School of Civil, Environmental and Mining Engineering
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THE UNIVERSITY OF ADELAIDE
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Selecting a Discount Rate for Economic Evaluation of Water Projects – the Sustainability Controversy

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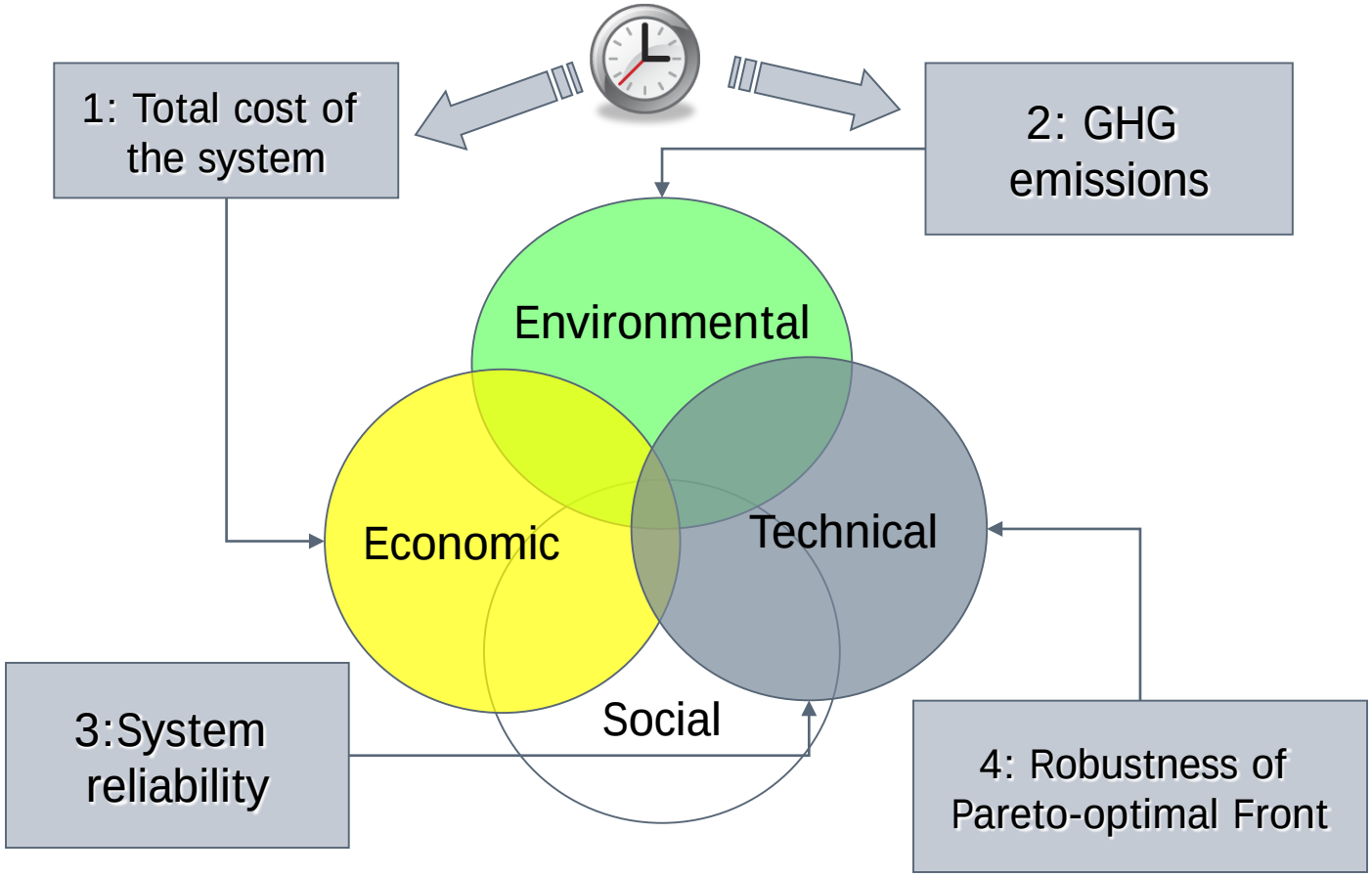
OUTLINE

