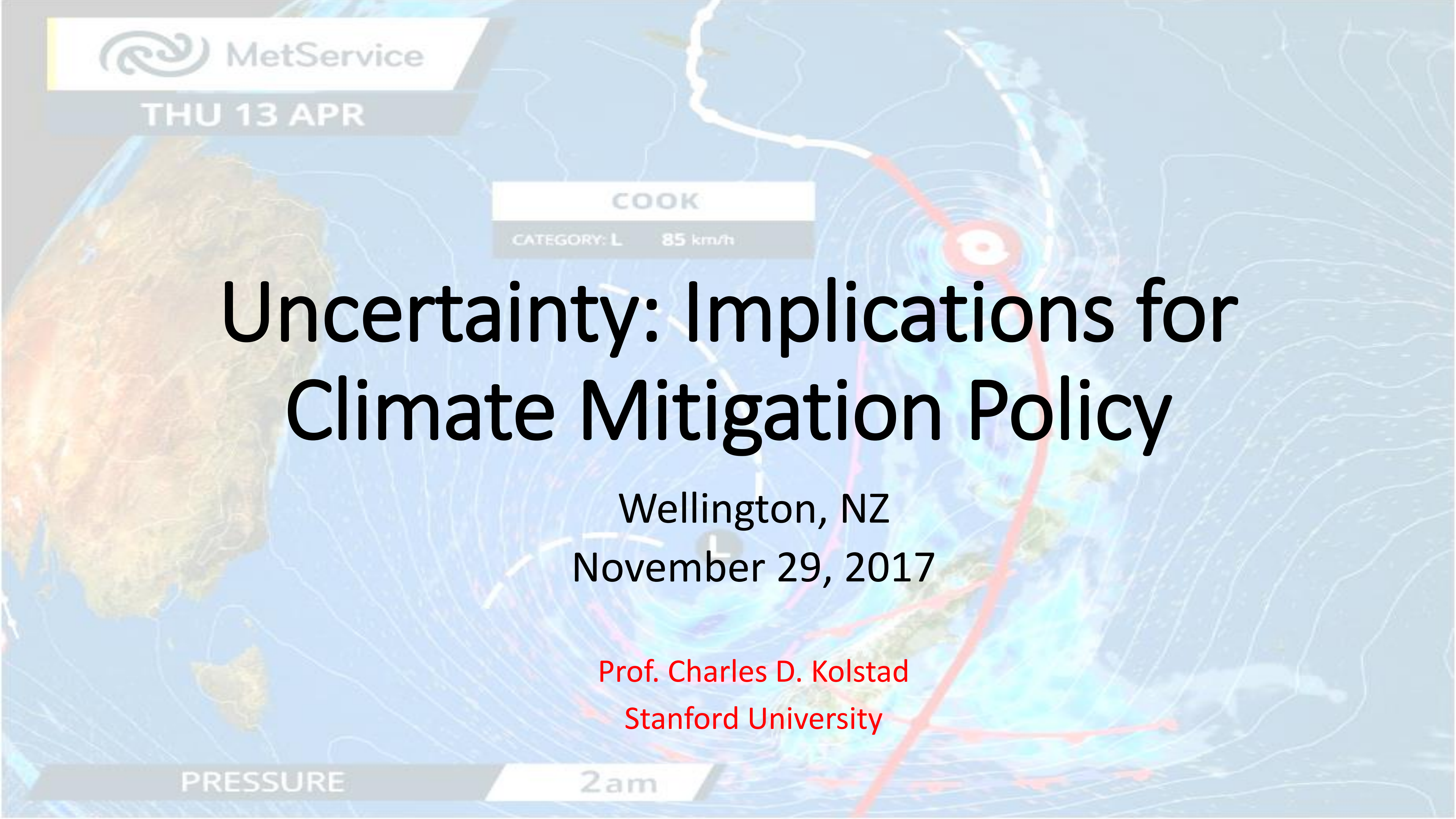


# Uncertainty: Implications for Climate Mitigation Policy

Wellington, NZ
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Stanford University

# Uncertainty is Complex

- “There are known knowns: there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns — the ones we don't know we don't know."
    - Famous contemporary philosopher (2003)

