Limits to Biophysical Growth

Sustainable Cities Sustainable Transport Forum, Melbourne

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Global and national challenges require immense change

- The world is tracking on the Limits to Growth 'business as usual' scenario
  - leads to ecological and economic collapse (possibly from 2020 onwards)
- Australian "Future Dilemmas" are also playing out
  - potentially conflicting challenges over the coming decades in labour, fuel and energy, water, land, food, emissions, infrastructure
- Range of responses
  - technology and marginal change are not likely to be enough (or may even make it worse)

The Limits to Growth

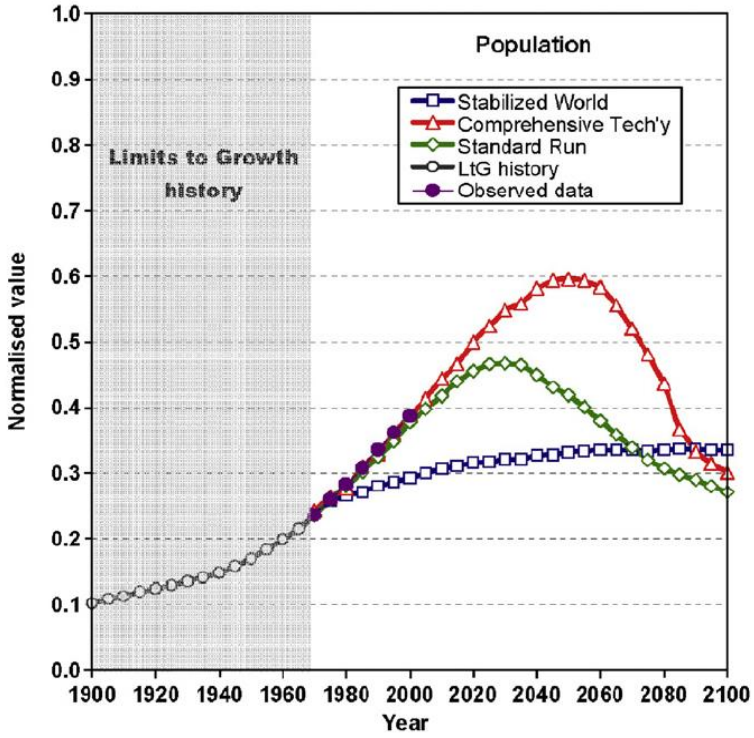
- Never said we would run out of resources
  - and certainly not by year 2000
- System dynamics model of the world economy and environment
  - population, resources, industry, agriculture, services, pollution
- Tested many different scenarios in the model e.g.,
  - “standard run” (business as usual)
  - “comprehensive technology”
  - “stabilized world”

- Scenarios from 1970 to 2100
  - compare global data from 1970 to ~2000

Population

- Population has almost doubled since 1970, to more than 6 billion
  - continued growth is all but inevitable

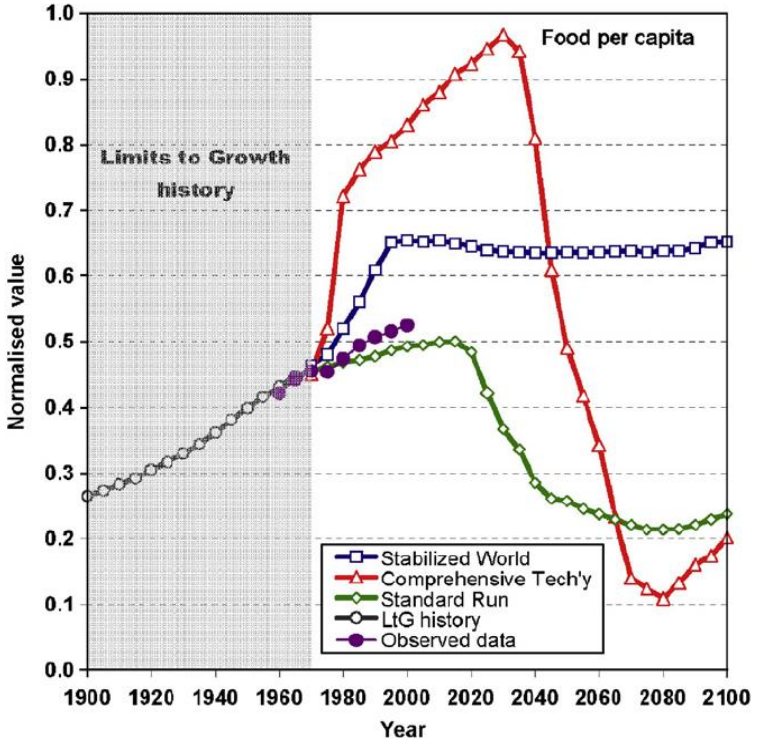
(scale: 1.0 ~ 16 billion)



Food per capita

- Food per capita is growing slowly
  - 15% increase on 1970
  - but possibly flattening out

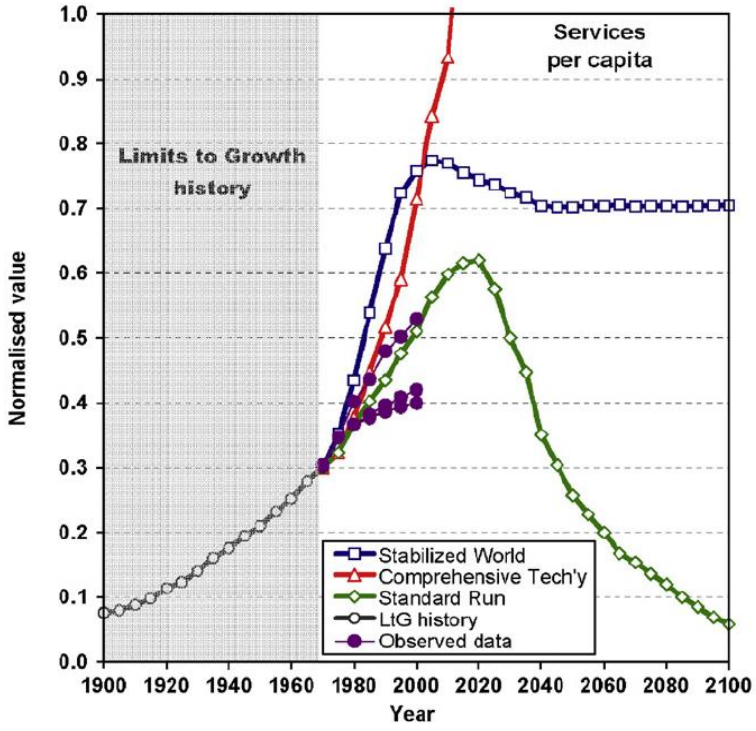
(1.0 ~ 2000 kilocalories per capita pa
~ 8.4 MJ per capita pa)