- Introduction
- Greenhouse gases and global warming
- The Stern Review on the economics of climate change
- Design of water distribution systems
- Present value analysis
- What discount rate should be used?
- Pareto tradeoff curve sensitivity analysis
- Conclusions

QUESTIONS POSED

- In present value analysis should a discount rate of 6 to 8% equal to the cost of capital be used?
- Or should a significantly lower discount rate or a time declining discount rate that is based on societal preferences be used?
- Is it fair to pass onto future generations both the extra operating costs and the additional greenhouse emissions? Intergenerational equity.

ASPECTS OF SUSTAINABILITY



THE STERN REVIEW OF ECONOMICS OF CLIMATE CHANGE (2006)

- Gordon Brown, then UK Chancellor of the Exchequer, commissioned the Stern Review in July 2005
- Sir Nicholas Stern was Head of the Government Economic Service
- Along side Stern, 20 officials plus a number of consultants worked on the review

GREENHOUSE GASES AND GLOBAL WARMING (Stern 2006)

- CO_2 concentration levels have increased from 280 parts per million (ppm) in the industrial revolution to 400 ppm (as of 2016)
- The level of CO_2 equivalent (CO_2-e) concentration (including methane and other 'greenhouse' gases) is currently greater than 430 ppm and rising at 2.3 ppm per year
- Current CO_2-e concentration is higher than at any time over the last 800,000 years

THE STERN REVIEW OF ECONOMICS OF CLIMATE CHANGE

- Stern predicts dire consequences will occur if the concentration of CO_2-equivalent greenhouse gases in the atmosphere exceeds 550 ppm
- Our actions over the coming few decades could create risks of major disruption to economic and social activity
- A number of threshold-crossing possible disasters associated with abrupt large-scale irreversible changes *may* result from climate change and global warming

POSSIBLE DISASATROUS CONSEQUENCES

- Collapse of Greenland and West Antarctic ice sheets
- Significant alteration of Gulf Stream
- Runaway climate-sensitivity amplification of global warming
- Sea level rise, drowned coastlines
- Possibly extreme weather patterns including droughts and floods
- Ecosystem destruction

THE STERN REVIEW OF ECONOMICS OF CLIMATE CHANGE

- Stern Review comes down very strongly on the side of undertaking decisive—and expensive measures starting now to reduce CO_2 and other greenhouse gas emissions
- The cost of continued greenhouse gas emissions at the current rate is large estimated to be equivalent to 5 to 20 per cent of global Gross Domestic Product (GDP) per year, now and forever

STERN REVIEW OF ECONOMICS OF CLIMATE CHANGE

- The Stern Report recommends that we need to progressively cut emissions by 3% per annum over the next century
- Stern estimates that the cost of mitigating policies should be limited to around 1 per cent of global GDP

STERN REVIEW OF ECONOMICS OF CLIMATE CHANGE

- To achieve such reductions of emissions, The Stern Review recommended that a very low discount rate of 1.4% be used for evaluating projects that lead to the production of greenhouse gases
- Suggesting such a low discount rate has led to significant CONTROVERSY
- However, there are a number of economists who agree with Stern

STERN REVIEW OF ECONOMICS OF CLIMATE CHANGE

- Stern's recommended expenditure would be predicted to result in temperatures a hundred years from now higher with an expected temperature rise of $E[\Delta T] \approx 2°C$ and would (hopefully) stabilise future temperatures permanently thereafter at $\Delta T \approx 3°C$

