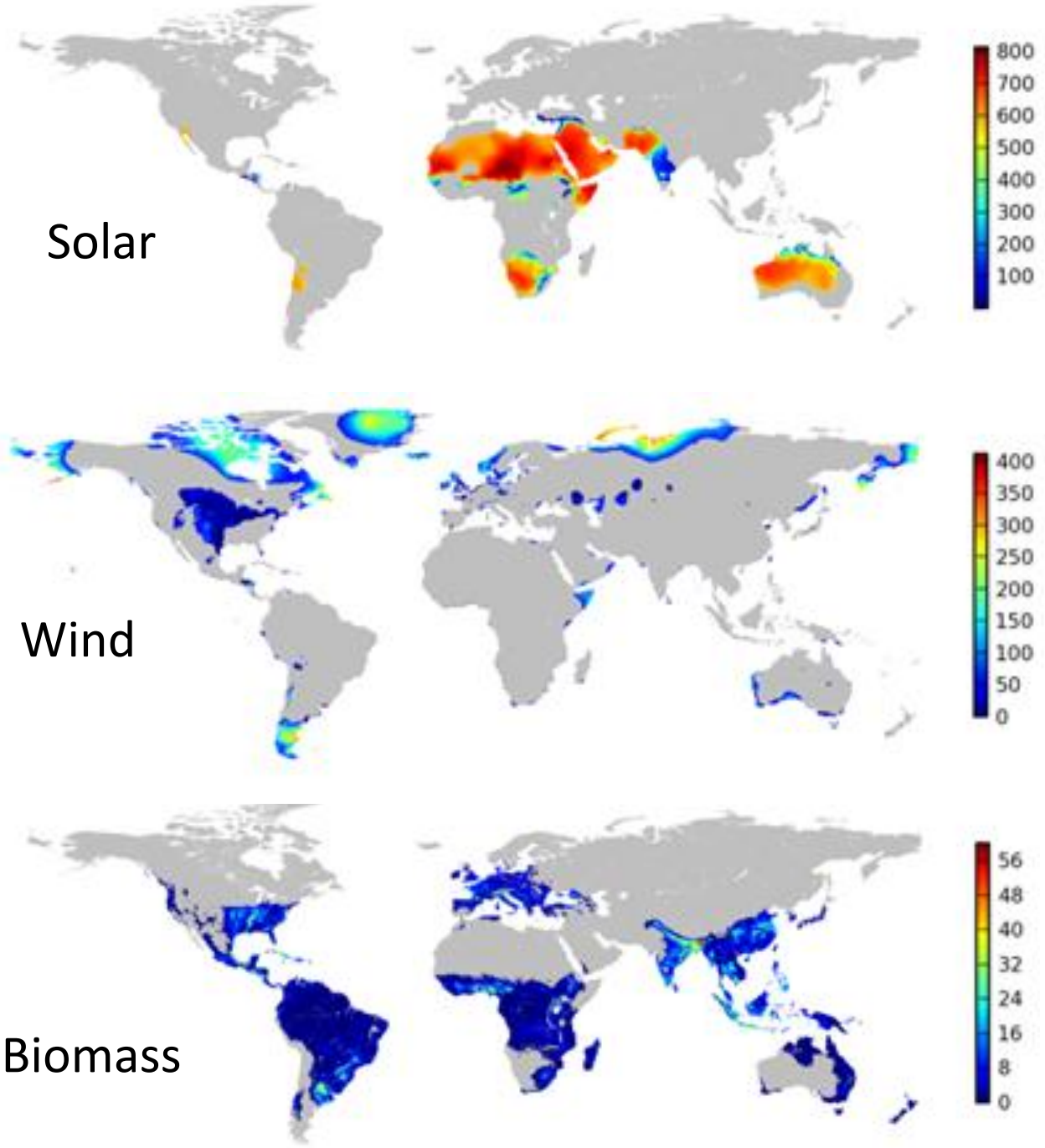


Solar



Wind

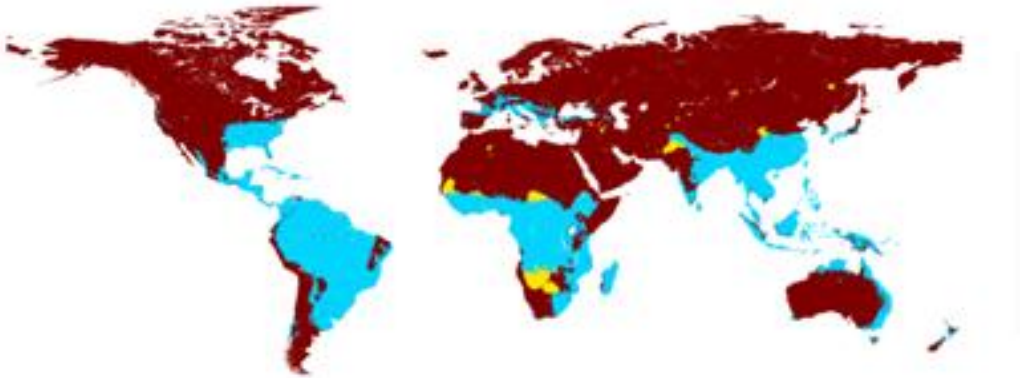
Potential
GJ/ha/y



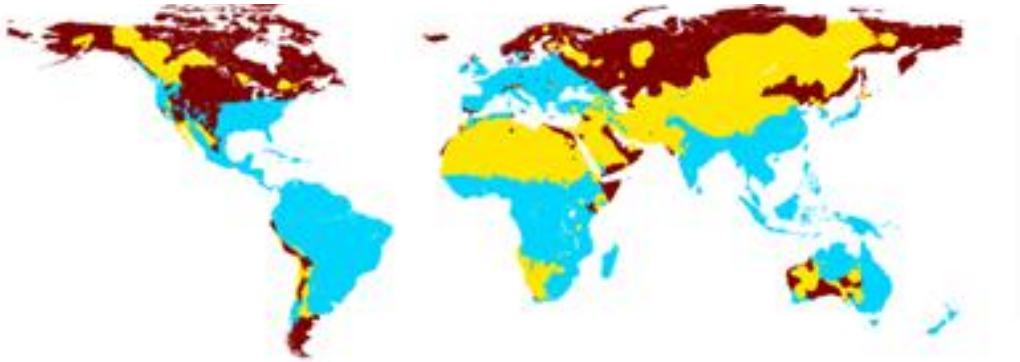