Services per capita

- Services per capita have grown quickly
  - up to 75% increase on 1970
  - show signs of diminishing growth
  - upper data – electricity p.c.
  - lower data – adult & juvenile literacy rates

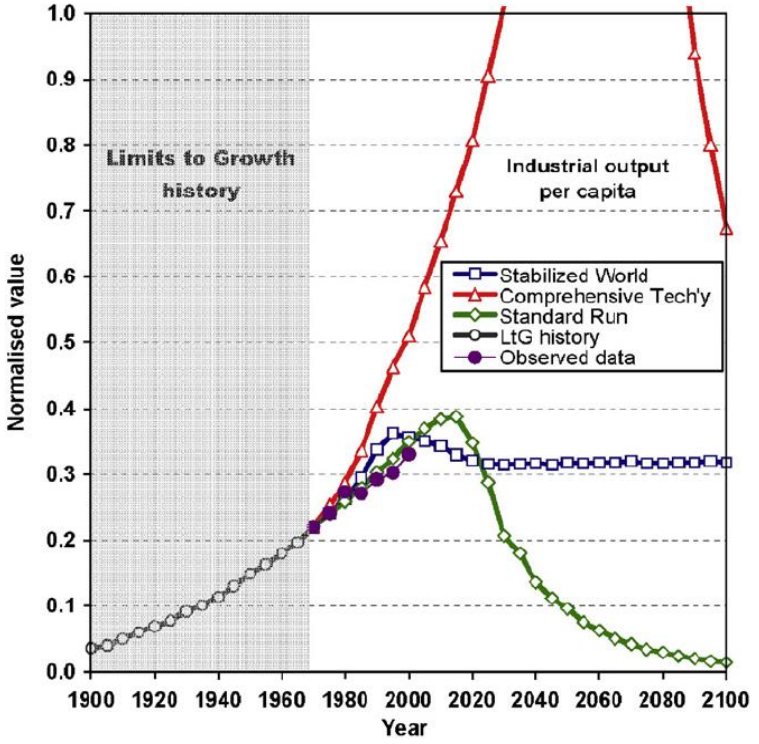
(1.0 ~ $1000 per capita pa in 1968 $,
~$12,000 per capita pa 2007 $)



Industrial output per capita

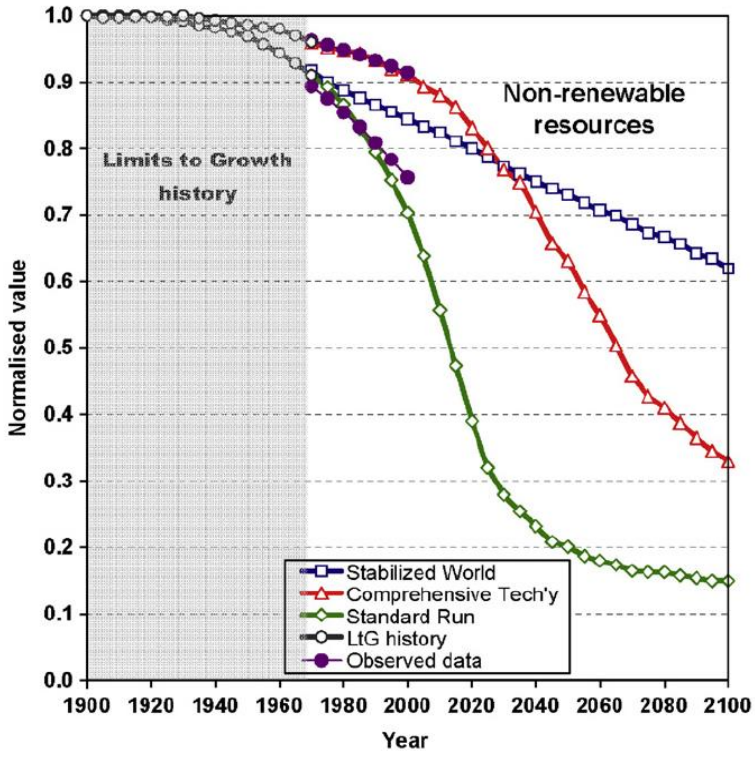
- Industrial output per capita growing moderately
  - a measure of material wealth
  - output also provided to agriculture and services
  - minor effects of oil crises @1980?
  - 50% increase on 1970

(1.0 ~ $1000 per capita pa, in 1968 $,
~$12,000 per capita pa 2007 $)



Non-renewable resources

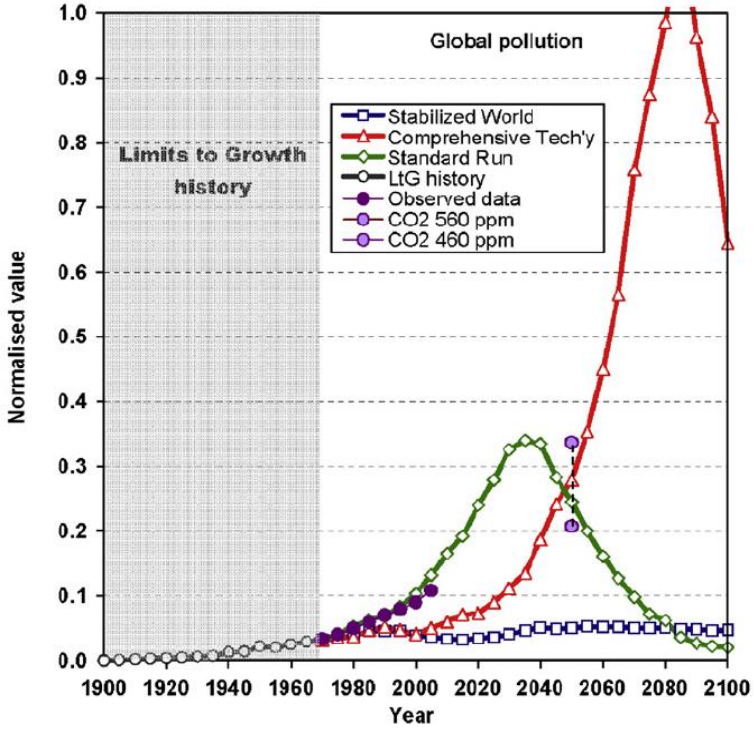
- Fraction of non-renewable resources remaining decreasing moderately
  - data based only on energy resources
    - i.e., “optimistic” for metals and other minerals, e.g., phosphorus, rare earth metals
  - upper resource estimate now ~90% remaining
  - lower resource estimate now ~75% remaining
  - requires much more industrial output for extraction when resources @50%