WATER DISTRIBUTION SYSTEMS & GHGs

- Water distribution systems produce greenhouse gases (GHGs) in manufacture, transport, installation and decommissioning
- GHGs also arise from pumping during operations when electricity is derived from burning of fossil fuels
- Life cycle analysis involving pumping requires present value analysis to convert annual operating costs into their present values
- How do we deal with future GHG emissions?
- IPCC recommends a discount rate of zero when quantifying future GHGs

WATER DISTRIBUTION SYSTEMS - COSTS

- Capital costs plus
- Present value of pumping costs
  - Static head
  - Friction head – depends on velocity and pipe diameter
- Large pipe, small V, low head loss
- Small pipe, large V, high head loss
- Only friction head can be influenced by pipe diameter size

PRESENT VALUE ANALYSIS-A LARGE RANGE OF DISCOUNT RATES ARE USED

American Gov't agencies & organisations	**Discount Rate**
Office of Management and Budget	**10%**
Bureau of Land Management	**10%**
U.S. Fish and Wildlife Service	**7.8% (nominal rate)**
U.S. Forest Service	**4%**
Congressional Budget Office	**2%**
Government Accounting Office	**The average cost of Treasury debt**
Municipal Governments	**3%**
Other non American governments	
English Government	**3.5%, for time periods beyond 30 years the discount rate declines**
Dutch agencies	**8% (nominal); 4% (real rate)**

PRESENT VALUE ANALYSIS

- Traditional exponential discounting approach

$$PV = C\sum_{n=1}^{t}\left[\frac{1}{(1+i)^n}\right]$$

  - Present value of a cashflow stream with a specified number of fixed periodic payments of value C
  - i = discount rate (for example 6%)
  - n = design life (e.g. 100 years)

