How to make the dairy farm more Carbon Neutral

Richard Eckard

piccc

Primary Industries Climate Challenges Centre

Primary Industries Climate Challenges Centre

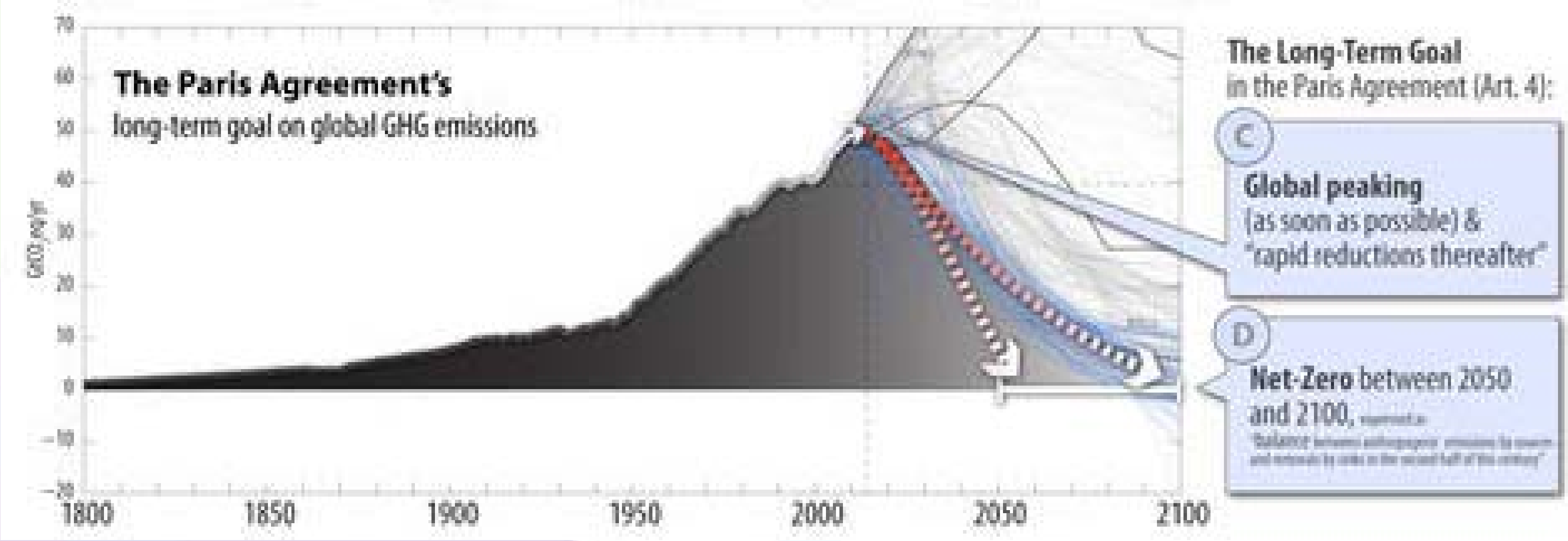
THE UNIVERSITY OF MELBOURNE

What is Carbon Farming?

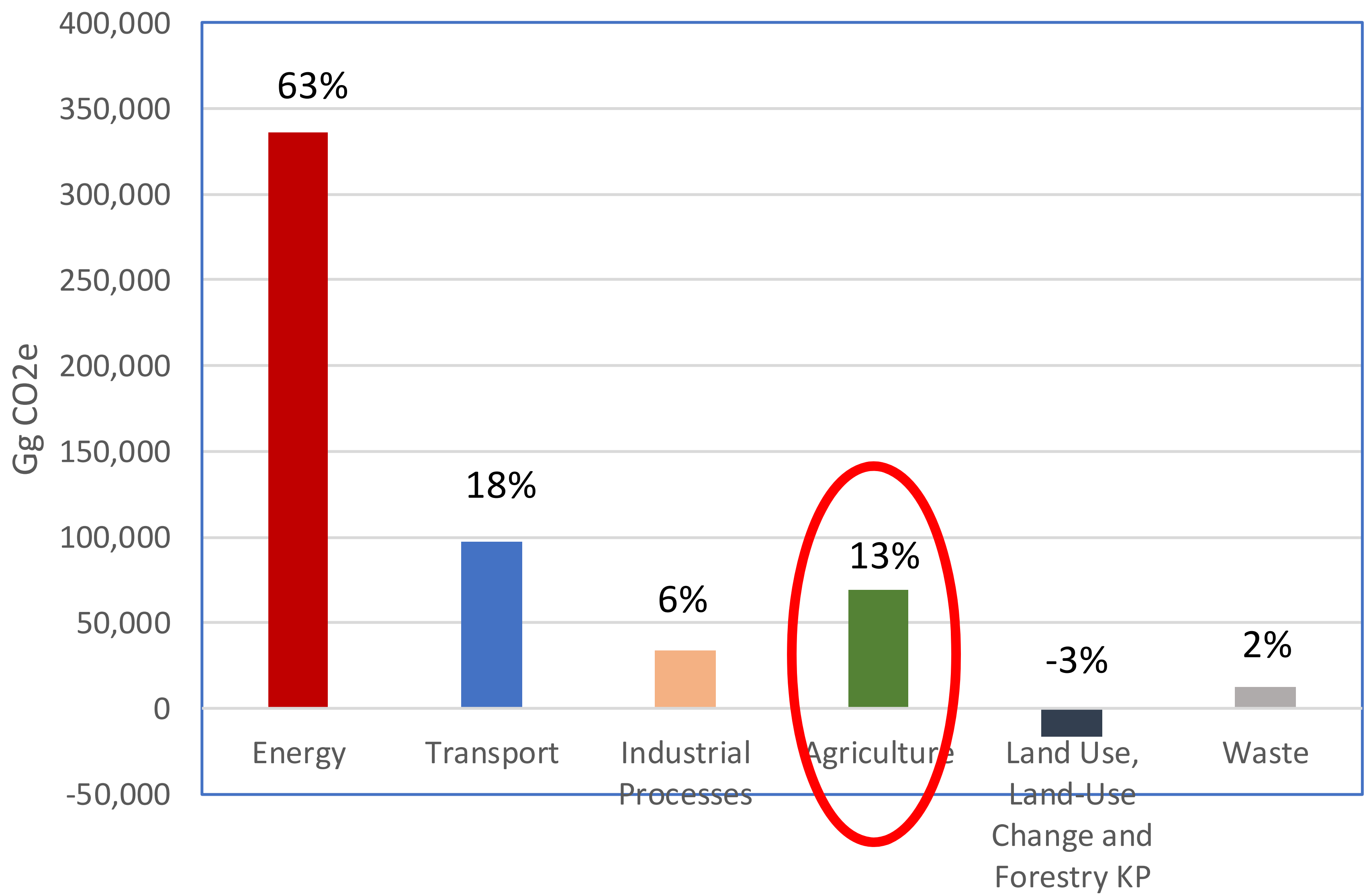
- Carbon Farming
  - Management principles that minimise GHGe, maximise carbon sequestration in the landscape, while improving the productivity and resilience of agricultural systems
    - Term not (yet) owned by a particular lobby group
    - Has bipartisan support in Australia
- Carbon Neutral
  - Management that minimises GHGe, and offsets the balance of emissions through sequestration of an equivalent amount of carbon dioxide in soils or vegetation
    - On an year-by-year basis
    - On net GHG cradle to farm-gate basis (LCA)

Why Carbon Neutral? COP21 Paris Agreement

- Net zero emissions from 2050
  - Any remaining GHG emissions need to be offset
  - Business and governments are aiming to comply