# Uncertainty: What are we talking about?

- **Uncertainty** pertains to level of knowledge about problem (parametric or structural)
- **Stochasticity** pertains to shocks—generally unknowable ex ante
  - Eg, coin flip
  - For example, weather: $y_t=\beta x_t+\eta_t$
    - $\beta$ uncertain parameter; y weather; x climate
    - $\eta_t$ is unobserved stochastic shock
- **Asymmetric Information**—concerning actions or types
  - Regulator, firm and emission control costs: regulator generally more poorly informed. Biased or just higher variance?
  - Insurer vs insured (moral hazard and adverse selection): problems for insurability
- **Abrupt Change and Irreversibilities**
  - EG, if Gulf Stream shuts down, we may not be able to back off on emissions a bit to restore it
- **Learning** is process by which uncertainty is reduced
  - variance can still increase
  - learning about parametric uncertainty slowed by stochasticity
  - Learning occurs at multiple points in process – agents, markets, governments

# Some facets of uncertainty

- Uncertainty and risk
  - Some uncertainty quantifiable; some not.  Some objective; some subjective; some both.
  - Uncertainty multifaceted: natural science, damage, costs
  - Uncertainty is different from stochasticity
  - Who is uncertain, who learns and does it matter? Scientists? Regulator? Farmer? Big business?

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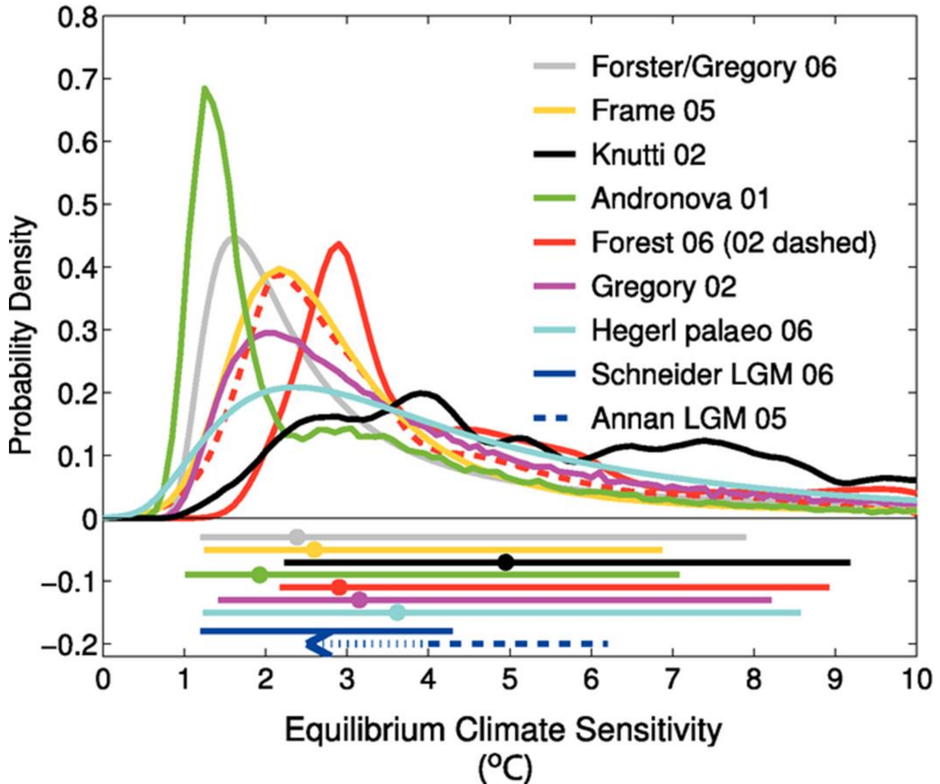
- Fat tails
  - As ΔT increases, damage grows more rapidly than π(ΔT) declines ➔ expected damage grows with ΔT