Energy Potential
Limited by

<$16/GJ ($100/bbl)
<20kg C/GJ
in
GJ/ha/y

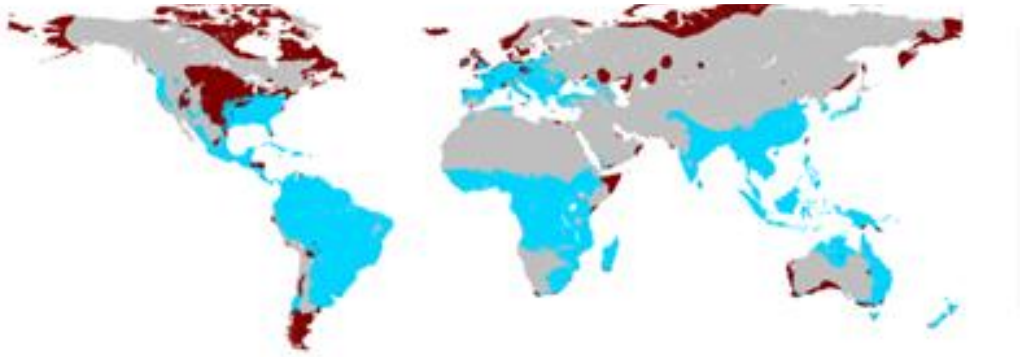
Pogson et al 2012



Lowest C emissions



