CBA of policy scenarios for revision of the TSAP

Mike Holland, EMRC mike.holland@emrc.co.uk

SEG5 meeting, Brussels, April 2013

Scenarios

- Corresponds to IIASA TSAP report number 10:
  - TSAP 2013 CLE (current legislation) baseline and MTFR (Maximum Technically Feasible Reductions) scenarios for 2025
  - A05 (scenario corresponding to a 75% gap closure between the CLE and MTFR scenarios for 2025)
  - CLE and MTFR scenarios for 2030

Impacts addressed

- Health
  - Updates for $PM_{2.5}$ and ozone mortality
  - No updates for morbidity
- Materials
- Crops

- No assessment of ecological impacts

Health benefits, 2025
All figures as thousands

Benefits: EU28			CLE - A05 2025	A05 - MTFR 2025
Acute Mortality	Premature deaths	O3	1.6	0.9
Respiratory Hospital Admissions	Cases	O3	2.2	1.3
Minor Restricted Activity Days	Days	O3	4,346	2,530
Respiratory medication use	Days	O3	1,706	992
Chronic Mortality	Life years lost	PM	541	173
Infant Mortality	Premature deaths	PM	0.089	0.029
Chronic Bronchitis	Cases	PM	28	8.9
Hospital Admissions	Cases	PM	16	5.2
Restricted Activity Days	Days	PM	50,402	16,125
Respiratory medication use	Days	PM	5,300	1,700
Lower Respiratory Symptom days	Days	PM	74,000	24,000

- Moving to A05:
  - 9% reduction in ozone effects
  - 20% reduction in $PM_{2.5}$ effects
- From A05 to MTFR
  - ~33% improvement in $PM_{2.5}$ benefits, ~50% improvement in ozone benefits relative to CLE-A05 shift

Benefits, €M/year

	CLE - A05 2025	A05 - MTFR 2025	CLE - MTFR 2025	CLE - MTFR 2030
Total, with median VOLY	45,257	14,563	59,820	59,408
Total, with mean VOLY	89,374	28,733	118,107	116,976
Total, with median VSL	80,629	25,648	106,276	110,374
Total, with mean VSL	149,953	47,636	197,589	205,826

Non-health damage

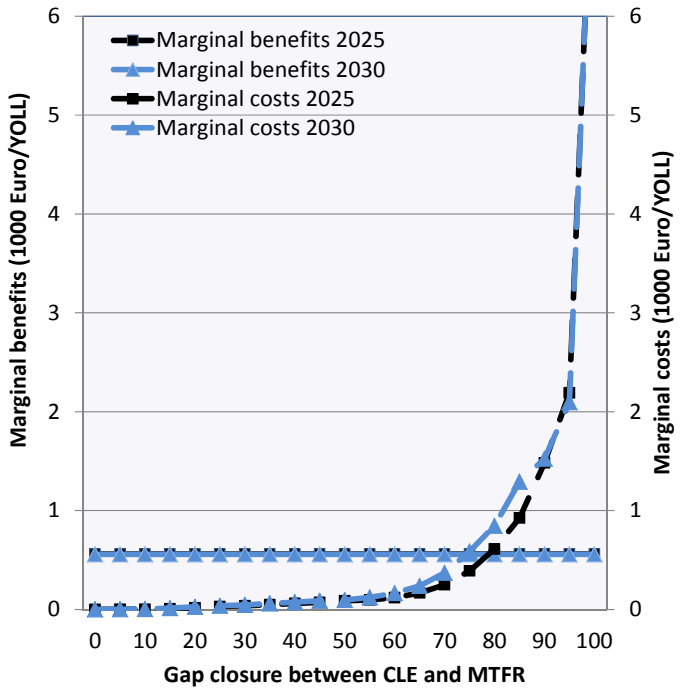
- Very limited assessment
  - Some agriculture, some materials
  - No natural ecosystems despite significant levels of exceedance including in Natura 2000 sites

€million/year	CLE-A5 2025	CLE - MTFR 2025
Crops	370	560
Materials	140	160

Benefit/cost ratios
>1 = net benefit, <1 = net cost

Benefits, EU28	CLE - A05	A05-MTFR	CLE-MTFR
Total with median VOLY	8.4	0.4	1.3
Total with mean VOLY	16.7	0.7	2.6
Total with median VSL	15.0	0.6	2.4
Total with mean VSL	28.0	1.2	4.4

- Substantial net benefit of moving to A05, but not of continuing further to MTFR
- Uncertainty in mortality valuation does not make a large difference to point where marginal costs and benefits are equal