<u>CO2 (ppm)</u>
Pre-industrial: 280
Current: 390

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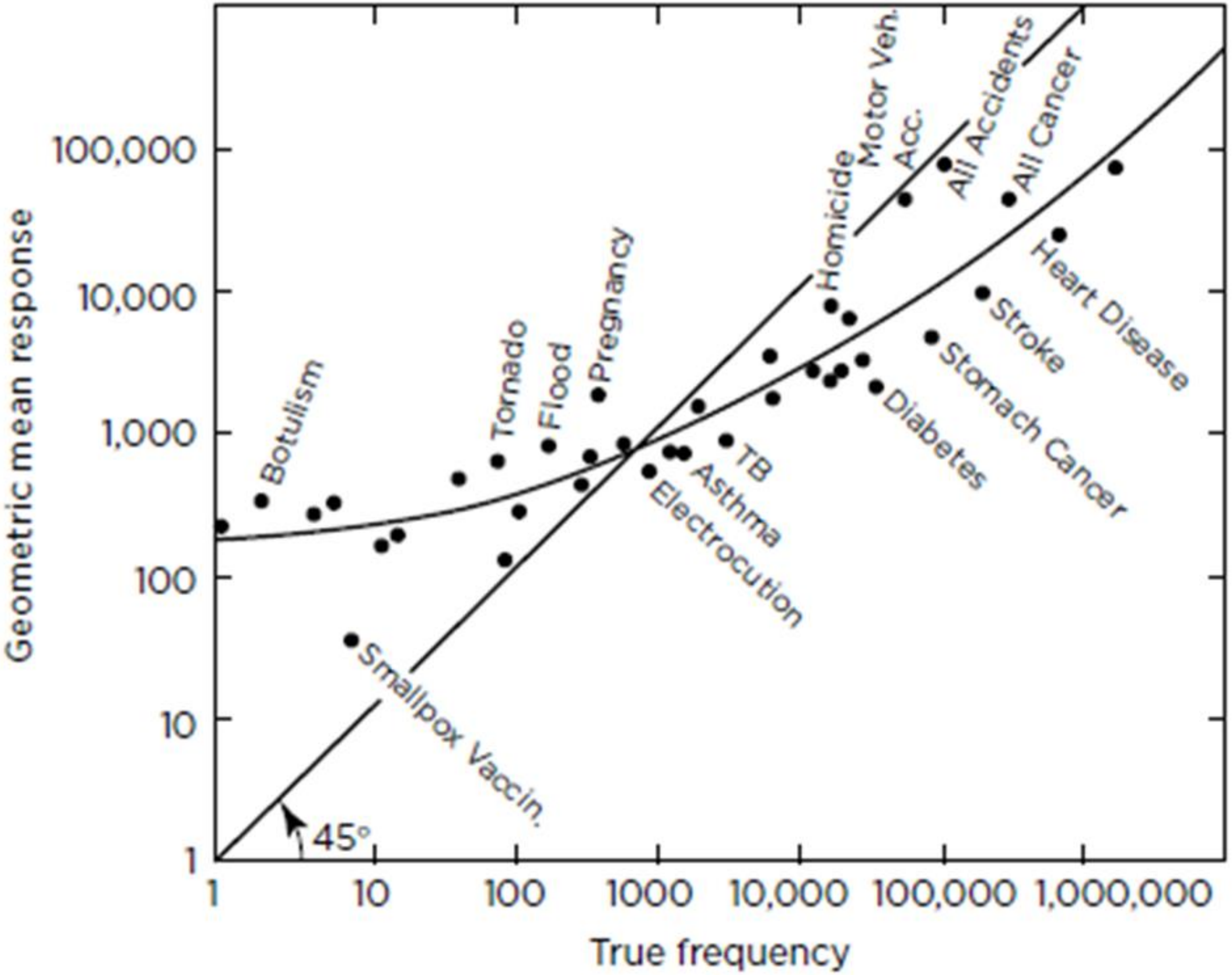

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- Irreversibilities
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- Evolution of future technology highly uncertain
  - Endogenous – depends on regulatory action adopted
  - Key to costs and damages (though adaptation)