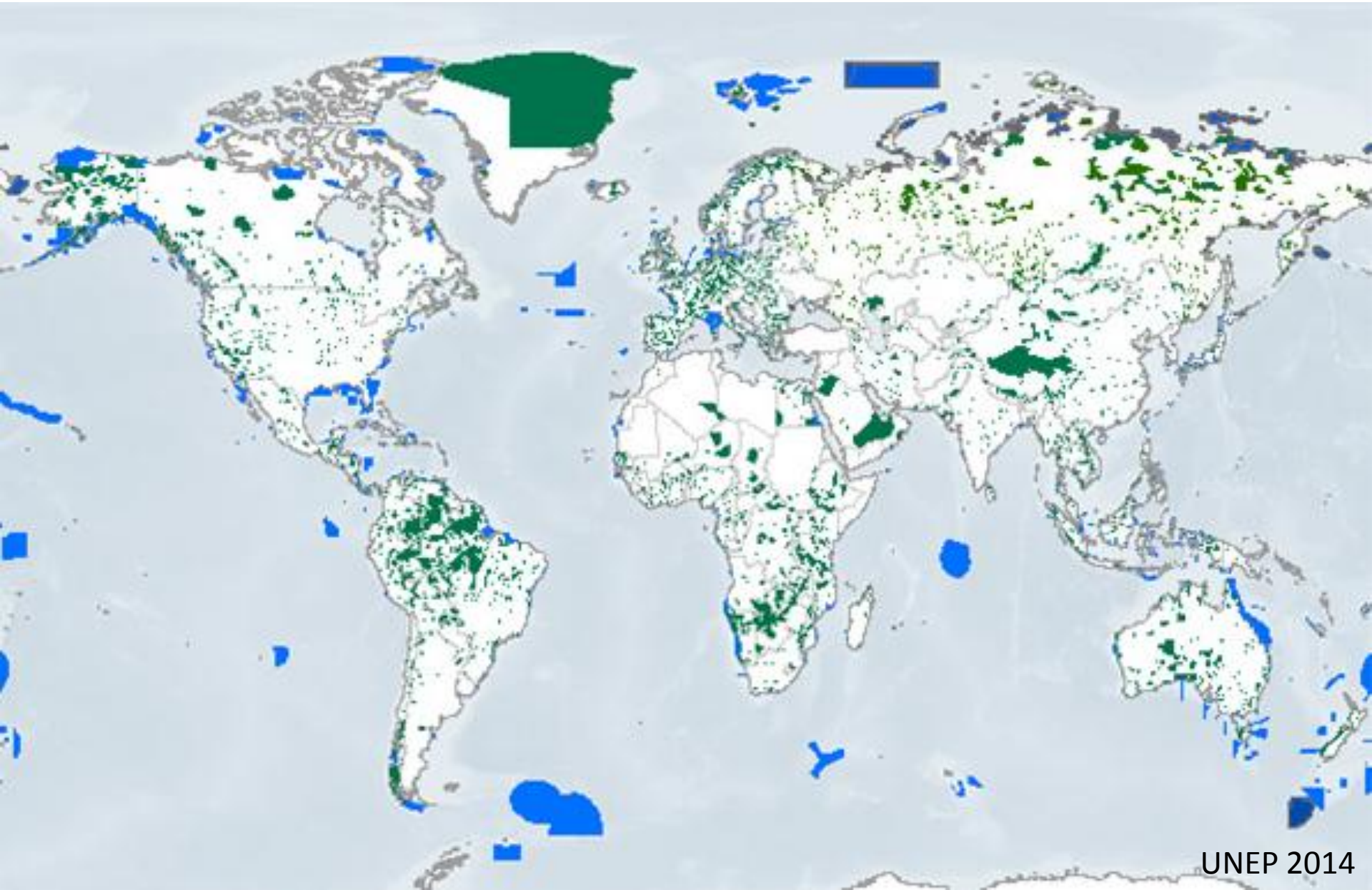
Lowest cost



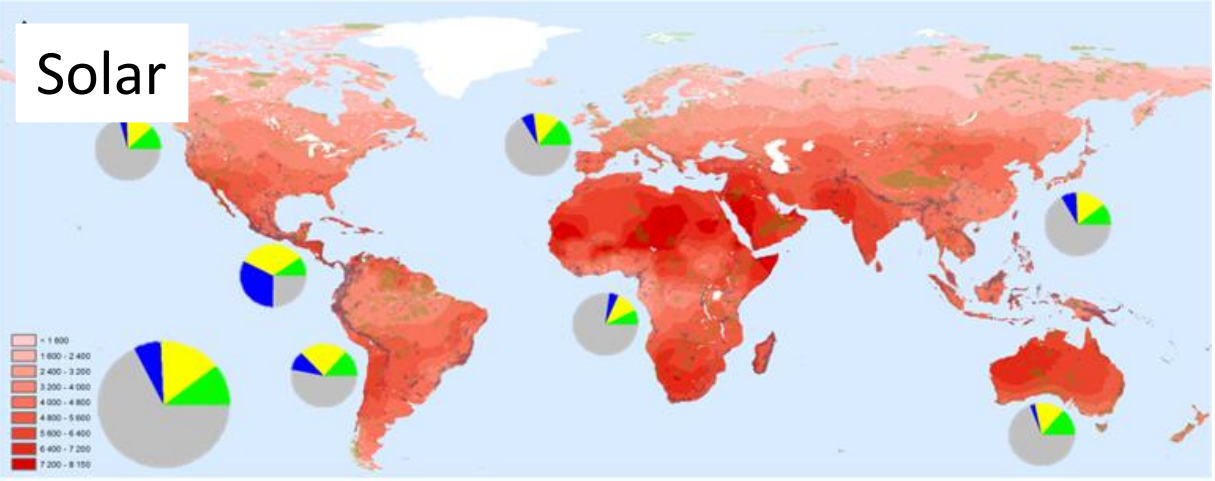
Highest power per ha
After restrictions