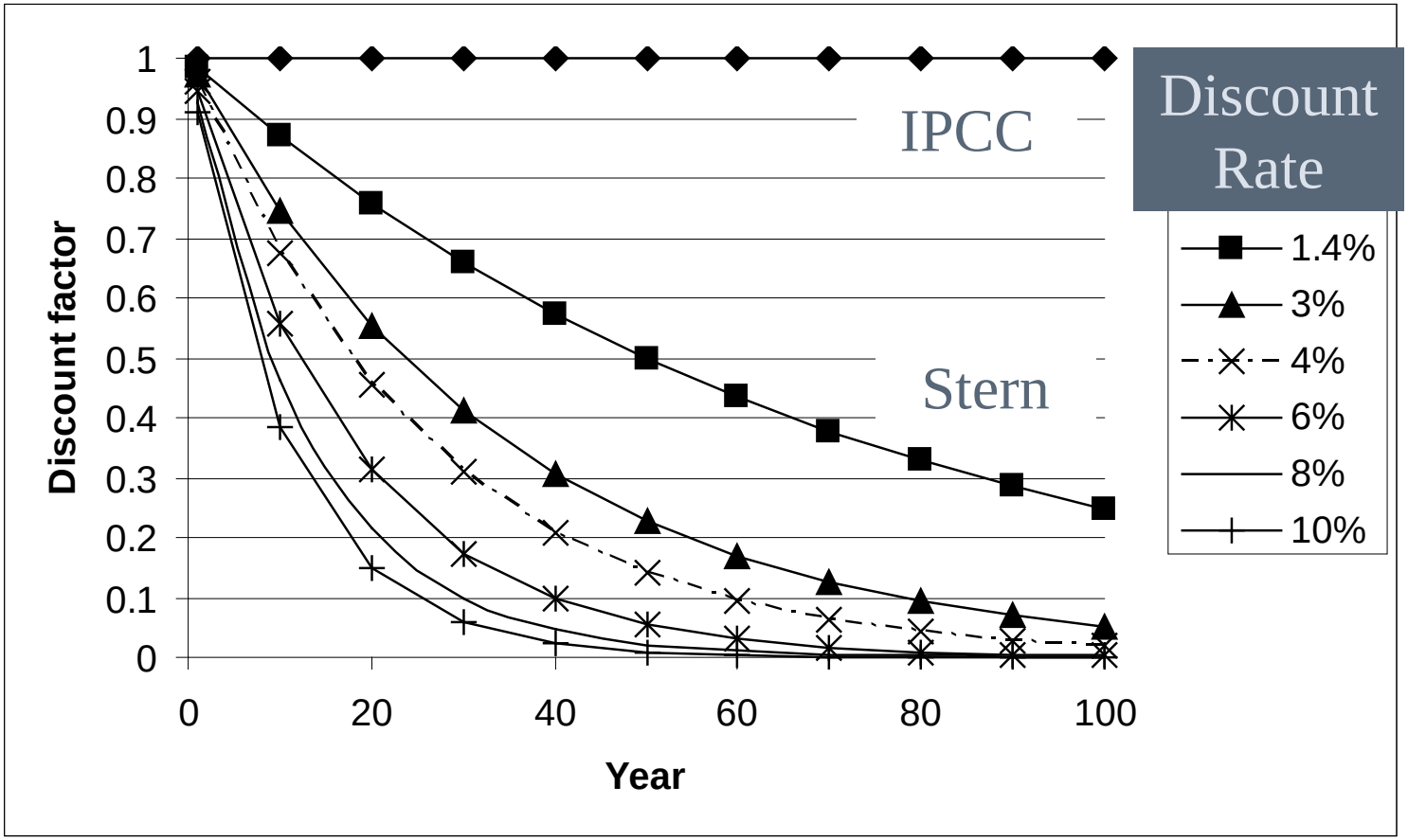
PRESENT VALUE ANALYSIS OVER 100 YEARS

Year	Cost	i = zero%	i = 1.4%	i = 6%	i = 8%
0	$ -	$ -	$ -	$ -	$ -
1	$ 100,000	$ 100,000	$98,619	$94,340	$92,593
2	$ 100,000	$ 100,000	$97,258	$89,000	$85,734
3	$ 100,000	$ 100,000	$95,915	$83,962	$79,383
4	$ 100,000	$ 100,000	$94,591	$79,209	$73,503
5	$ 100,000	$ 100,000	$93,285	$74,726	$68,058
6	$ 100,000	$ 100,000	$91,997	$70,496	$63,017
7	$ 100,000	$ 100,000	$90,727	$66,506	$58,349
8	$ 100,000	$ 100,000	$89,474	$62,741	$54,027
9	$ 100,000	$ 100,000	$88,239	$59,190	$50,025
10	$ 100,000	$ 100,000	$87,020	$55,839	$46,319

PRESENT VALUE ANALYSIS OVER 100 YEARS

Year	Cost	i = zero%	i = 1.4%	i = 6%	i = 8%
90	$ 100,000	$ 100,000	$28,614	$528	$98
91	$ 100,000	$ 100,000	$28,219	$498	$91
92	$ 100,000	$ 100,000	$27,830	$470	$84
93	$ 100,000	$ 100,000	$27,445	$443	$78
94	$ 100,000	$ 100,000	$27,067	$418	$72
95	$ 100,000	$ 100,000	$26,693	$394	$67
96	$ 100,000	$ 100,000	$26,324	$372	$62
97	$ 100,000	$ 100,000	$25,961	$351	$57
98	$ 100,000	$ 100,000	$25,602	$331	$53
99	$ 100,000	$ 100,000	$25,249	$312	$49
100	$ 100,000	$ 100,000	$24,900	$295	$45
PV TOTAL		**$ 10,000,000**	**$ 5,364,265**	**$1,661,755**	**$ 1,249,432**
% of TOTAL COST		**100%**	**54%**	**17%**	**12%**

HOW CAN WE TAKE THE TEMPORAL DIMENSION INTO ACCOUNT?