# Example of Uncertainty: Past Technological Change

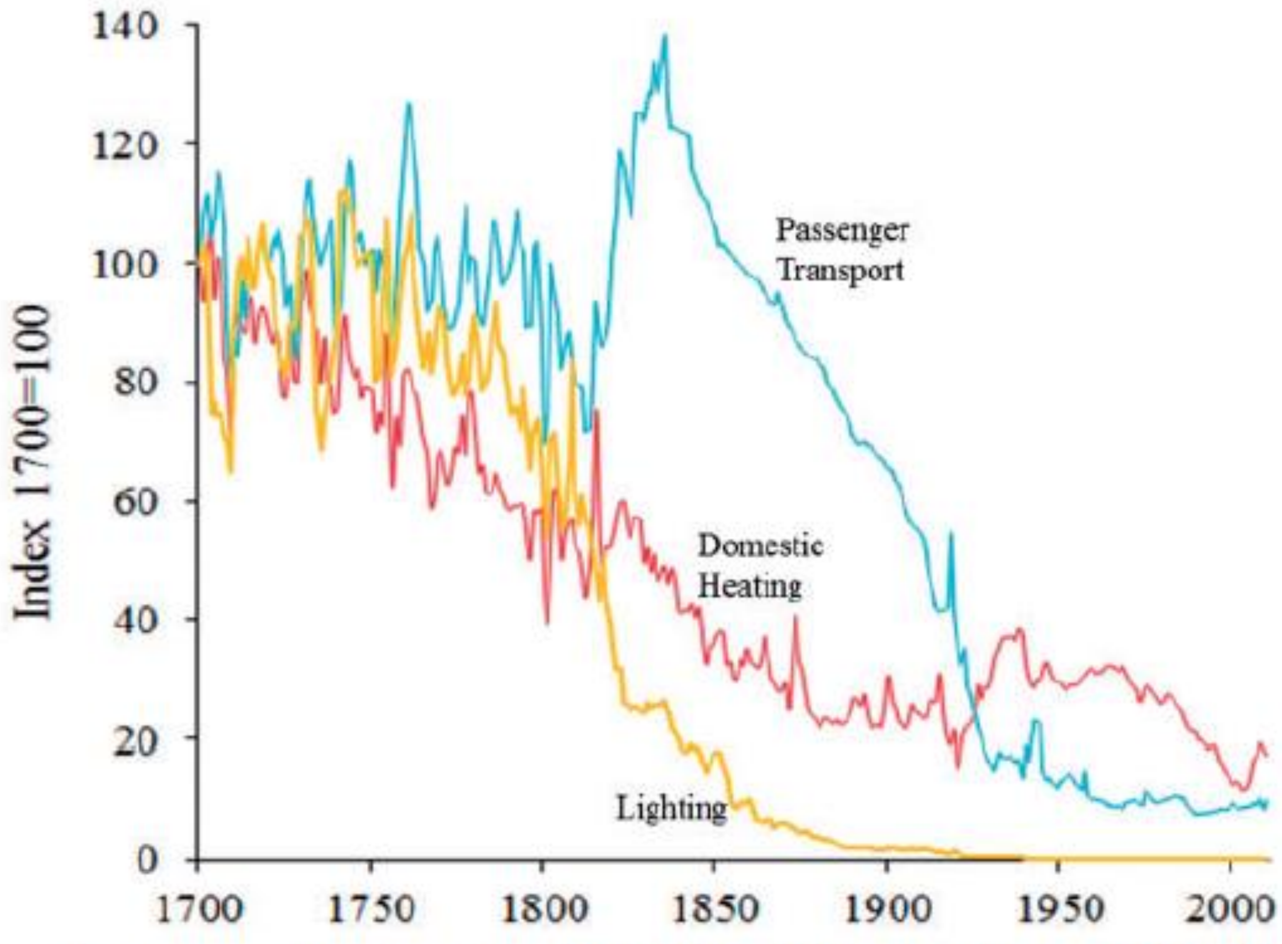
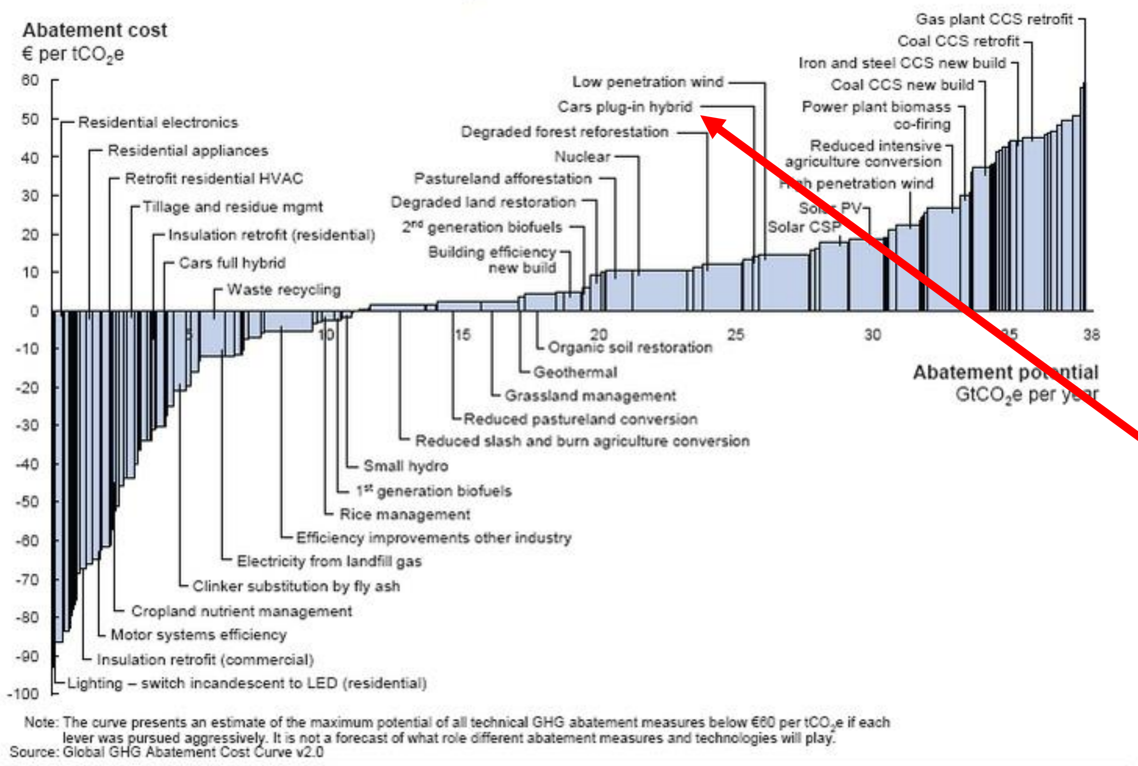