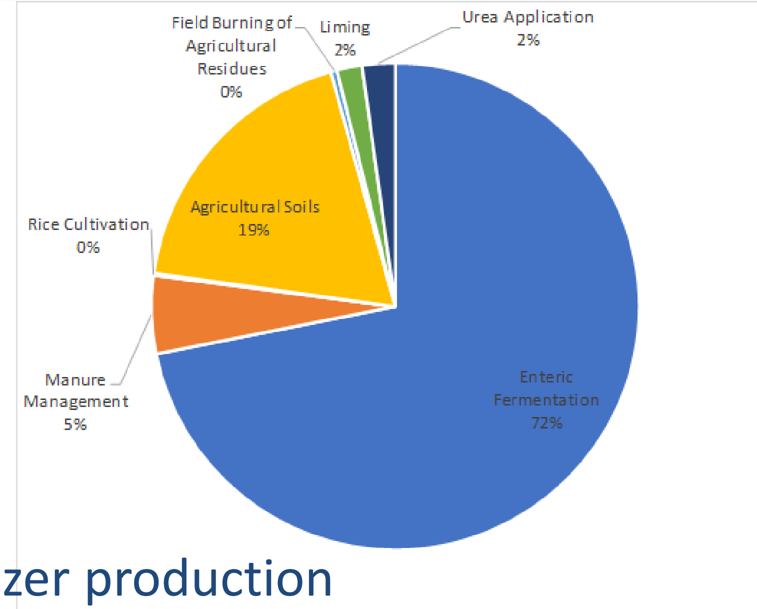


Why Carbon Neutral?
Australian National Emissions



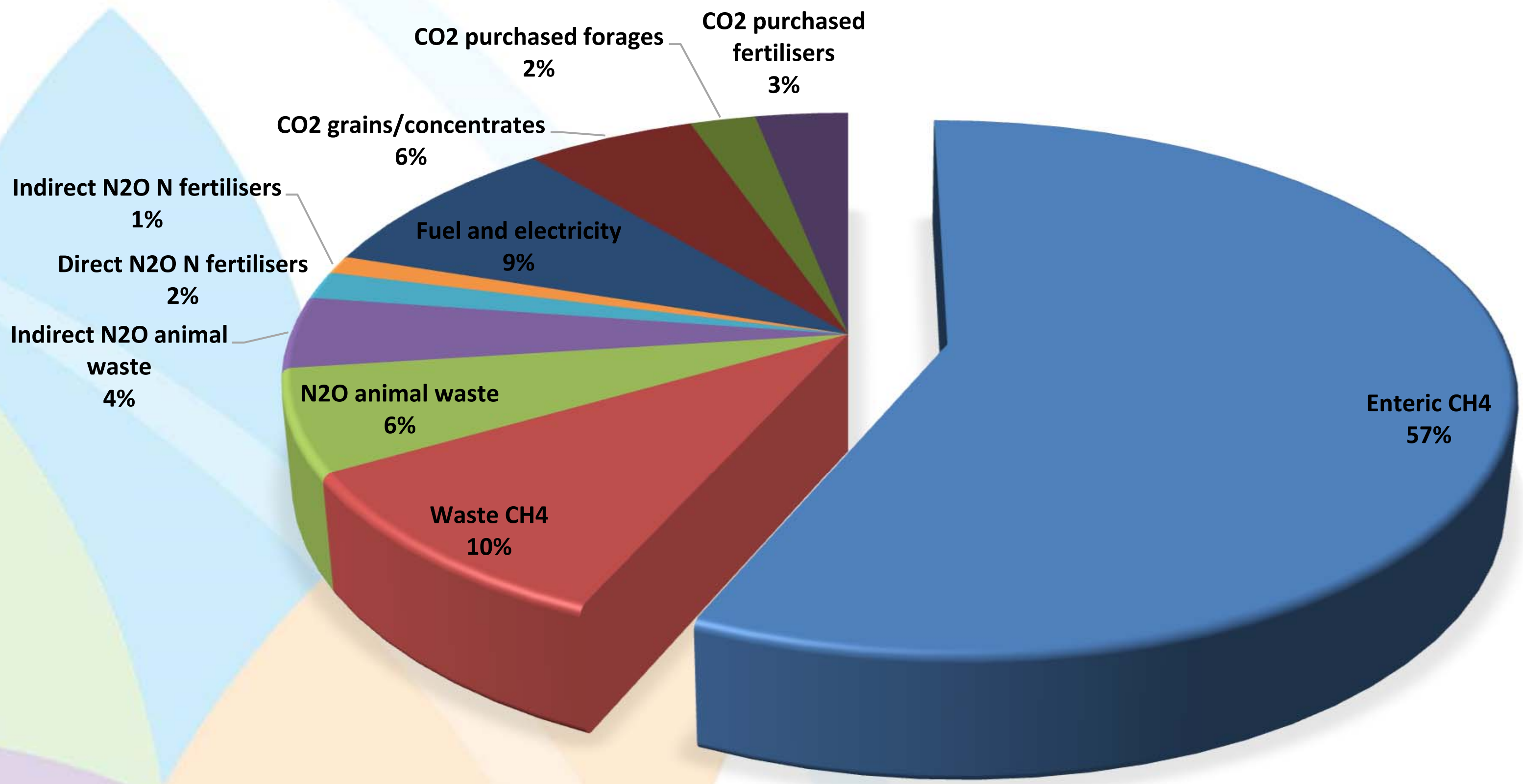
DOE 2018

Why Carbon Neutral? Agricultural emsisions



- Methane
  - Ruminants, waste management
- Nitrous Oxide
  - Fertilizer, excreta, waste, legumes etc.
- Carbon Dioxide
  - Energy, lime, urea application and fertilizer production
- But agricultural land also has the capacity to sequester CO_2 in the soil and into trees

Typical Dairy Farm Emissions



Christie *et al.* 2016

COP21 - Paris Agreement

Investors responses

FAIRR - an index to analyse livestock production against the Sustainable Development Goals (SDGs).

A resource for institutional investors on risk of investment in livestock.

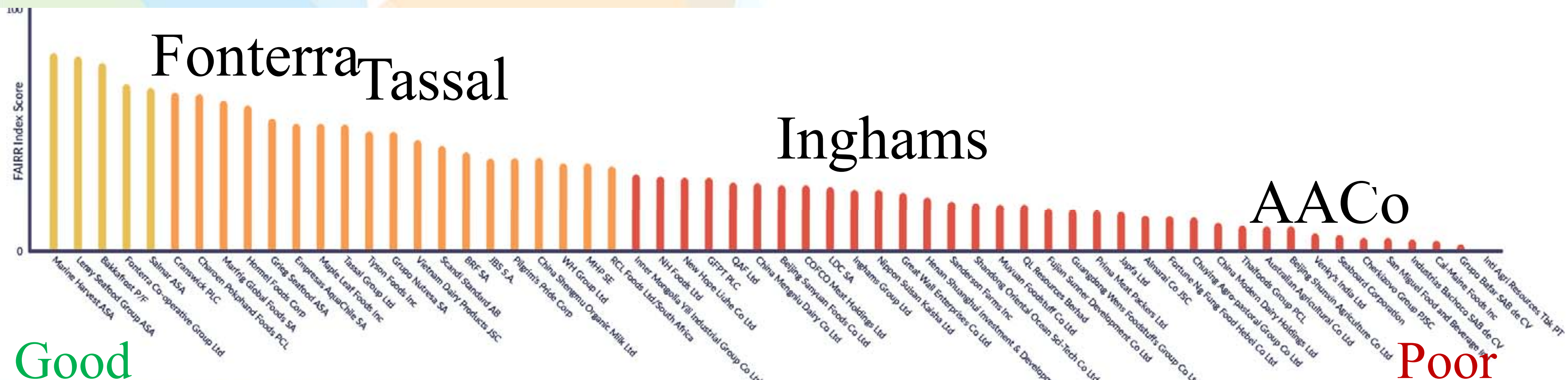


Figure 3: FAIRR Index league table (all factors): final company scores (out of 100)