Global pollution

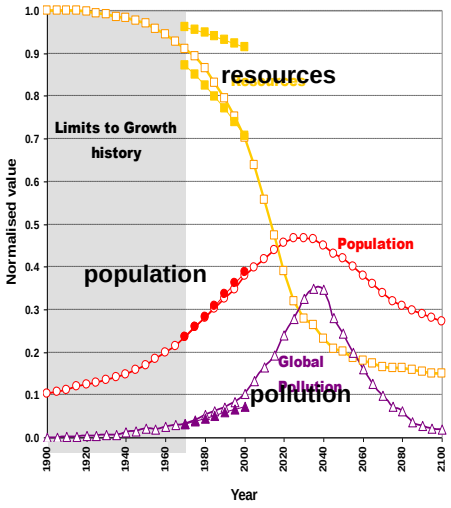
- Global pollution growing exponentially
  - model pollution reduces life expectancy and agricultural productivity
  - data is atmospheric CO_2 concentration
  - ~300% increase on 1970
  - IPCC scenarios for 2050 are broadly consistent with LtG scenarios

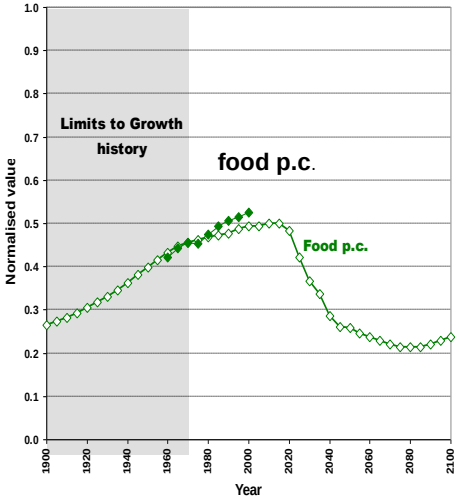
(0.0 ~ 300 ppm CO_2; 1.0 ~ 1080 ppm)

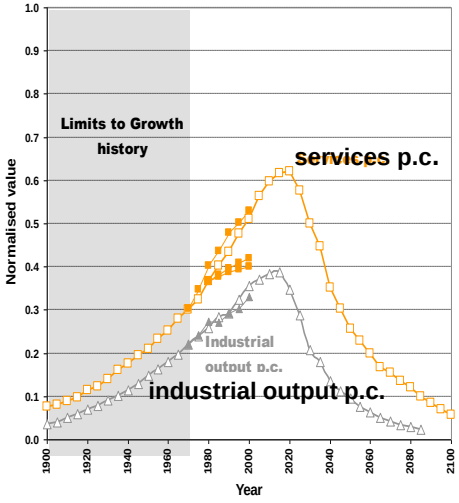


The collapse occurs through resource depletion and environmental pollution

- increasing population and demand for material wealth
- drives more industrial output, which requires more resources
- decreasing resources require more of the industrial output for resource extraction
- pollution from industry continues growing exponentially
- industrial capital is not maintained to support increased production
- industrial system collapses
- increasing pollution and lack of inputs to agriculture degrades food production
- food production and health services fall
- population falls after demographic delays





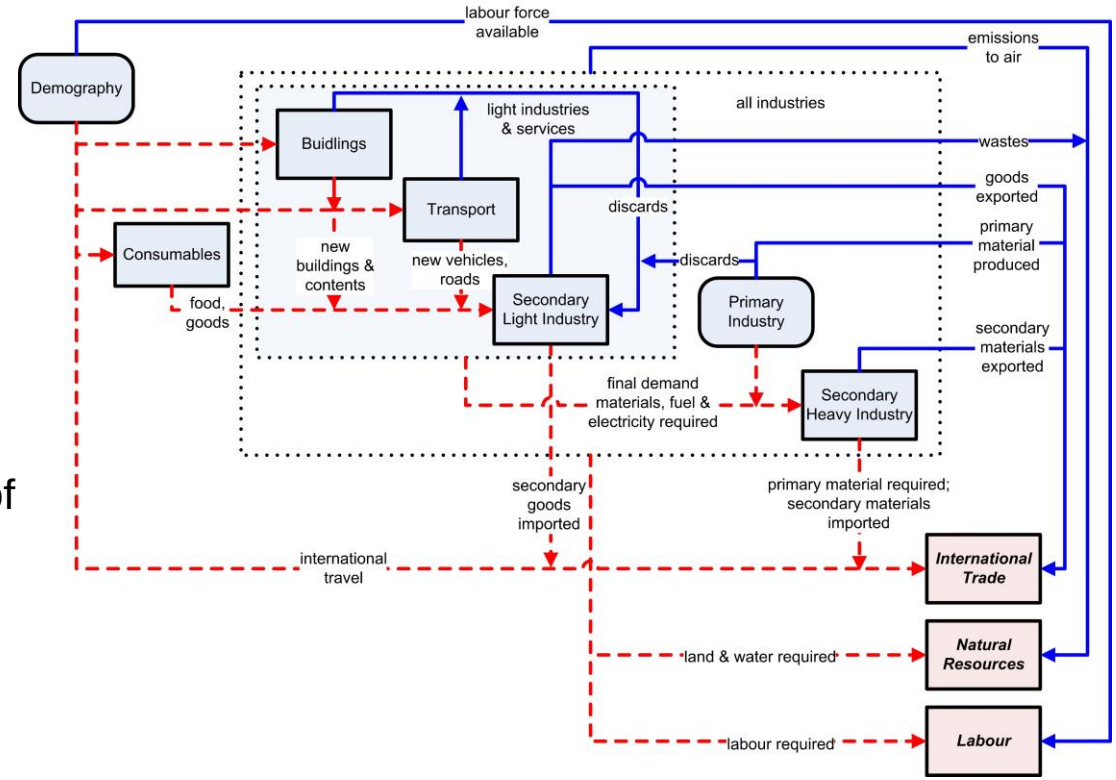


Other lessons from The Limits to Growth

- Other scenarios show similar effects
  - differences in timing and specific combination of factors
- In general, attempting to solve one challenge makes others worse
  - like pressing in on a balloon, first in one direction, and then another when it expands, etc. until it bursts
- Early action is required
  - action delayed until 2000 results in some ecological and economic impact
- Only less materialist lifestyle combined with technological progress leads to a sustainable global system
  - requires material lifestyle at about a 1950's (+ or – decades?) level
    - 1 car per household, 1 TV, houses 50% smaller, no aircon?
  - population control

What about the Australian context?