**Figure 3** Prices of consumer energy services in the United Kingdom (Index 1700 = 100), in real terms (2000 values), 1700–2010
*Source:* Fouquet (2011); see online Supplemental material.

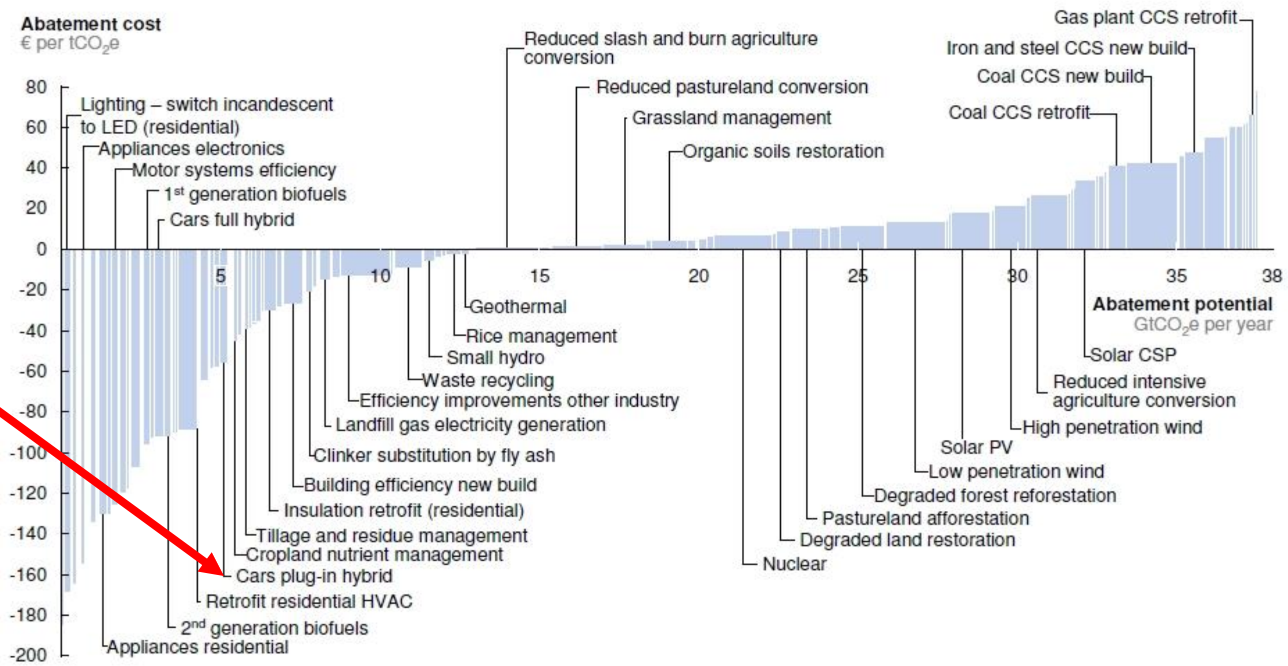
# Example of Uncertainty: Future Technological Change