COP21 - Paris Agreement
Supply chain responses

- Fonterra
  - Climate-neutral growth to 2030 for pre-farmgate emissions from a 2015 base year
- Unilever
  - Reducing the GHG impact of their products by 50% by 2030, compared to baseline of 2010
- Mondelez
  - Reduce absolute GHG from manufacturing 15%
  - 100% renewable energy
- Nestle
  - Zero environmental impact in our operations
- Mars
  - Reduce GHG across our value chain 27% by 2025 and 67% by 2050 (from 2015 levels)
- Kellogg Company
  - 65% reduction by 2050
  - 100% renewable energy
- Pfizer
  - 60 to 80% by 2050
- Wilmar international
  - 89.72% less GHG from 2013 to 2020
  - 100% renewable energy
- Olam
  - Reduce GHGs by 50% by 2030 both in our own operations and in our supply chain
  - By 2050, we aspire to be carbon positive in operations, requiring a 5% emissions reduction per year from 2031 – 2050

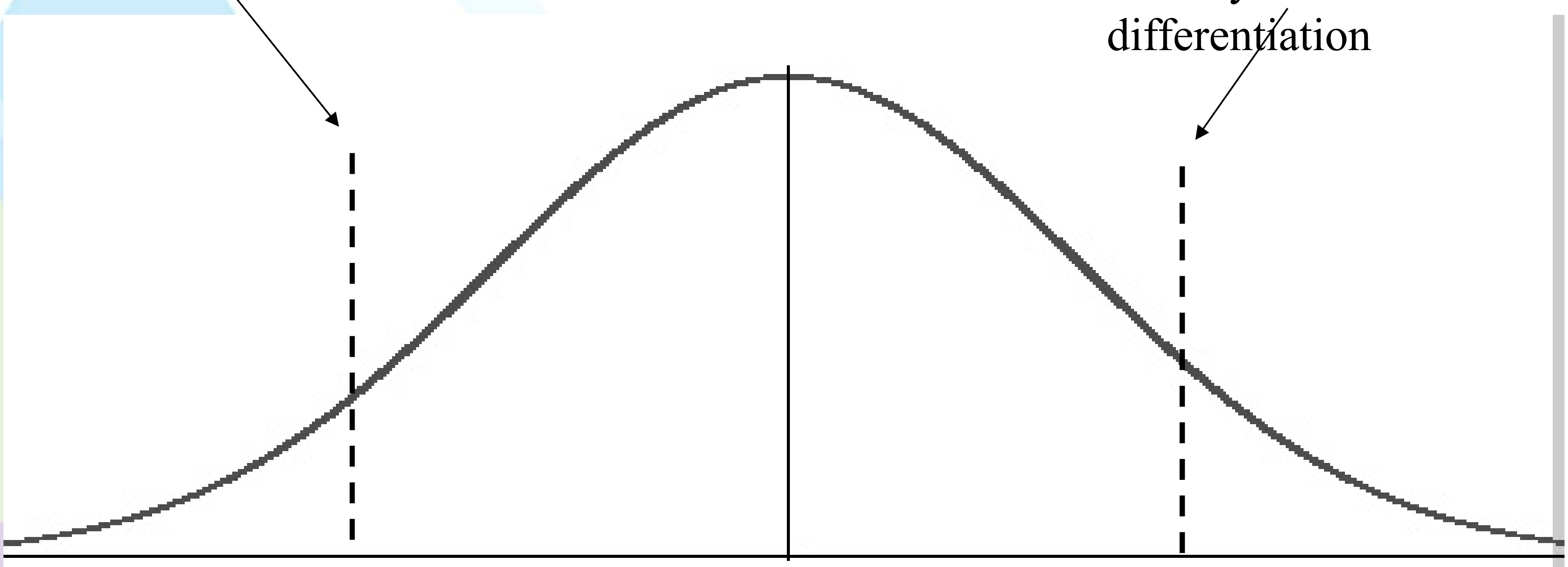
- **All responding to the Paris 2050 neutral target**
- **Of the 100 largest economies 69 are companies and 31 are countries**
  - Government policy may now be less influential than market forces

(Unilever 2010; Fonterra 2017)

COP21 - Paris Agreement
Government vs industry

Where government policy typically operates – picking up the laggards

Where industry policy typically operates – leading the way for market differentiation

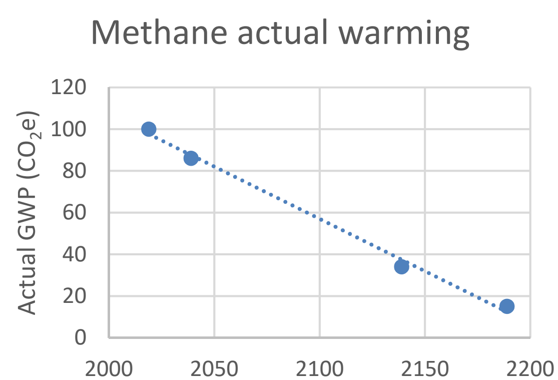


Of the 100 largest economies 69 are companies and 31 are countries

Government policy may now be less influential than market forces

COP21 - Paris Agreement
Livestock Industry Responses

- Meat and Livestock Australia
  - Australian beef can be carbon neutral by 2030 (CN30)
    - *Given the right industry, R&D and policy settings*
- Mato Grosso do Sul (MS), Brazil
  - "MS carbon neutral" initiative
    - Including livestock
  - Carbon neutral Brazilian Beef
- New Zealand
  - Proposed Zero Carbon Bill
    - Net zero by 2050 – long lived gasses
      - Includes agriculture
    - Livestock methane target
      - 10% by 2030 and 24% - 47% by 2050 (over 2017)



COP21 - Paris Agreement
Potential impact on dairy

- Danone purchased SILK/Whitewave (2017)
  - $12.5B Silk brands
    - Fastest growing US food and beverage company
      - 19% annual compound ground 2012 – 2015
    - Total milk sales in US declined 13% (2010-2015)
      - Plant based milks growing at 11% and organic milk at 23%
  - Danone media quotes:
    - "Accelerate our towards **sustainable** and profitable growth"
    - "Healthier and more **sustainable** eating"
      - Code for lower emissions

COP21 - Paris Agreement
Carbon Neutral Livestock

- Rapidly rising interest in Australia
  - Arcadian Organic & Natural's Meat Co's
    - 100% carbon neutral across its entire supply chain
    - Purchasing carbon credits
  - NAPCO
    - Five Founders beef brand – carbon neutral hoofprint
    - Purchasing carbon offsets
  - Flinders + Co Meats
    - Carbon neutral wholesale/distribution activities
- Regular carbon audits requested
  - Large corporates to family farms
- Major supermarkets - carbon neutral groceries
  - At 70c/week