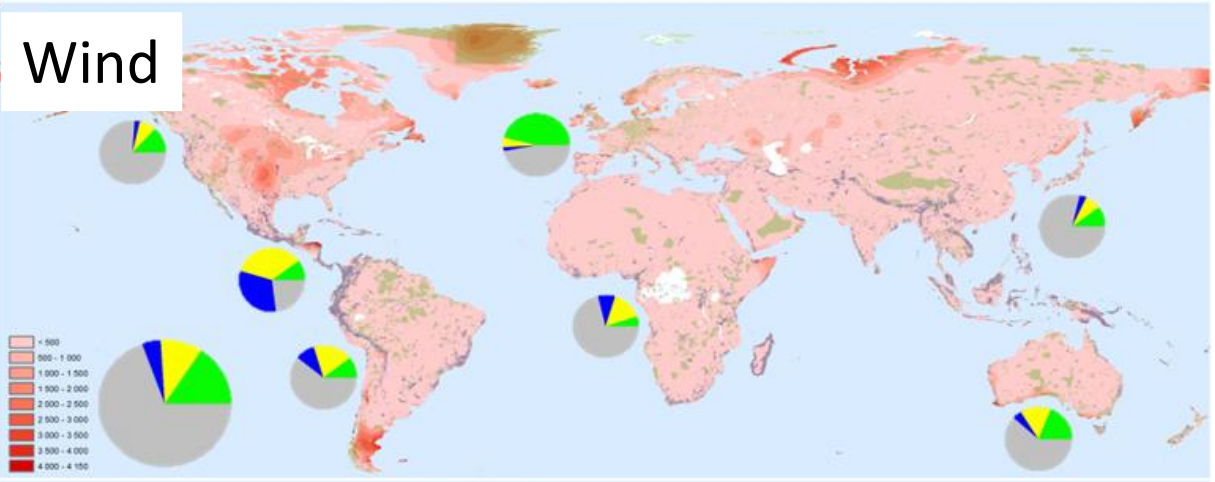
Solar Biomass Wind

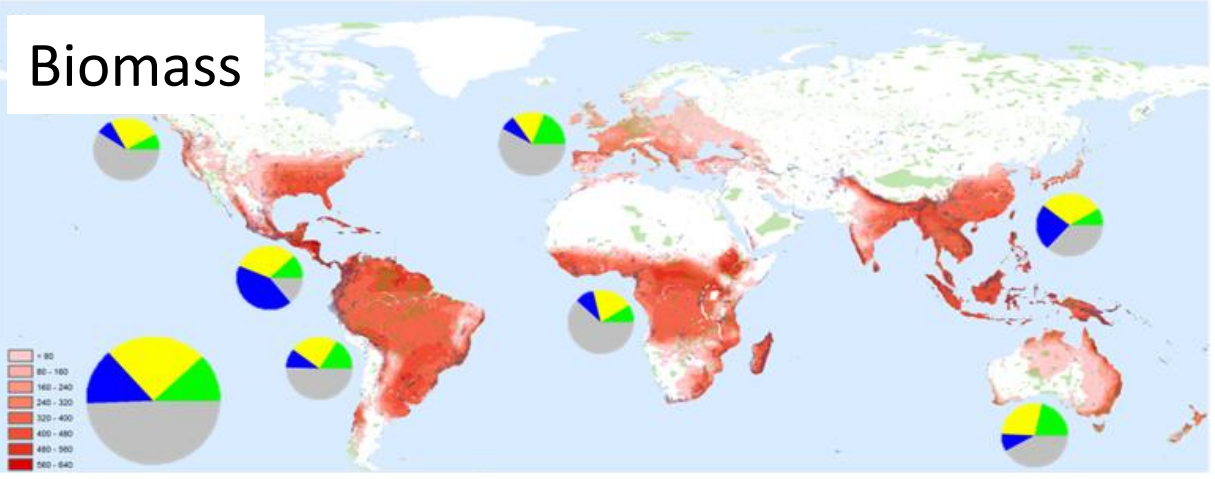
Protected Areas - Convention on Biological Diversity