- Australian Stocks and Flows Framework, ASFF
  - Based on mass/energy conservation
  - Grounded with historical data
  - Transparent assumptions and data
  - Quantitative exploration of scenarios
  - Free of ideology
- Many studies
  - originally Future Dilemmas



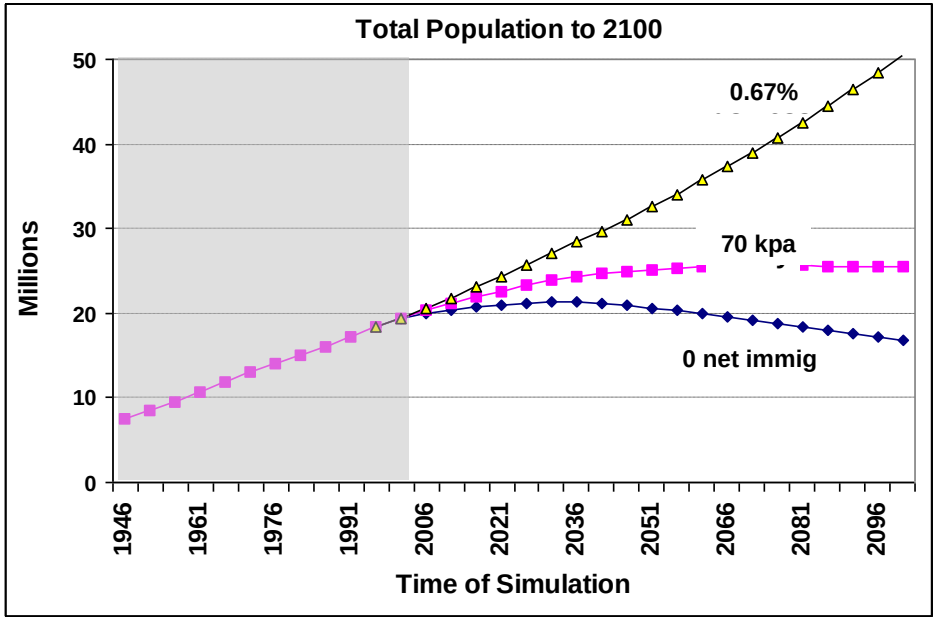
Australia faces multiple confounding environmental and economic challenges

- population
  - currently adding 1 new Canberra each year
  - population reduction might be difficult, slow
- labour
  - aging $\Rightarrow$ effective labour force may decrease by 20-30% by 2030
- agriculture
  - possible complete degradation of land in 4-6 decades
- fisheries
  - catch rate peaked in the 1990s, unlikely to increase
- water
  - 30% reduced river flow by mid century with ~2 °C global temperature change (cf 1990)
- transport fuel
  - domestic oil production could be 20% of demand by 2030
- infrastructure
  - all new power plant commissioned after 2011 must be C-free in 2050 to achieve 90% C reduction (of 1990 level); 60% target has a 2015 cut-off
  - 1/3rd of today's buildings may still exist in 2050
- GHG emissions
  - CO_2 emissions plateau and rise even with buildings 50% more efficient, cars @3L/100km, coal power plant at maximum thermal efficiency

Population growing

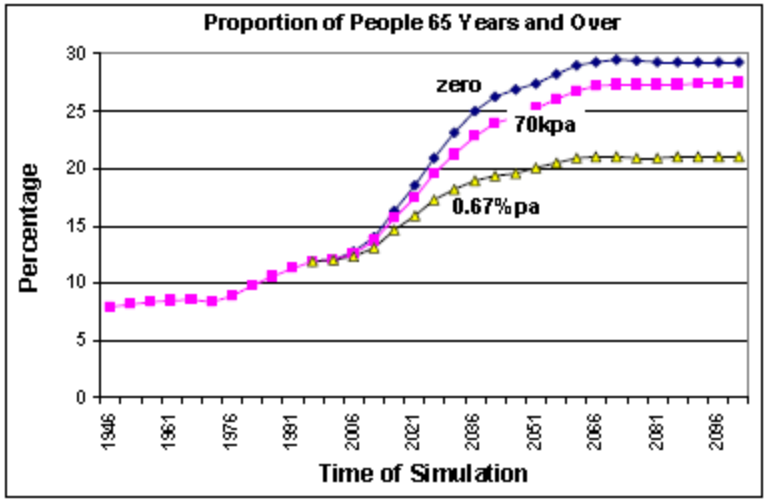
- Population
  - likely to increase by 50% or
  - 30+ million by 2050
  - currently increasing by ~300,000 pa
  - net immigration > natural increase