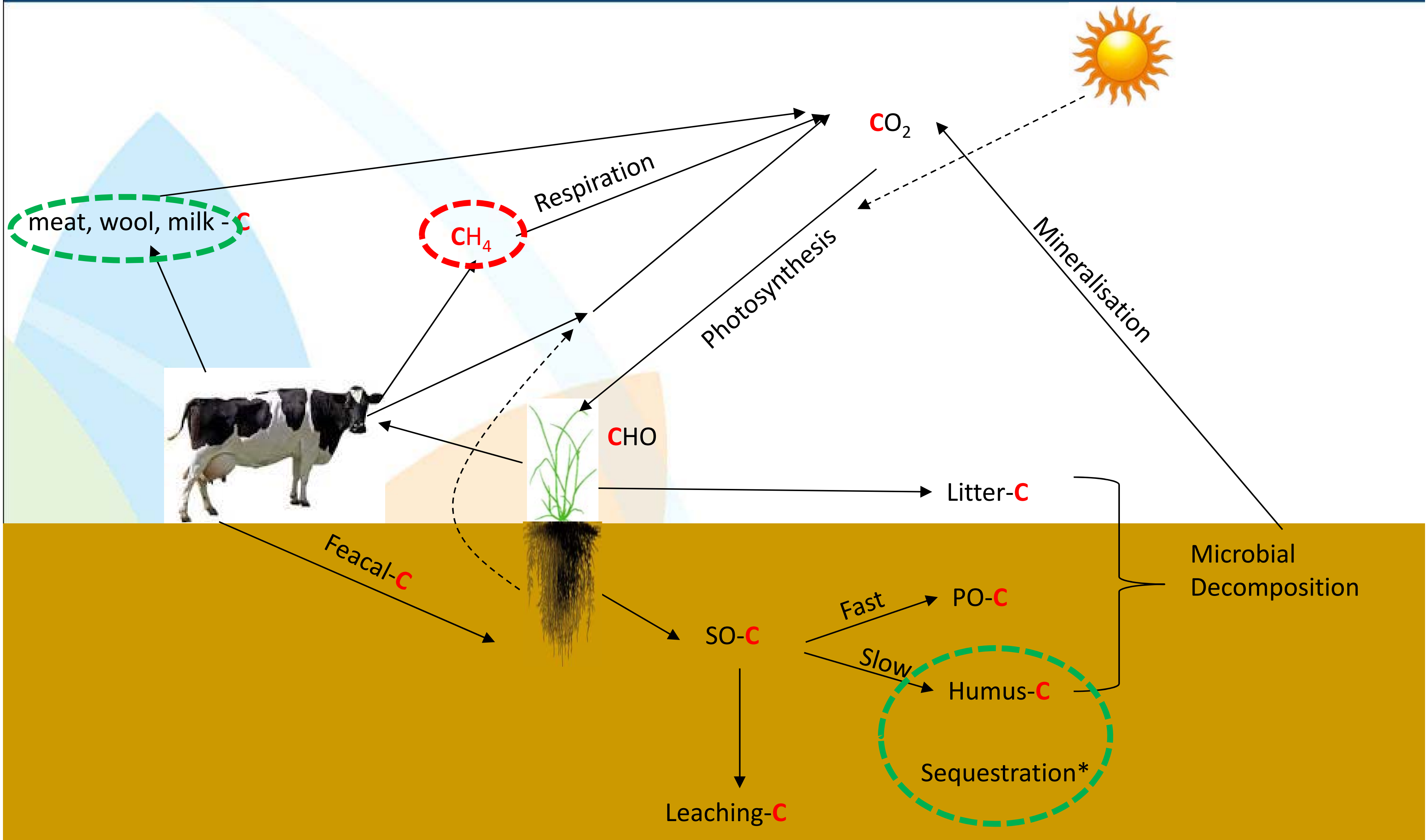
Carbon Neutral vs Carbon Account

- Carbon account (CA)
    - (t CO_2e)
  - All GHG emissions arising within the operational and organisational boundary of the farm enterprise.
  - Scope 1 (*direct*) emissions and sources of sequestration.
  - Scope 2 (*indirect*) emissions from electricity
  - **Not** scope 3 (*downstream*) emissions
- Carbon footprint (CF)
    - (t CO_2e/t product)
  - Life cycle of all products produced
  - Includes pre-farm emissions from purchases and livestock

Why Carbon Farming?

- Common efficiency metrics
  - Nitrogen use efficiency
  - Water use efficiency
  - Energy use efficiency
- Why not "Carbon Use Efficiency"?
  - Atmospheric C (CO_2) -> Plants
    - CHO and protein = 43-48%
  - Plant C -> Animals
    - Proteins, carbohydrates, lipids, and nucleic acids (~23%)
  - Plant C -> Soil
    - Soil organic carbon
  - Energy efficiency