UNEP 2014







Red gradient
Is
energy density

Green areas
Are
Current
Protected areas

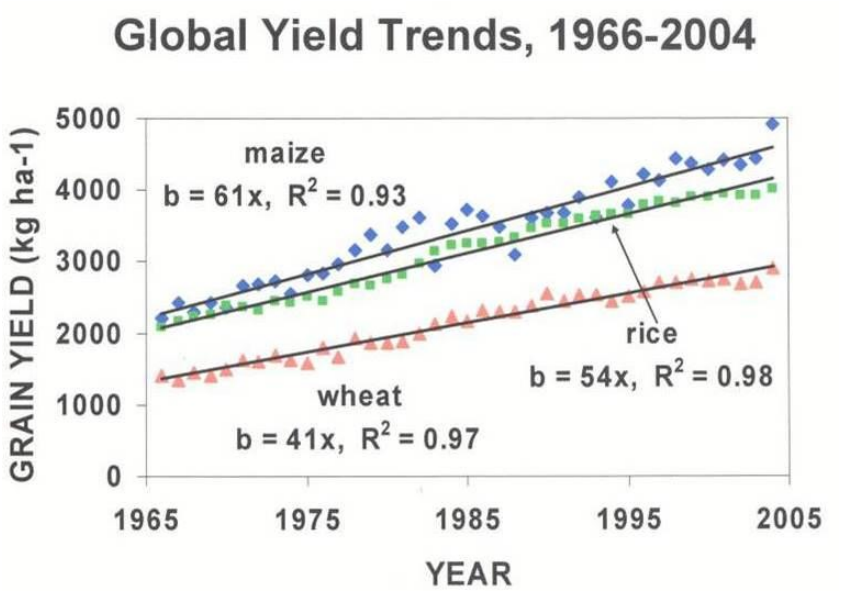
Blue areas
Are
Aichi target 11 of CBD
17%

Yellow pie
is
Aichi 30%

Outline

- People
- Energy
- Emissions
- Resources limits
- **Food**
- Way forward

Crop yields are not the Issue



Improved by:

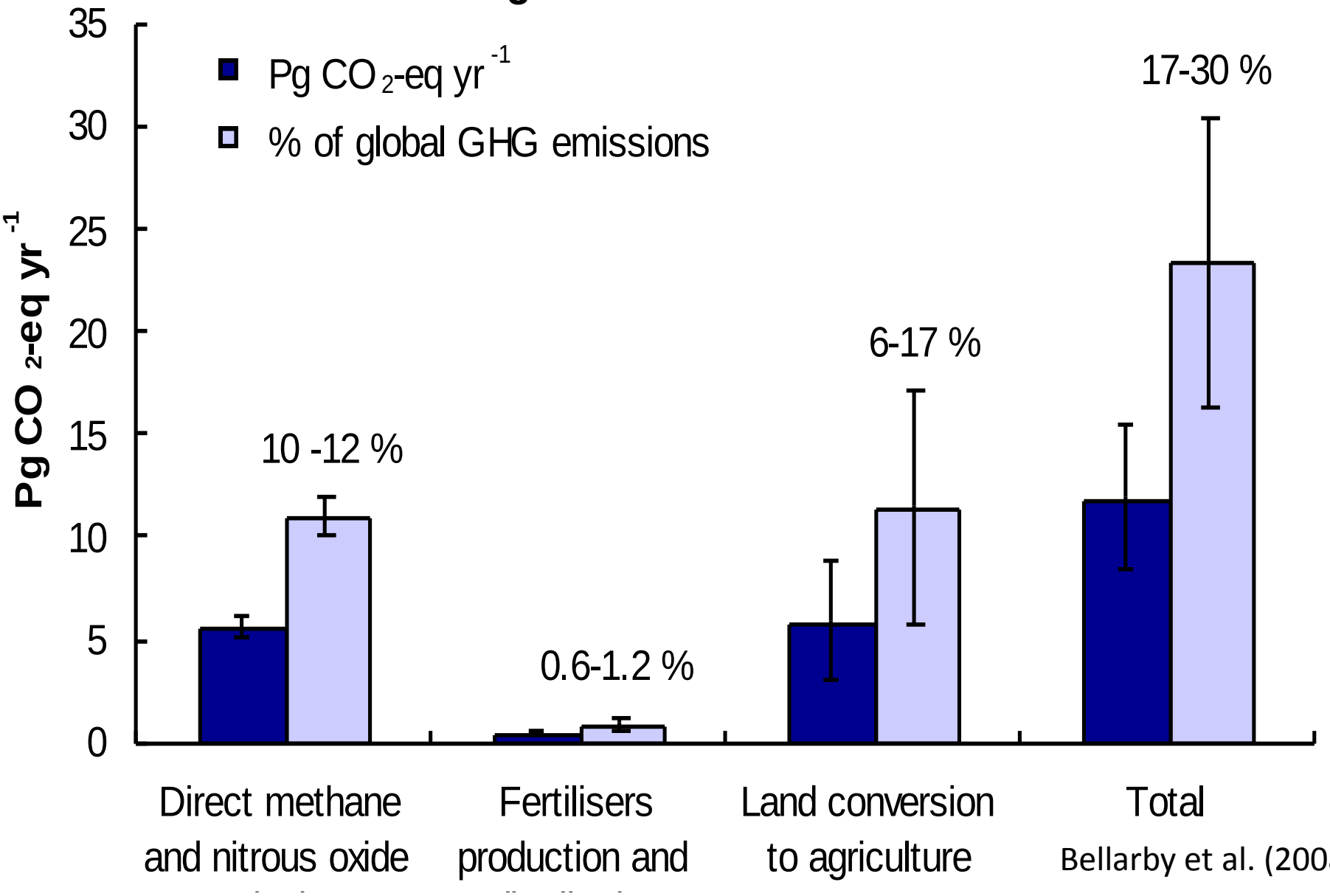
- Fertilizer and chemical use
- Improved agronomy $\Rightarrow$ precision farming
- Plant breeding
  - Extend the growing season
  - Partitioning C to edible parts
  - Drought, heat, frost and pest resistance