  - **1 new Canberra each year**

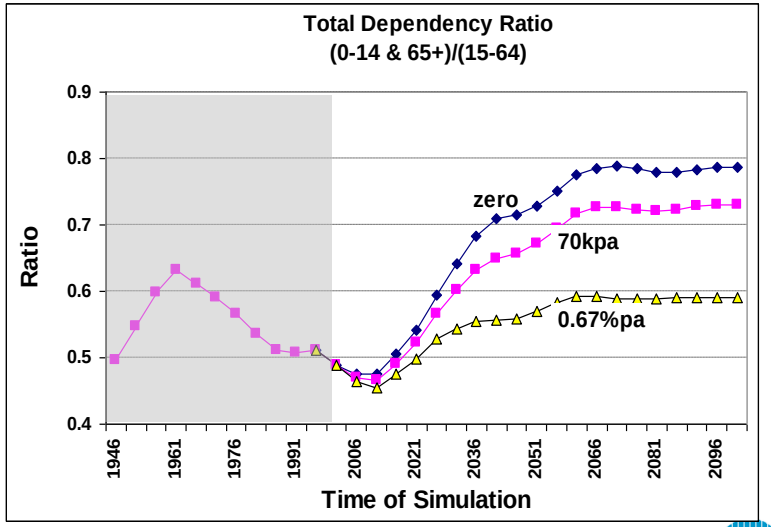


Population aging

- High immigration does not halt aging

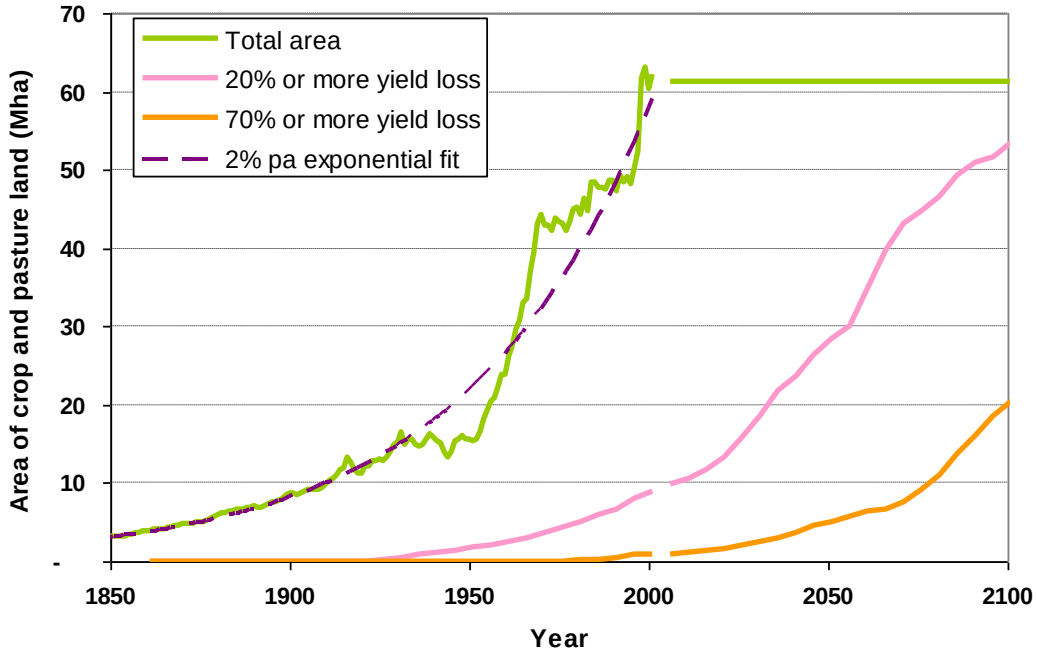


- Labour force constraints
  - effective labour force may decrease by 20-30%



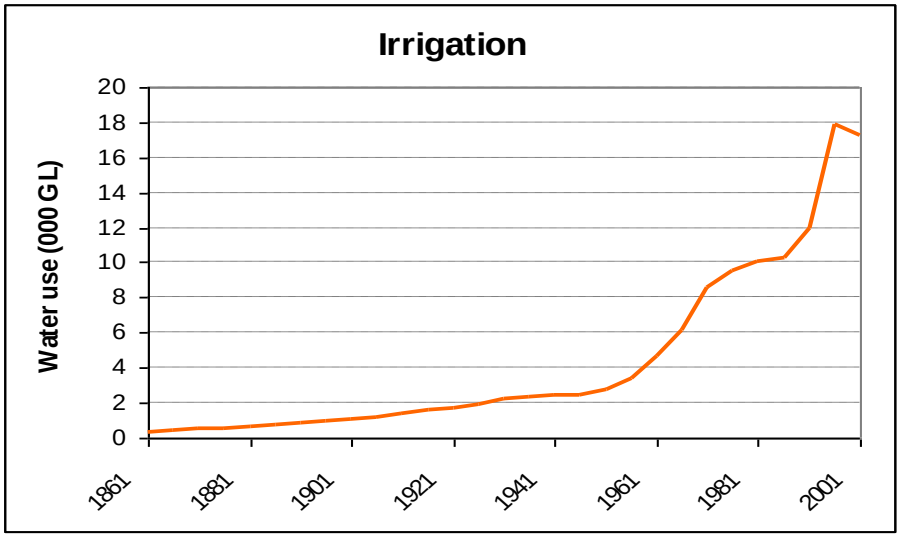
Agriculture has expanded rapidly

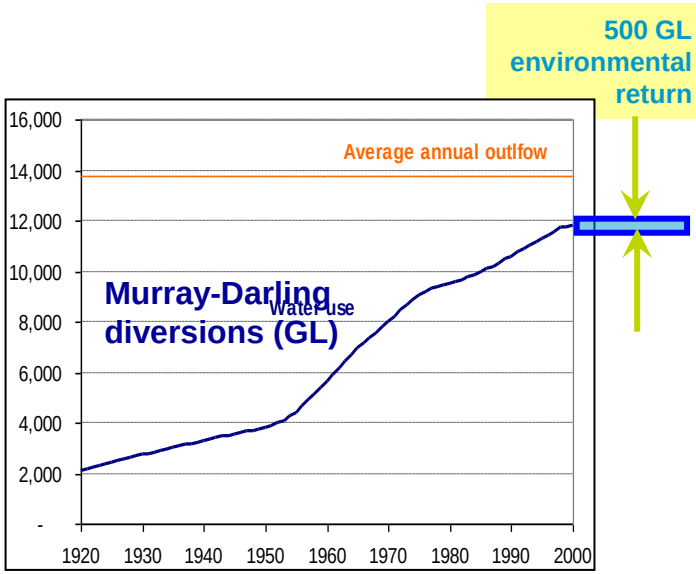
- adding new land has masked degradation of older land
  - past 2% pa growth unlikely to continue
    - doubling every 3 decades would require ½ Australian land area before 2100
- no change to land area may mean half may be degraded in 5 decades



Water use has increased rapidly

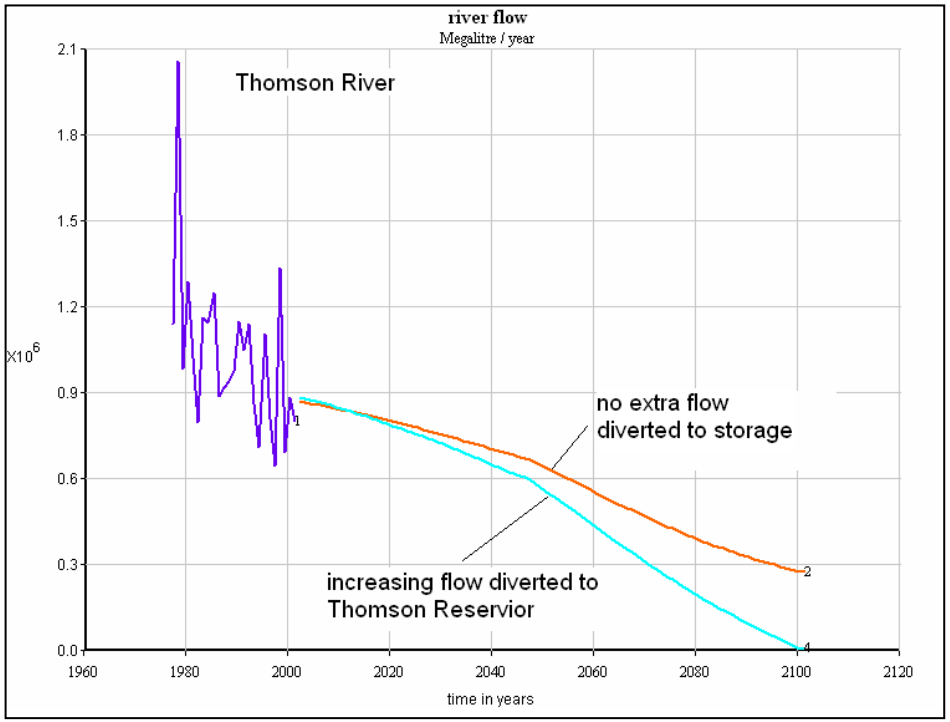
- many southern rivers are stressed, over allocated
  - 500 GL to be returned to the Murray is a small fraction