The Carbon Cycle in livestock

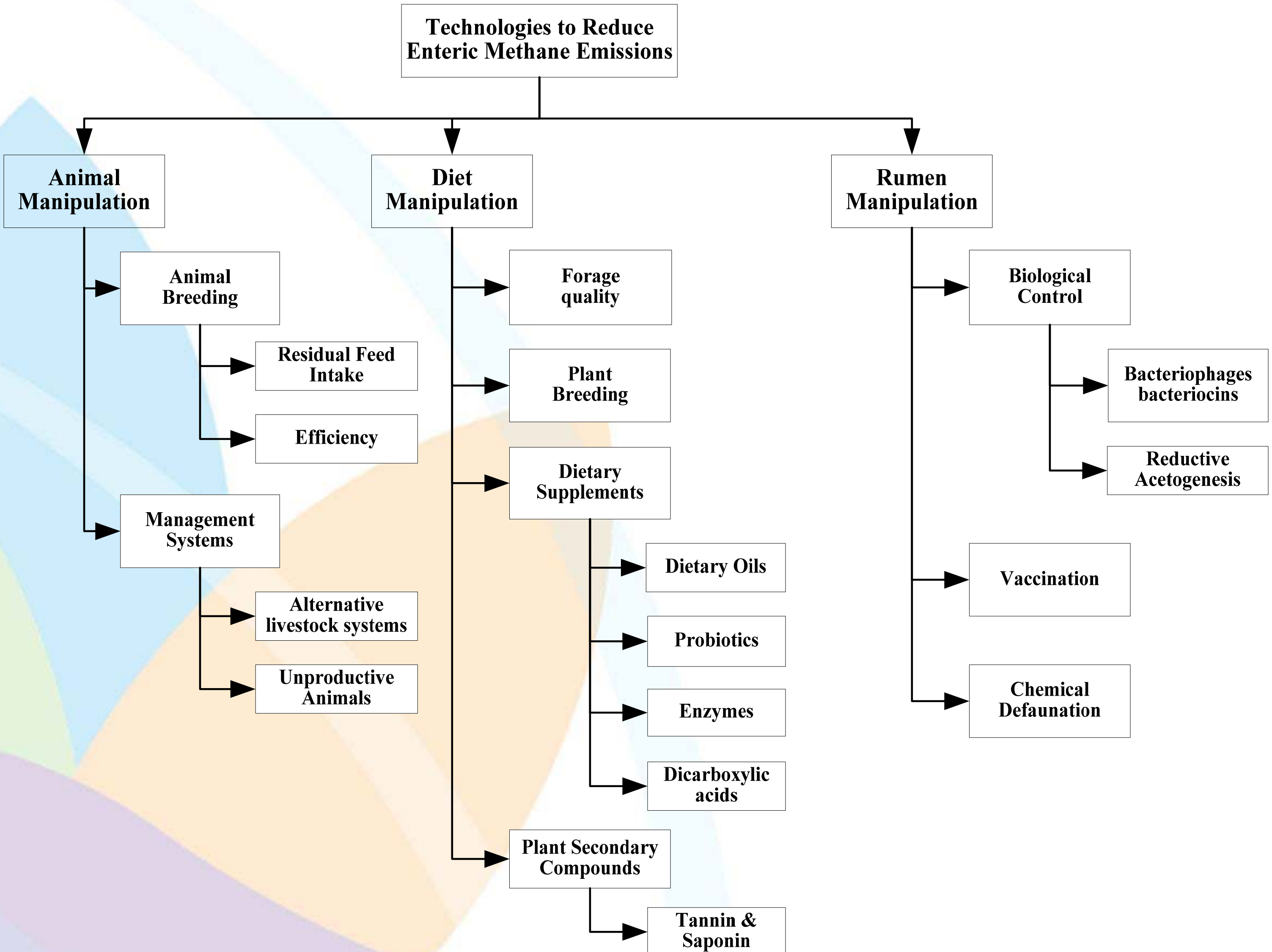


~Half of all products/compounds in farming is carbon

After Eckard, 2009

What can be done on farm now?
Methane

Methane from animal production

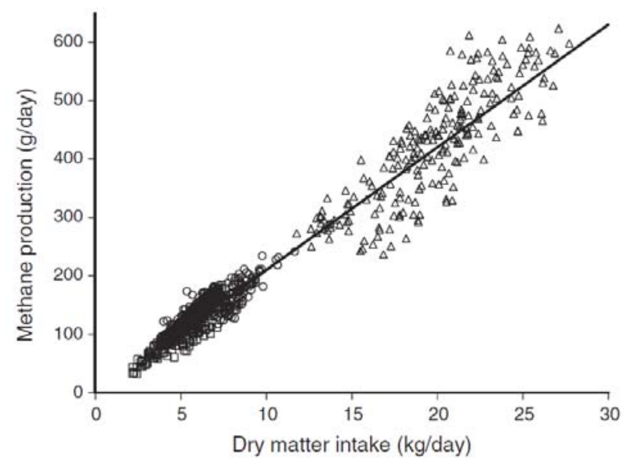


Eckard *et al.* 2010

Factors affecting enteric methane loss

- Rumen passage rate
  - More/less time producing methane
- Forage quality
  - Faster digestion
- Rumen pH
  - More acid less CH_4
- Secondary compounds
  - Tannins (legumes), saponins, oils (by products)
- Direct inhibitors and vaccines

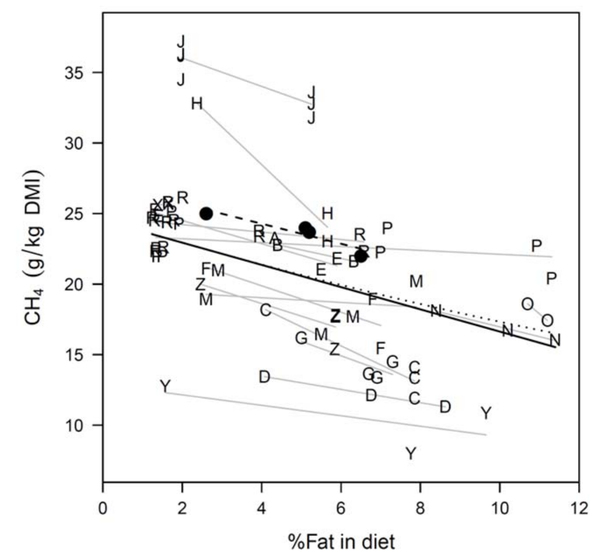
Methane (g/day) = 20.7 x kg DMI /day



Charmley *et al.* 2016

Solutions to enteric methane
Dietary supplements

- Lipids/Oils (~20%)
  - 1% added fat = 3.5% less CH_4
- Tannin (>20%)
  - e.g. Forage legumes
- Grape marc (~20%)
  - Oil and tannin
  - Cottonseed oil (14%) + tannin (11%)
  - Rapid adoption in feedlots

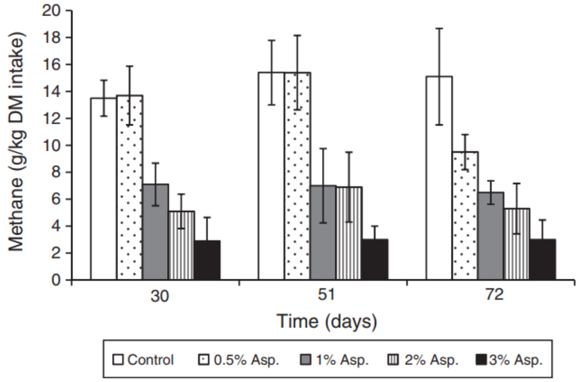


Grainger et al. (2009); Moate et al. (2011; 2014; 2016); Williams et al. (2019)

Solutions to enteric methane
Dietary supplements

- Asparagopsis taxiformis/ Red Algae (>80%)
  - >90% less *in vitro* CH_4
  - >80% less *in vivo* CH_4 (sheep)

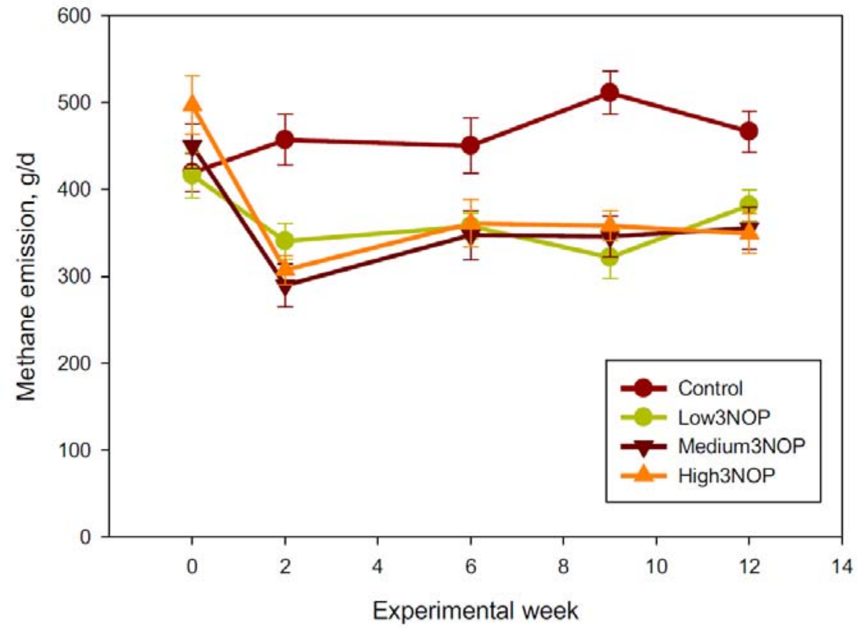
- Bromoform halogenated compounds?
- Research has demonstrated significant mitigation is possible



Van Nevel and Demeyer (1996); Machado et al. (2014); Li et al. (2018); Eckard and Clark (2018); Li *et al.* (2018)

Solutions to enteric methane
Rumen manipulation

- 3-nitrooxypropanol (3-NOP)
  - Inhibitor of methaogenesis
  - – *In vitro* (85-96%)
  - – *In vivo* (30-42%)
  - – Cost?
    - 180 mg/cow/d at peak
      - – 350 g/day for 200 cows
    - $12-18/kg at @$12/t CO_2e carbon price
      - – $5/day for 200 cows?
  - – Controlled release technology in development

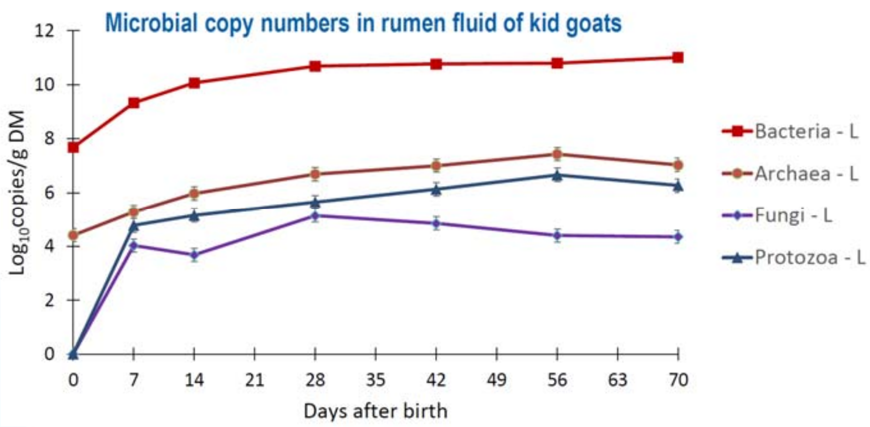


Hristov *et al.* (2015)