(negative costs largely from assumptions on markets and technological change)

V2.0– McKinsey, 2009

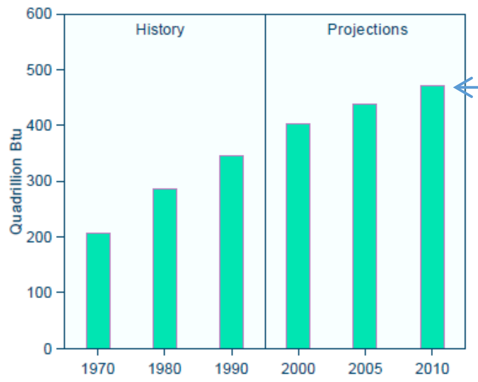



V2.1—McKinsey, 2010



# Example of Demand Uncertainty: Energy Demand & prices

Figure H1. Total World Energy Consumption, 1970-2010

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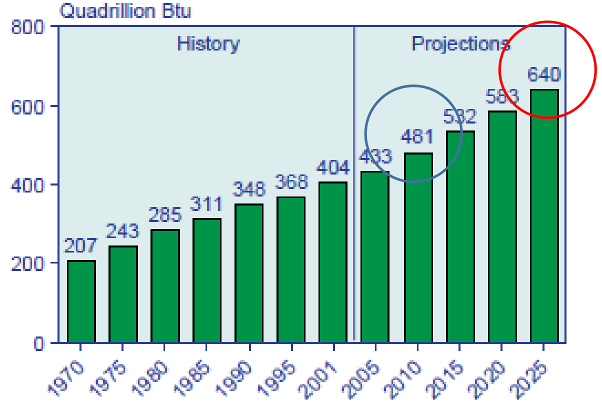
1993 US Energy Information Administration International Energy Outlook (1993 EIA IEO)

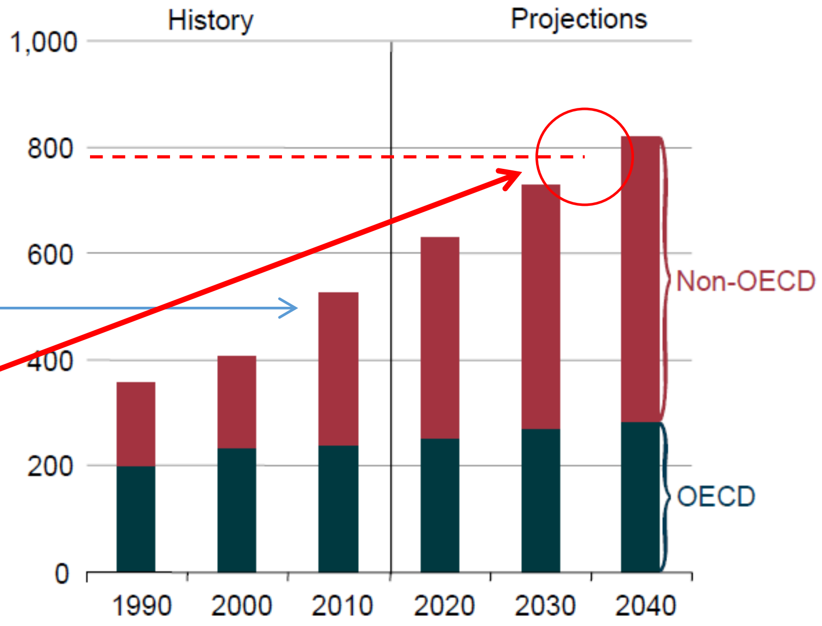
Figure 2. World Energy Consumption, 1970-2025