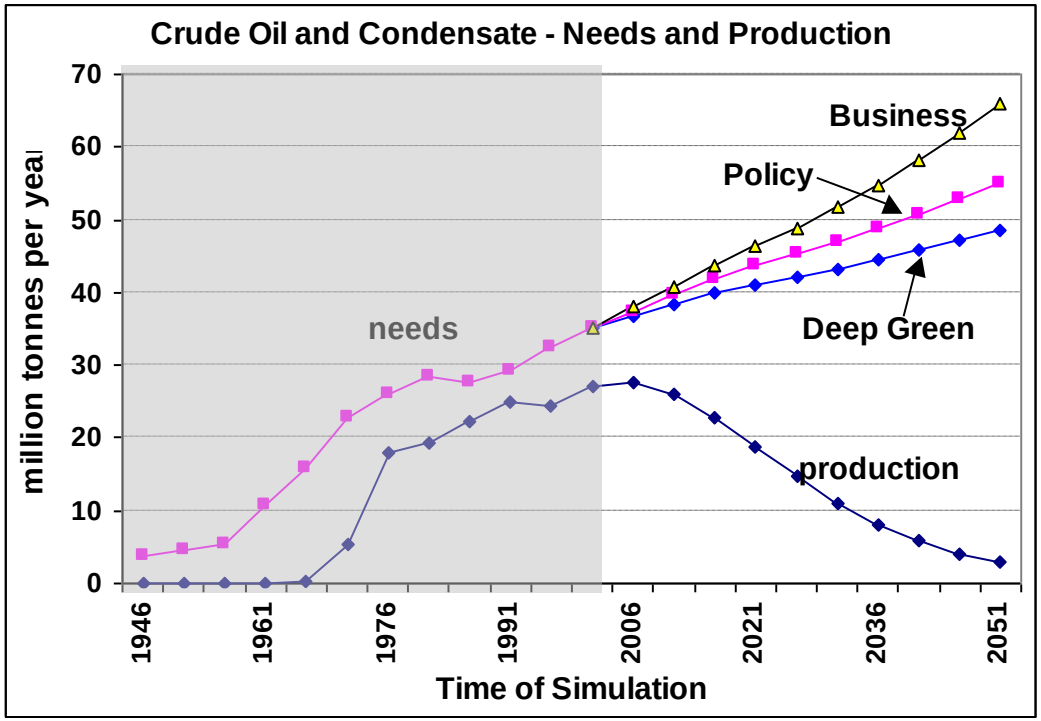
Water resources threatened by climate change

- River flow (e.g., Thomson supplying Melbourne) cannot be maintained indefinitely
  - 2.2 °C global temperature change (relative to 1990) would reduce river flow by more than 30% by mid century



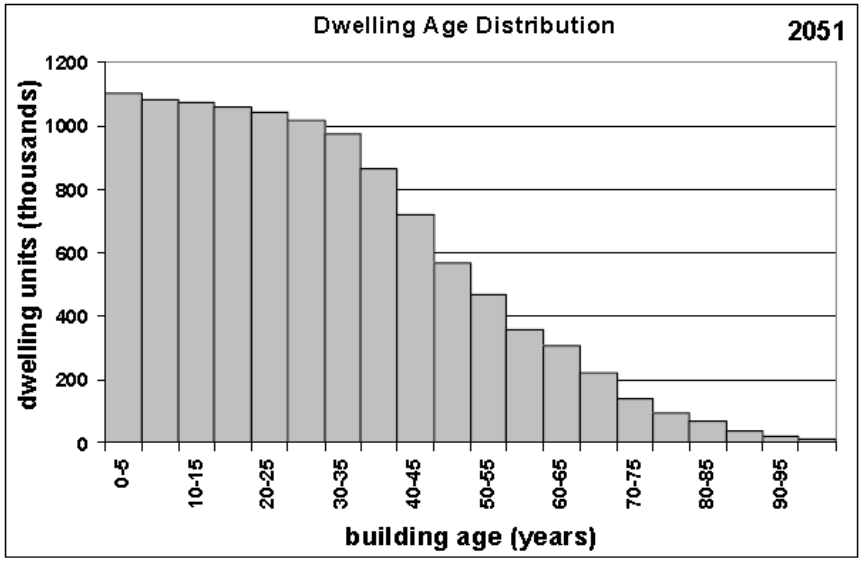
Transport fuel – imports or a transition?

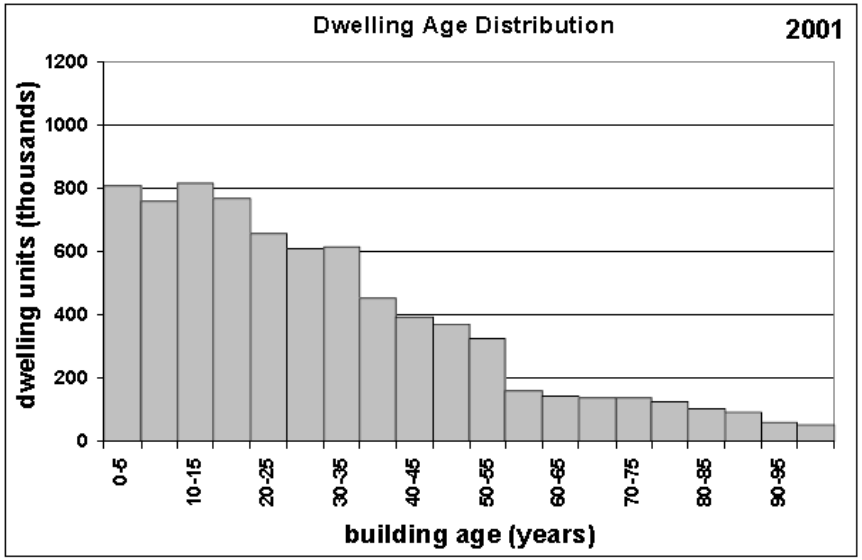
- growing domestic oil deficit
  - importing 80% by 2030?
  - shift to natural gas could provide security until about 2030



Urban stock lasts a long time

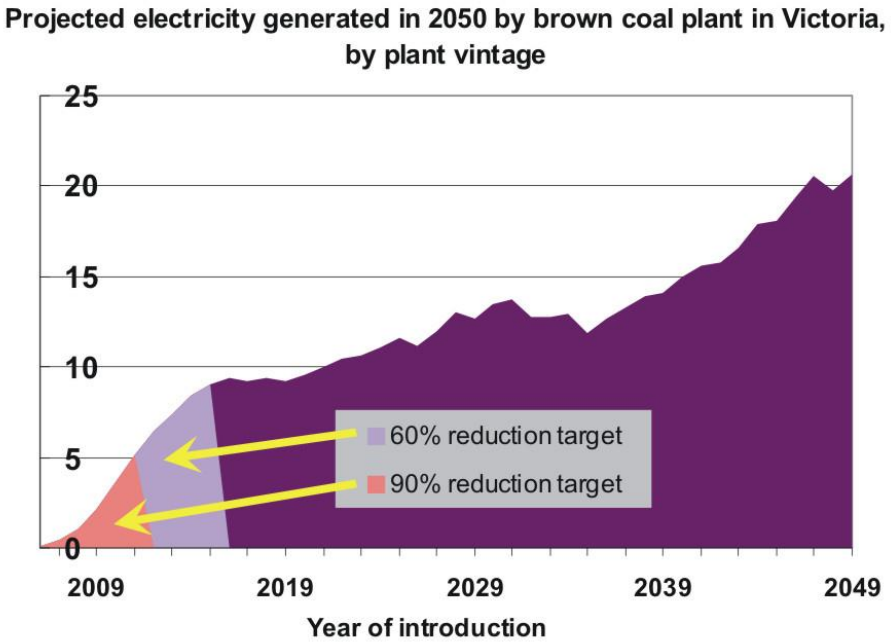
- Dwellings
  - 1/3rd of today's buildings may still exist in 2050
  - requires new buildings to be even more energy and water efficient than the overall target