Duval and Kindermann (2012); Martínez-Fernández et al. (2014); Hristov et al. (2015); Vyas et al. (2018); Alvarez-Hess et al. (2018)

Solutions to enteric methane
Rumen manipulation

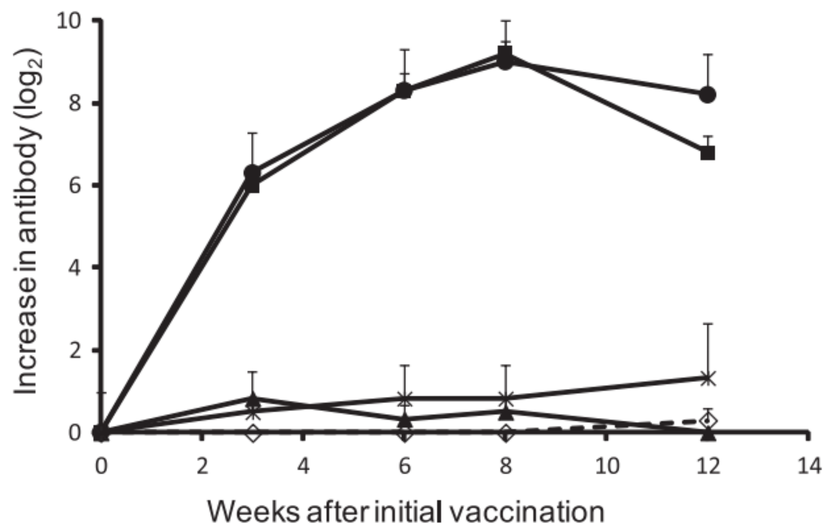
- Early life programming
  - Maternal influence on microbial community structure post-weaning
  - Nutritional intervention in early life =>
    - Modified structure of the archaeal community
  - Holds potential for
    - Low-cost, intergenerational, sustainable solution
  - No conclusive results yet
    - Potential mitigation unknown



Jiao *et al.* (2015); Yáñez-Ruiz *et al.* (2015);; Abecia et al. (2014); Eckard & Clark (2018)

Solutions to enteric methane
Rumen manipulation

- Vaccine (20%?)
  – Methanogen surface proteins have been shown to be immunogenic in ruminants
  – Saliva antibodies shown in sufficient quantities
  – Ultimate CH_4 impacts still unclear
  – Important potential longer-term



Wedlock et al. (2013); Eckard & Clark (2018)

Solutions to enteric methane
Low emitting feeds

- Forage rape & fodder beet (18% less CH_4)
  - 20 to 50% of diet

- High sugar and high lipid ryegrass (?%)
  - No published evidence as yet
  - Less clear for high sugar, than high-lipid ryegrass

Sun et al. (2015); Jonker et al. (2017; 2018)

Solutions to enteric methane
Animal Breeding

- Breed for lower methane /kg DMI
  - Genomic markers developed for sheep
  - Heritability in cattle (h=0.2)
    - Could be related to passage rate or smaller rumen
  - Potential longer-term (5 to 10%)
    - Gains around 1% per year
    - Low incentive for adoption
    - Compatibility with other traits?
- Breed for increase FCE?
  - Less DMI for the same production (thus less CH_4)
  - More consistent with other productivity traits?

Pickering et al. (2015; Pinares-Patiño et al. (2013); Cabezas-Garcia et al. (2017); J. Lassen, Viking Genetics)

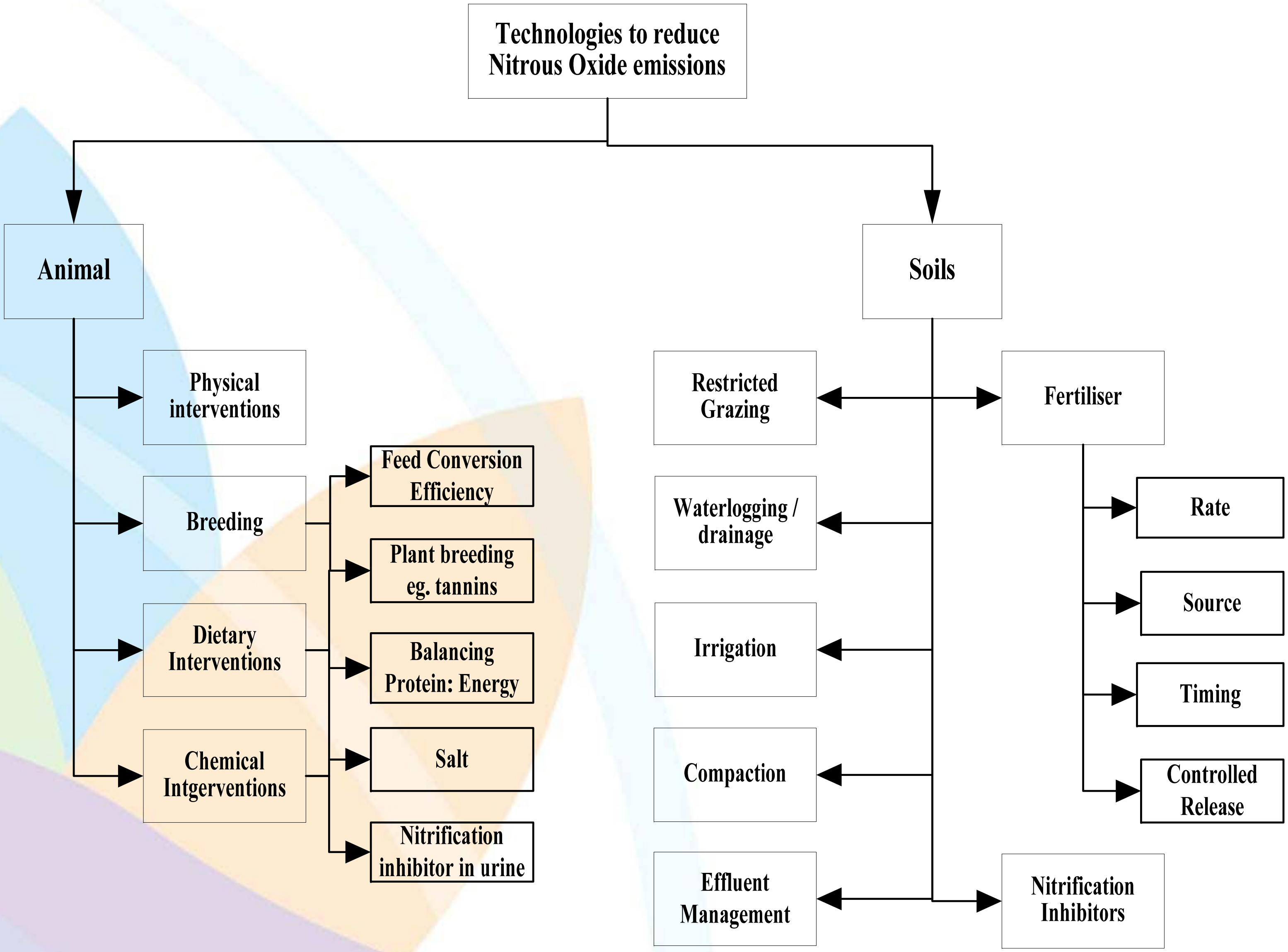
Solutions to enteric methane
Animal manipulation

- Animal and herd management
  - Reducing unproductive animals
  - Health and management
  - Extending lactation
    - Changing the effective replacement rate

Eckard et al. (2010); Reisinger et al. (2017); Browne et al. (2014)