Peter Gregory, SCRI, 2014

Food production and supply challenges

- Distribution and storage infrastructure
- Energy for tillage, fertilizers and chemicals
- Suitable land availability
- 5-15 litres of water per g of biomass
- 2-4.6 g of C photosynthesis per MJ sunlight
- Growing season change & pest migration
- Diet

Global contribution of Agriculture to Greenhouse gas emissions



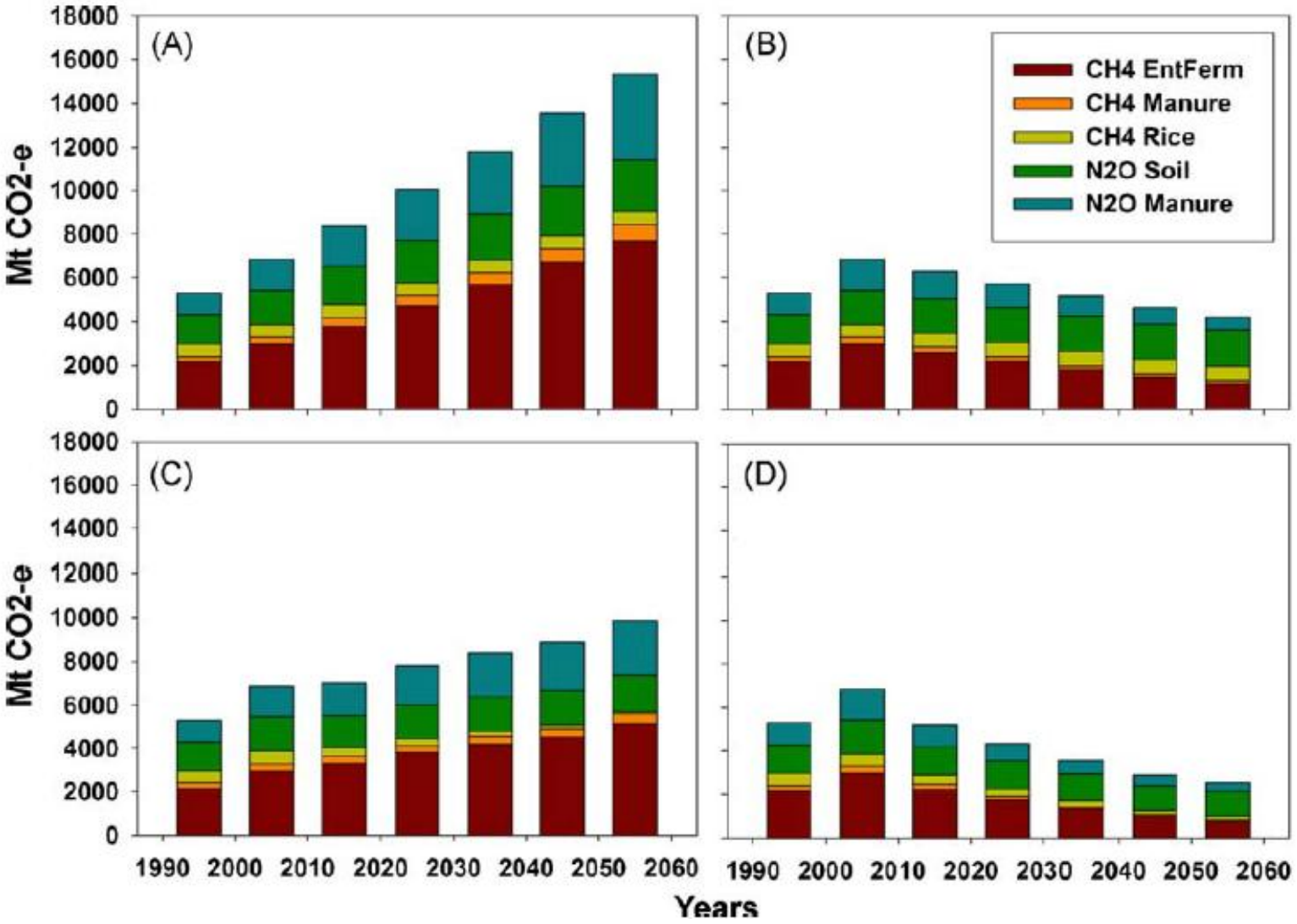
Bellarby et al. (2008)