WEITZMAN'S ANALYSIS OF THE STERN REVIEW

- Weitzman raised scepticism in relation to the formal analysis in the Stern Review that leads to the conclusion that a low discount rate needs to be used.
- He also says that he believes that "*we are actually a lot less sure about what discount rate should be used for discounting climate change than is currently acknowledged.*"

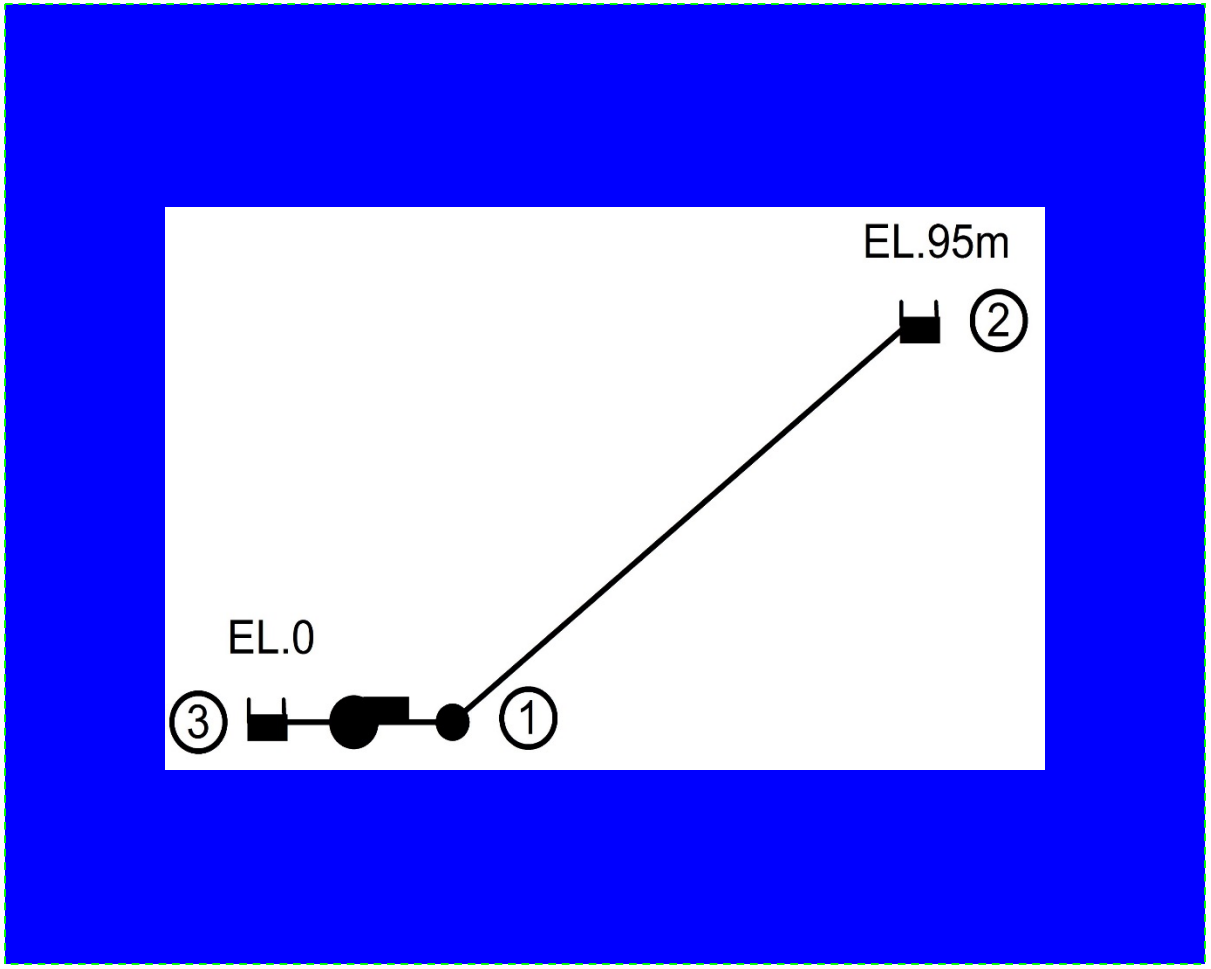
WEITZMAN'S ANALYSIS OF THE STERN REVIEW

- The Stern Review may have used the wrong methods but may have come up with the right answer regarding the use of a low discount rate