2003 EIA IEO

530

Figure 1. World energy consumption, 1990-2040 (quadrillion Btu)




2013 EIA IEO

NB: 1 Quad ≈ 1.05 x $10^{18}$ joules
1 Quad ≈ 0.025 BTOE

# Risks & Climate: The Big Picture

- Abrupt Changes
  - Gulf Stream Shutdown, West Antarctic Ice Sheet Loss, Mass Migration
- Risk Increases from continuous climate change
  - Weather events & flood (NB: weather ≠ climate)
  - Commodity (energy, raw materials) shocks
    - Availability
    - Price
  - Wildfires
  - Civil unrest
  - Asset value shocks
  - Product market shifts and shocks
  - Currency risk
  - Bankruptcy (Insuring against flood)
- Risks mostly unrelated to realized climate change
  - Energy prices
  - Agricultural prices
  - Technological change
    - New vehicle technologies
    - Batteries
    - Supply technologies (eg, natural gas)
- Risks related to mitigation policy
  - Technological change and incentives for innovation
  - Energy markets
  - Renewable supply (solar and wind)

# Who makes decisions about climate and uncertainty?

- Private decisions:
  - How to adapt to expected changes in climate?
  - How to exploit business opportunities generated by changes in climate
  - How to develop skills in demand in world of changed climate?
- Public decisions:
  - How to manage emissions and mitigation to meet global commitments?
  - How to incentivize private agents to manage their own risk?
  - How to structure domestic non-climate policies (eg, ag policies) to better deal with risk of climate changes?
  - How to harden domestic infrastructure to deal with risks?
  - How to streamline private insurance markets to better handle climate risk?
  - Opportunities to be global leader in specific areas?

# Individual decisions: Ways of Managing Risk

- Insurance markets (good for risk, not uncertainty)
  - Some risks insurable (require risk pooling)
    - Fire risk, Health risk
  - Insurance provides signal of risk (through price)
  - Some risks difficult to insure: flooding
- Financial Instruments
  - Options on price risk
  - Weather derivatives
  - Catastrophe bonds
    - Pay off in certain well defined states of the world
      - Eg, Pay if Category 5 hurricane hits downtown New Orleans next year pays $1
    - Both sides of market involved
  - Risk pooling not necessary
  - Allows hedging of risk but doesn't eliminate damage from change
- Information markets
  - Prediction markets – efficient provision of information
- Real Options
  - Insurance and derivatives do not undo damage, only hedge risk
  - Mitigation and adaptation reduce damage and vulnerability
  - Real options can reduce risk (eg, irrigation and air conditioning)
    - Diversified raw material sources
    - Produce multiple products in negatively correlated markets

# Some Issues for Today:
# Uncertainty and Government Policy in Small Economy

- Uncertainty about cost of abatement technology: act now moderately or wait for low-cost technology and then move aggressively?
- Aggressively exploit domestic comparative advantage (eg, managing livestock methane emissions), hoping leadership leads to long-term payoff?
- Act now (leader) or wait until picture of costs and benefits is clearer (follower)?
- Focus on managing risk (eg, hardening infrastructure) rather than predicting future climate impacts?
- Develop domestic markets for privately managing risks?
- Where to lead aggressively?  Where to follow passively?

# Mitigation Policies for Small Open Economy

- Leading vs. Following
  - Leaders can shape global perspectives and institutions—”market-makers”
  - Followers tend to be “price-takers” or “market takers”
- Leaders can take risks to shape globe for own benefit
  - Requires resources and knowledge to make the market
  - Innovations for reducing methane emissions from livestock
  - Institutions for dealing with fishery risks from climate changer
  - Demonstrate that carbon neutrality need not disrupt the economy
  - Demonstrate policies that are adaptable as technology changes
  - Establish leadership position in certain mitigation technologies
  - Establish leadership position in international negotiations
- Followers
  - Accelerated mitigation likely to only generate costs without much benefit
  - May be sector specific – follow in some areas; lead in others.

# Conclusions

- Uncertainty and Learning Dominate Climate Policy
- Country-level policies should not be uniformly aggressive for small open economy
- Focus investments and actions where they can matter
  - For instance, take leadership role in methods for reducing livestock methane
- In areas where following is the only option
  - Be conscientious and look for opportunities to lead