Infrastructure lasts a long time

- Electricity generation plant
  - some current electricity plant may still be operating in 2050
  - rapid change (5-10 years) is required to achieve GHG targets



- 2015 is the cut-off year for a 60% C reduction target (on 1990 level) in 2050
- 2011 is the cut-off for a 90% target
  - assuming all new electricity plant after the cut-off are 100% C free (in 2050)
  - assuming all plant before the cut-off emit C
  - assuming continued energy consumption growth of ~3%pa

Global and national challenges require immense change

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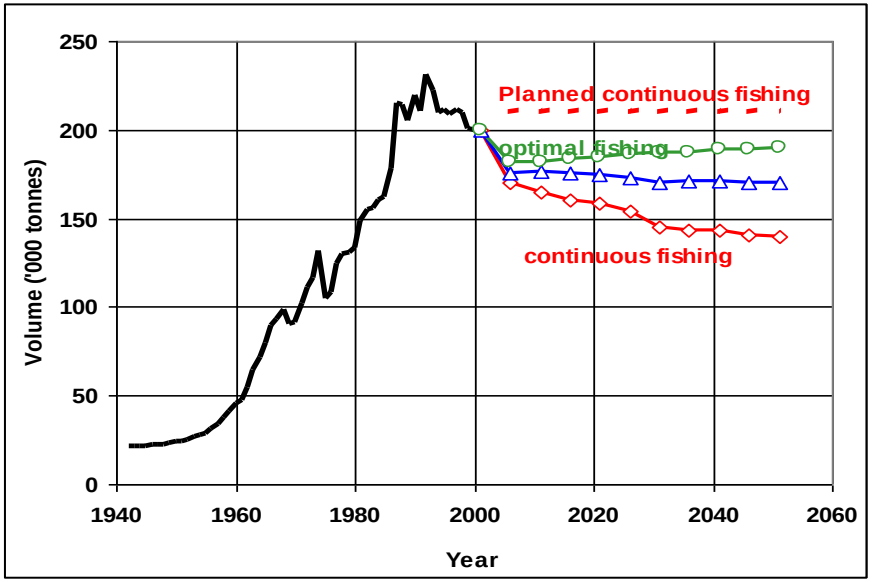
  - leads to ecological and economic collapse (possibly from 2020 onwards)
- Australian "Future Dilemmas" are also playing out
  - potentially conflicting challenges over the coming decades in labour, fuel and energy, water, land, food, emissions, infrastructure
- Range of responses
  - technology and marginal change are not likely to be enough (or may even make it worse)

Seafood catch is constrained

- catch rate has peaked in 1990's
  - fish stocks depleted
  - future catch cannot grow strongly, and may decline



Population, growing and aging

- Population
  - likely to increase by 50% or
  - 30+ million by 2050
  - currently increasing by ~300,000 pa
  - net immigration > natural increase
  - **1 new Canberra each year**
- Labour force constraints
  - aging population
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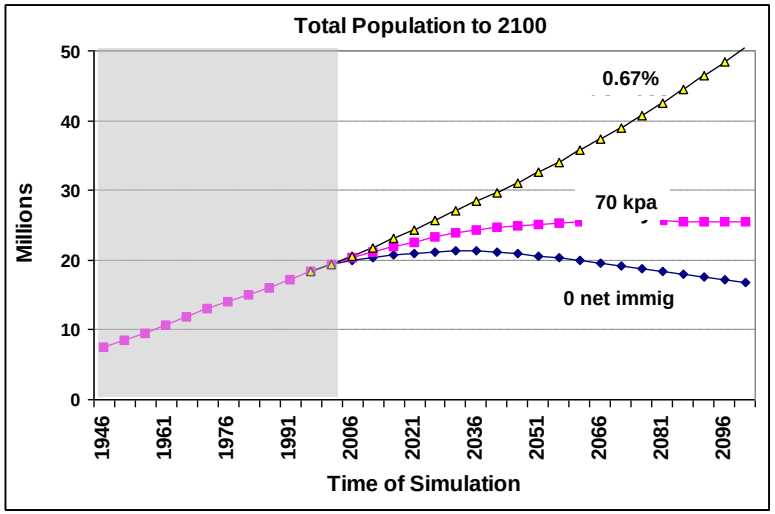
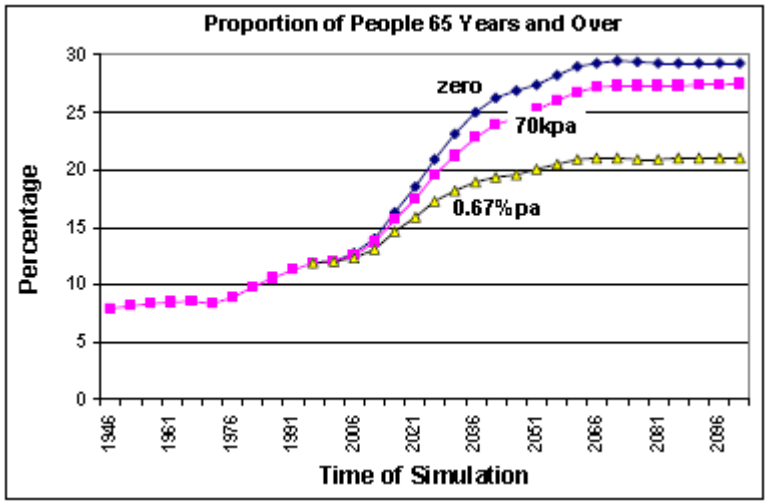
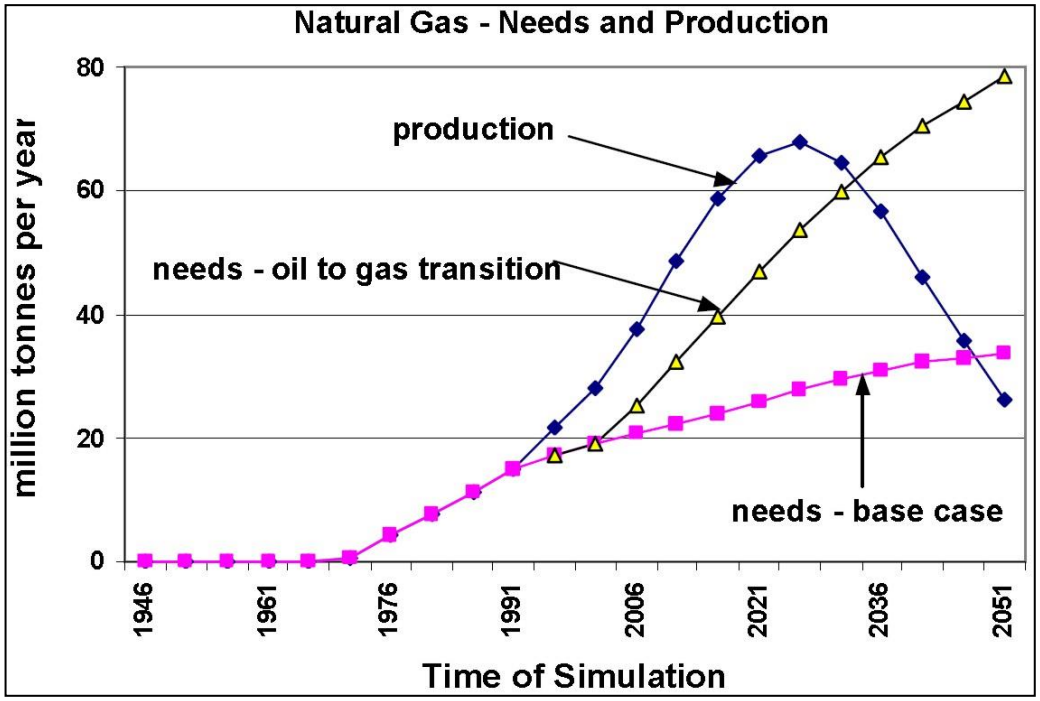