- Spending money to slow global warming should NOT be viewed as being about consumption smoothing BUT RATHER as being about how much insurance needs to be bought to offset the small chance of a ruinous catastrophe that is difficult to compensate by ordinary savings

WEITZMAN'S ARGUMENT FOR LOWER DISCOUNT RATES

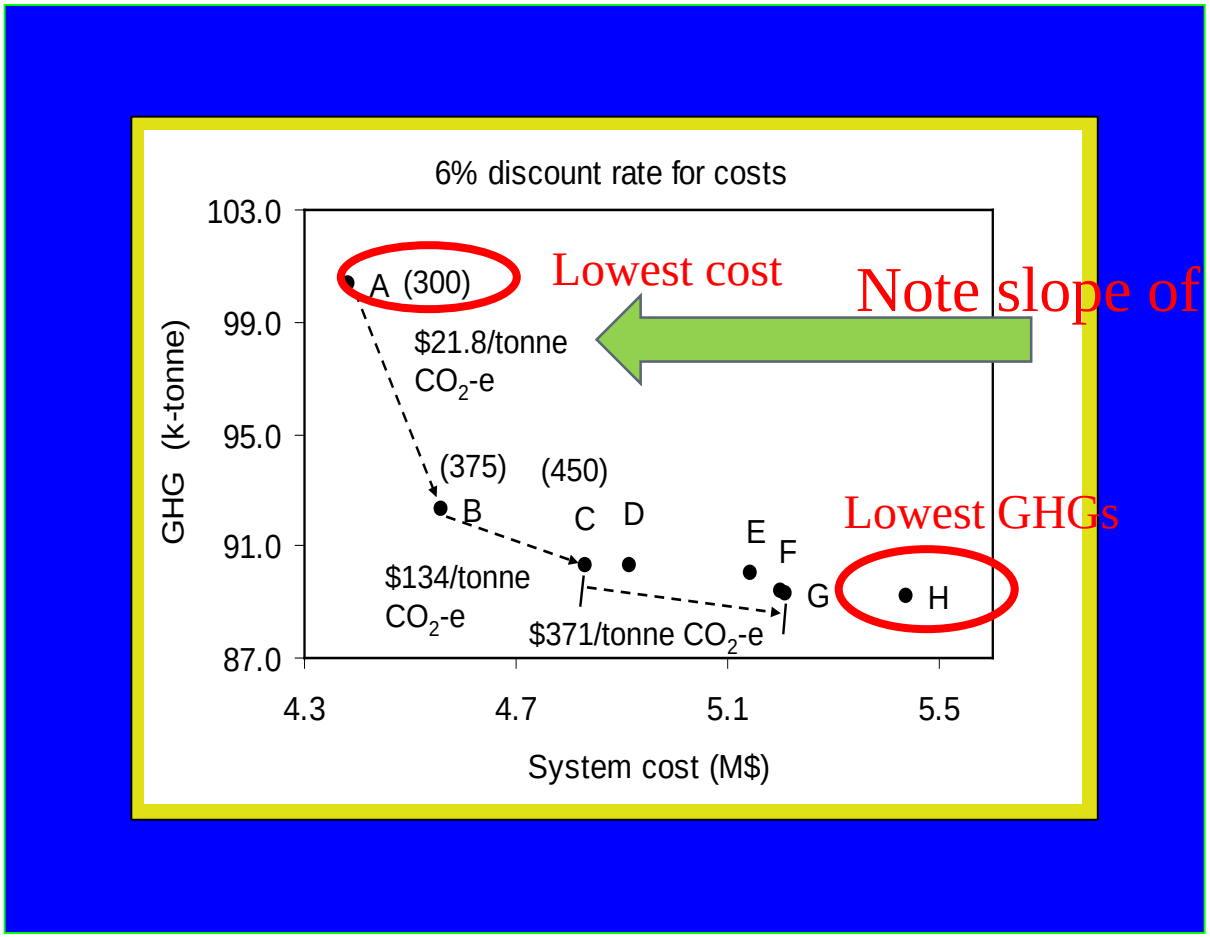
- Say there is a 50% chance that the discount rate should be 6%
- AND there is a 50% chance that the discount rate should be 1.4%
- The geometric average or effective discount rate is 2% which is closer to the Stern value of 1.4% than the 6% cost of capital
- Thus take the average of the discount factors (2%) not the arithmetic average of the discount rates (3.7%)