GHG emissions of diets

1.4 – 4.4 kg CO_2 per day **3.7 – 6.1 kg CO_2 per day**

There are high contrasts between low consumption and high consumption dietary patterns around the world.

Reducing GHG emissions – dietary change *vs*. technical mitigation



Without technical mitigation

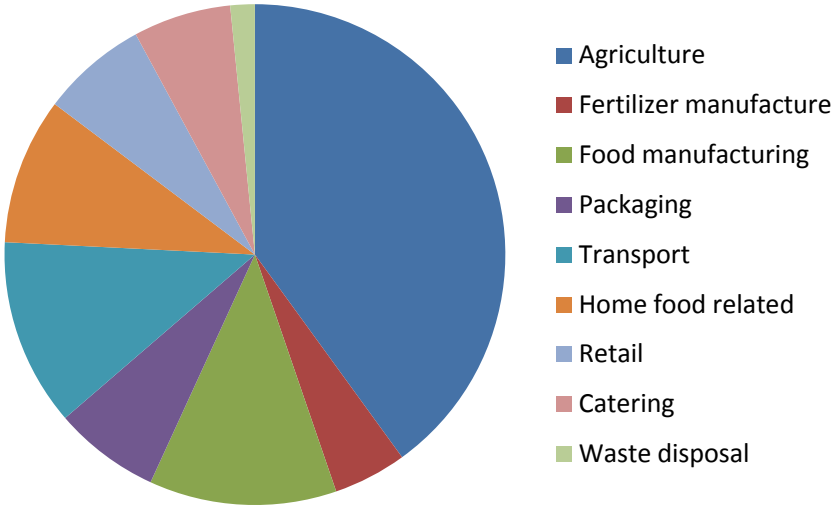
With technical mitigation

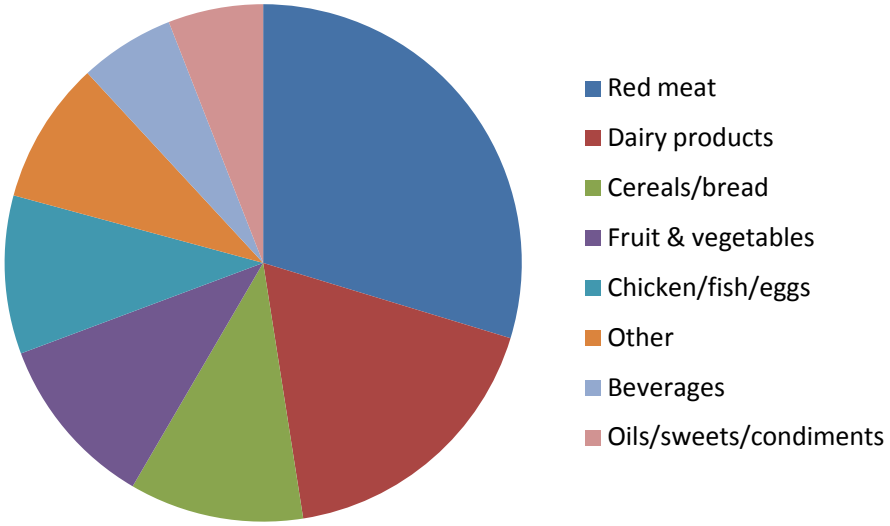
Increased meat

Decreased meat

Popp et al. (2011)