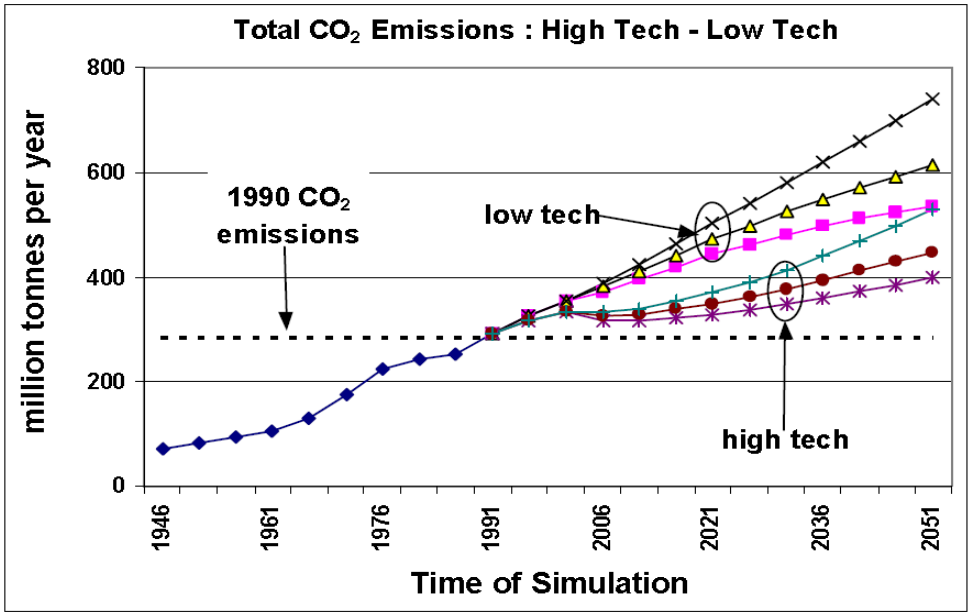
Transport fuel – transition to gas?

- switch to gas provides a few decades
  - bio-fuels may affect (or be affected by) biodiversity, land, water, amendments and labour constraints
    - unlikely to supply more than a fraction of the fuel required



Greenhouse emissions increasing from energy use

- GHG emissions
  - increasing well beyond Kyoto level
  - substantial efficiency improvements have temporary effects
    - buildings 50% more efficient by 2020
    - electricity generation at maximum thermal efficiency
    - cars at 3 L/100km by 2020
    - no rebound effect assumed



Summary

- Analysis approach – Australian Stocks and Flows Framework (ASFF)
  - whole-system physical account – explicit process model
  - transparent, long-term, dynamic, data-rich
- Results – National Sustainability Challenges
  - oil deficit growing
  - fish stocks depleted
  - agricultural land degraded
  - water resources over-allocated
  - workforce under pressure
  - trade balance worse
  - waste flows growing
  - pollutants and GHG increasing
- Key message:
  - a national stocks and flows framework is ideal for integrated sustainability analysis

Australia faces multiple confounding environmental and economic challenges

- labour
- agriculture
- fisheries
- water
- biodiversity
- transport fuel
- infrastructure
- GHG emissions

- Attempting to solve one problem may increase the others
  - Most issues depend on or impact many of the others

Why does growth appear necessary?

- Innovation (production efficiency) encourages growth
  - savings to consumers can be used to consume more
  - savings to producers can be invested in more production
  - displaced labour (from technological efficiency) would lead to high unemployment
  - so increased consumption provides a demand for greater production and labour employment

What possible economic changes or systems?

- What modifications or alternatives are available?
- What are their benefits and weaknesses?
- How likely is any change?

What possible economic changes or systems?

- Tax reform – ecological tax (on resources and wastes)?
  - does this address efficiency and growth? (cf C intensity & GHG)
- Cap and trade?
  - carbon…nitrogen, hydrogen (water), phosphorus…?
  - serious questions about the reality of C reduction possibilities (e.g., IEA!!)
- Economic crisis = window of opportunity for change?
- Other monetary systems?
  - e.g., mutual credit union, commodity backed money (“Economia”, Geoff Davies)
- Strategy & prices set by physical reality / forecasting?
  - monitoring (is not enough); modelling, back-casting
- Likelihood of change very low?
  - powerful vested interests, lack of public acceptance, multiple simultaneous change
  - prepare emergency plans for rapid response?
  - prepare lifeboats?
    - a new “Canberra” each year! could they be largely self-reliant?

These system-wide analyses show…

- The scale of the challenge is immense
  - marginal change is not enough
- Technology alone is likely to make things worse
  - rebound (backfire) effect & growth
- Less material consumption is required
  - large lifestyle changes are required (along with technological improvements)
  - but how to maintain employment?
  - how to deal with innate innovation?
    - less days/week
  - how to transition orderly, not transpose chaotically?
    - rate of change similar to the past, but in the opposite direction (does that “double” the challenge?)

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