What can be done on farm now?
Nitrous oxide

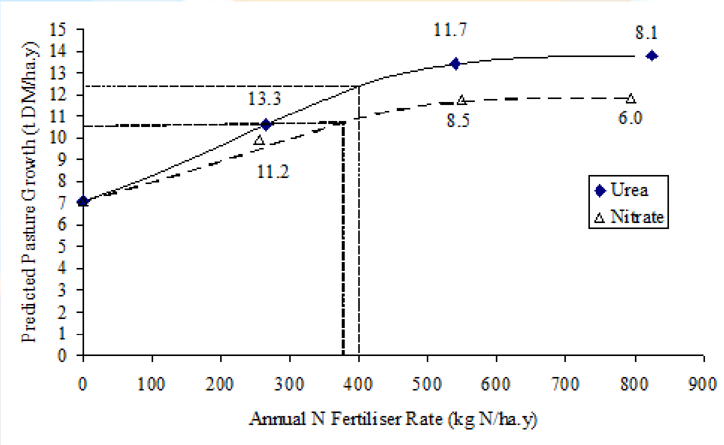
Nitrous oxide from animal production

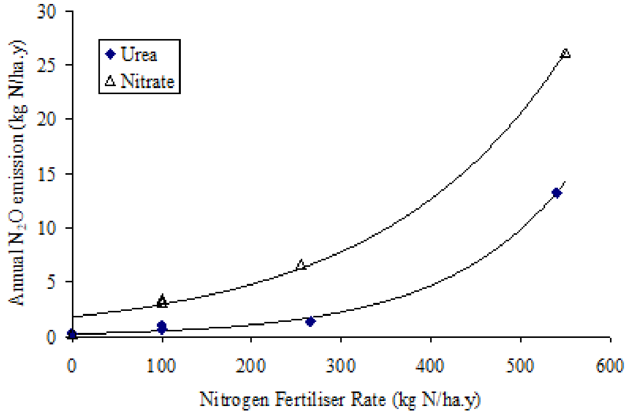


Eckard *et al.* 2010

Nitrous oxide - Nitrogen fertiliser

- N fertiliser
  - 3.5% of total dairy farm emissions
- Improving N use efficiency
  - Follow Fert$mart BMPs
    - 37 and 74% less N loss

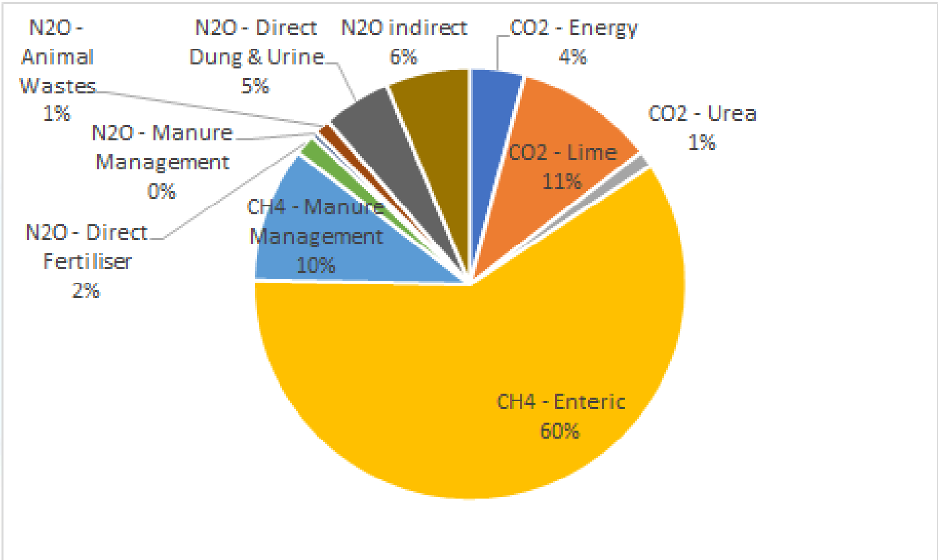




Eckard R.J. et al. (2006); Christie et al. (2018); Smith et al. (2018)

Nitrous oxide - Animal excreta

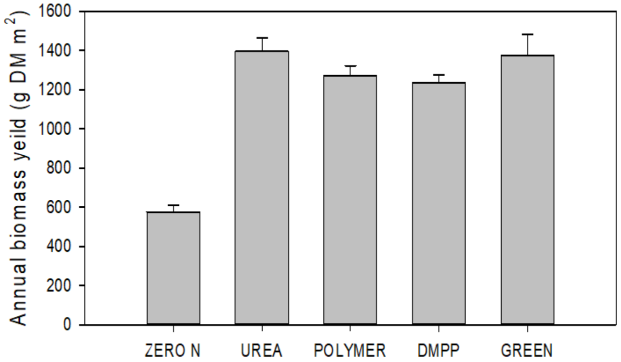
- Excess dietary N excretion in the urine
  - Balancing the energy to N ratio
    - 50% and 57% less N2O
  - Options include
    - Grain, brassicas, plantain or fodder beet
    - High sugar ryegrass



Christie et al. (2014); de Klein and Eckard (2008); Reisinger et al. (2017); Jonker et al. (2018)

Nitrous oxide – Nitrification inhibitors

- DCD
  - Spray and coated-urea
  - 61 and 91% less N2O from urine patch
  - Temporarily banned
    - Likely codex listing by July 2019
- DMPP
  - Coated-urea fertiliser
  - Similar efficacy to DCD-coated urea
- Reduce the N rate by expected N loss savings



Di et al. 2010; de Klein et al. (2010); NZAGRC (2016); Dougherty et al. (2016); Rowlings et al. (2016); Suter et al. (2016); Nauer et al. (2018)

What can be done on farm now?
Soil and tree carbon

Primary Industries Climate Challenges Centre

THE UNIVERSITY OF MELBOURNE

Soil organic carbon

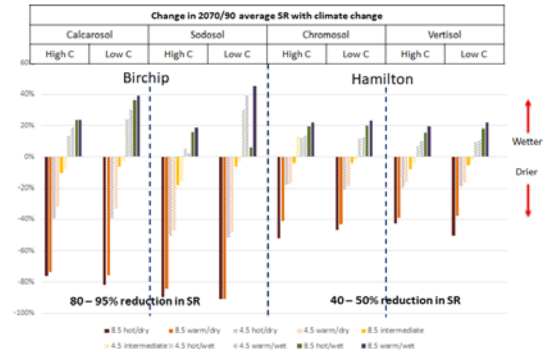
- Building soil carbon is good practice
  - Healthy, more productive and resilient soils
  - Adaptation to climate change

Biological roles	Physical roles	Chemical roles
- Reservoir of nutrients	- Water retention	- Cation exchange
- Biochemical energy	- Structural stability	- pH buffering
- Increased resilience	- Thermal properties	- Complex cations
- Biodiversity	- Erosion	