UK food GHG emissions & mitigation

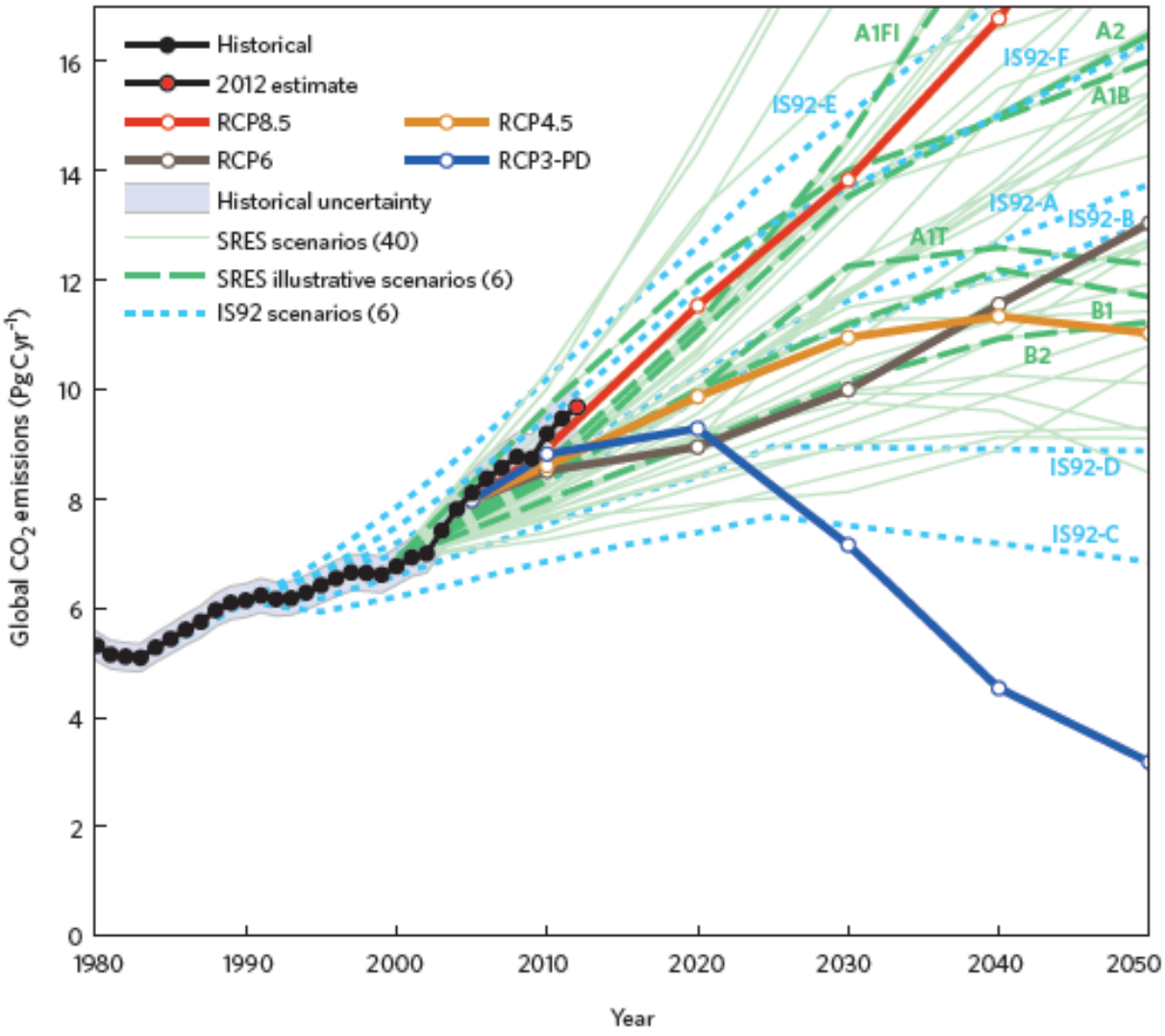




- Reduce red meat and dairy in diet
- Reduce processed foods
- Reduce non seasonal foods
- Reduce calorific intake

Outline

- People
- Energy
- Emissions
- Resources limits
- Food
- **Way forward**



We're on course for a 4 degree world

Speech to the United Nations, 8th November, 1989

Margaret Thatcher

“Every ONE will be affected and no one can opt out. Those Who consume more must give up more to help those who consume less.”


One Planet