CASE STUDY – SENSITIVITY ANALYSIS



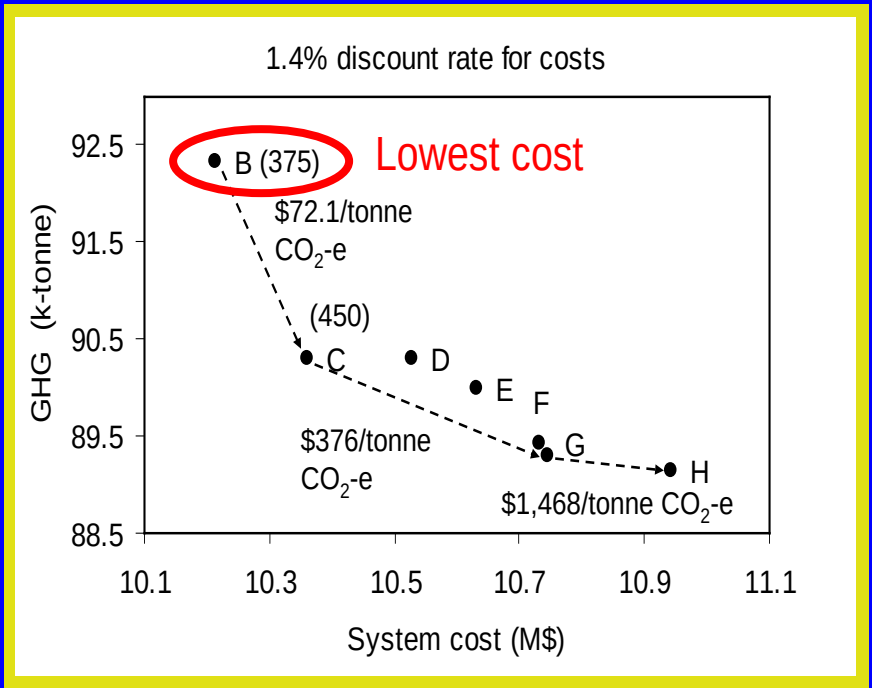
PARETO OPTIMAL TRADEOFF CURVE – MULTI-OBJECTIVE OPTIMISATION

Tradeoff for i = 6%



PARETO OPTIMAL TRADEOFF CURVE – MULTI-OBJECTIVE OPTIMISATION

Tradeoff for i = 1.4%



Note solution A is no longer on the Pareto curve

MY CONCLUSION OF THE ARGUMENTS

- A lower discount rate of 1.4% should be used in the evaluation of water projects
- Capital costs will be slightly higher
- Operating costs will be lower for us and future generations
- GHGs will be permanently lower for us and future generations

CONCLUSIONS

- Global warming is occurring
- Stern predicts dire consequences and suggests immediate action be taken
- Water distribution systems can reduce GHGs in pumping systems by selecting larger pipe diameters with lower velocities
- A discount rate of 1.4% should be used in a sensitivity analysis to provide decision makers with consequences