Source: Jeff Baldock

Soil organic carbon

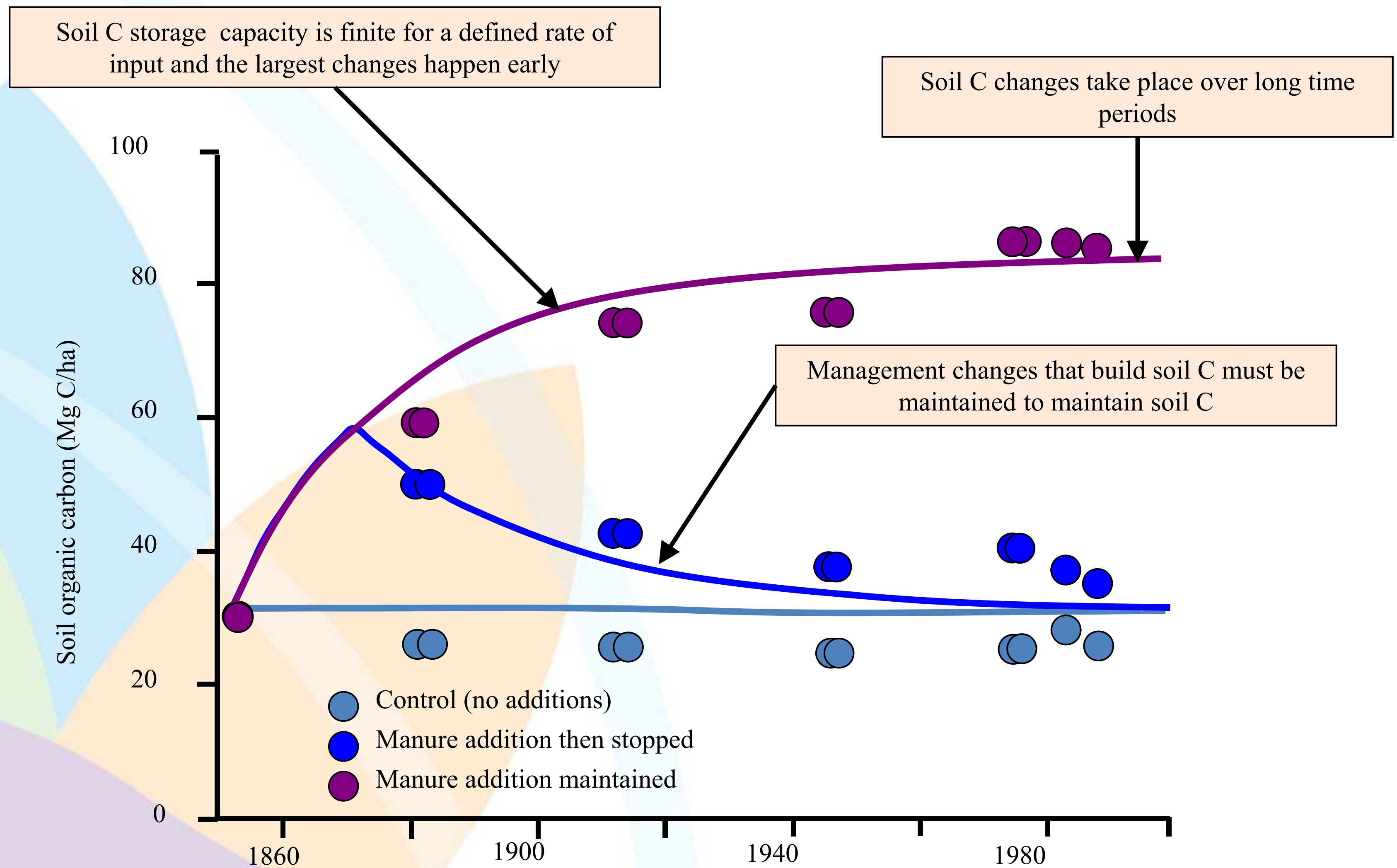
- Soil organic matter/ soil carbon
  - High under permanent pastures
- SOC possibly decreasing
  - Under high stocking rates and N
  - Under climate change in SE Australia
- Reliance on SOC as an offset may be limited



Schipper et al. 2010; Meyer et al. 2018

Management of soil carbon

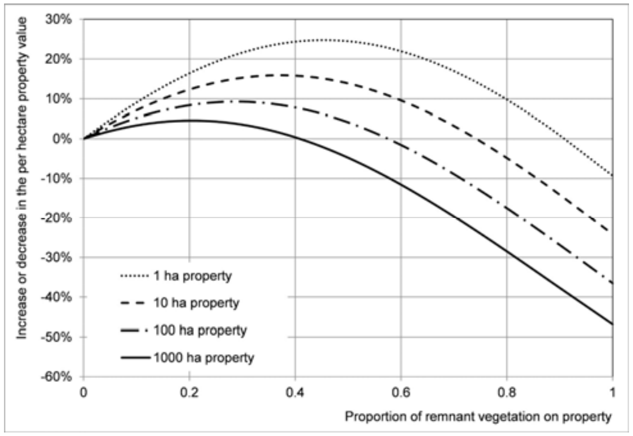
Saturation and permanence



Petersen et al. (2005) Soil Biol Biochem 37: 359

Rethinking trees on farm

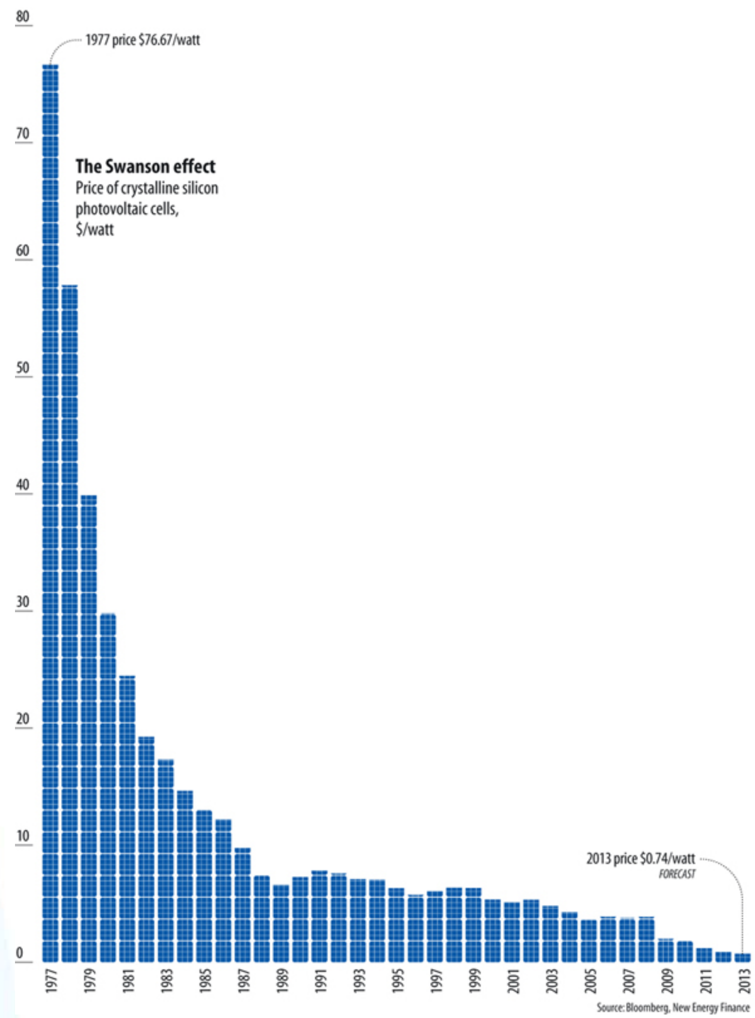
- Trees for carbon credits
  - Struggle to match milk value of land
    - Leddin et al. (2012)
- Combining multiple benefits
  - Salinity, biodiversity, aesthetics, shade and shelter, heat and cold stress
  - Income diversification/ financial resilience
    - Carbon offset income
    - Timber income
  - Nutrient sink areas in catchments
  - Capital appreciation
    - 20% tree coverage = 4% price premium
- How do we design trees on farm for these multiple objectives?



Leddin et al. (2012); Polyakov et al. (2015)

Energy Efficiency and Renewables

- Price per unit energy is dropping
- Moving to renewables
  - An economic decision
  - Manage price volatility in future



In Short

- If dairy needed to reduce GHG emissions
  - Current technology -50% is possible
    - The balance would need to come from offsets/ trees
- 3-NOP and seaweed
  - Show that far higher mitigation is possible in future
- GHG emissions are a very real threat to the future of dairy
  - Alternatives are making inroads
  - By 2050 our supply chain will only buy low emissions
    - Will it be milk or 'mylk'
  - Matching the GHGe of alternatives becomes an imperative

piccc.org.au

Primary Industries Climate Challenges Centre

THE UNIVERSITY OF MELBOURNE