Ozone mortality: Sensitivity analysis

- REVIHAAP recommendation:
  - Sensitivity analysis for chronic ozone effects on mortality

EU28	TSAP CLE	TSAP A05	TSAP MTFR	TSAP CLE	TSAP MTFR
	2025	2025	2025	2030	2030
Acute effects: deaths (=YOLL)	17,736	16,124	15,188	17,140	14,626
Acute effects: damage (€M/yr)	1,023	930	876	989	844
Chronic effects: years of life lost	156,668	142,491	134,251	149,223	127,425
Chronic effects: damage (€M/yr)	9,040	8,222	7,746	8,610	7,352
Ratio, chronic damage: acute damage	8.8	8.8	8.8	8.7	8.7

Lost working days, values as €million/year
Included as part of restricted activity days

	TSAP CLE	TSAP A05	TSAP MTFR
	2025	2025	2025
EU28			
Lost working days	57,800,510	46,360,571	42,700,691
Value of lost working days	7,514	6,027	5,551
All countries			
Lost working days	85,506,302	73,458,494	69,642,010
Value of lost working days	11,116	9,550	9,053

Healthcare costs, €million/year

EU28, €M/year		TSAP CLE	TSAP A05	TSAP MTFR
		2025	2025	2025
Respiratory hospital admissions	O_3	24	22	20
Respiratory medication use	O_3	19	17	16
Chronic bronchitis	$PM_{2.5}$	1,617	1,298	1,196
Respiratory hospital admissions	$PM_{2.5}$	51	41	38
Cardiac hospital admissions	$PM_{2.5}$	32	25	23
Respiratory medication use	$PM_{2.5}$	27	22	20
Effects assumed to have negligible healthcare costs	Acute mortality (O_3) Minor restricted activity days (O_3)			
Unquantified effects that ***may*** have significant healthcare costs	Chronic morbidity (in addition to chronic bronchitis) ($PM_{2.5}$) Infant morbidity ($PM_{2.5}$) Restricted activity days ($PM_{2.5}$) Lower respiratory symptoms ($PM_{2.5}$)			
Total where quantified		**1,770**	**1,425**	**1,314**

Conclusions from the analysis

- Mortality assessment includes REVIHAAP/HRAPIE updates
  - Does not change the view that air pollution generates substantial health impacts
- Analysis based very largely on health benefits alone indicates net benefit of moving to A05
- Morbidity assessment still as CAFE
- More detail provided in some areas
  - Healthcare costs (incomplete)
  - Working days lost

Other work

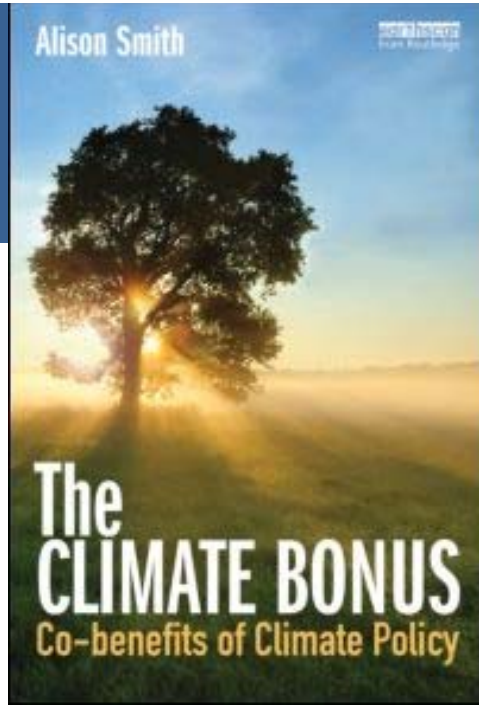
- Development of national benefit assessment tools
- Ecosystem valuation
- NEBEI
- Cooperation with REVIHAAP/HRAPIE
- Development of TUBA
- Externalities of climate policies
- The Cornish Question

Cooperation with REVIHAAP/HRAPIE

- Different roles of CEA and CBA
- Flexibility of CBA for uncertainty analysis
- Format of sensitivity analysis
- Testing of functions

Full cost accounting for climate policies

- Accounting for externalities of climate policies
  - Co-benefits, e.g.
    - Improved air quality
    - Reduced excess winter deaths
    - Energy security
    - Active lifestyles
  - Trade-offs, e.g.
    - Fuel poverty
    - Land rights
    - Some accident risks



	Click on abatement options to move to worksheets containing full details	Nuclear	Coal
Generation stage: Human health	Major accident risk	- -	-
	Occupational health	- -	-
	Air pollution and health: UK	- -	- -
	Air pollution and health: outside UK	- -	- -
	Noise: disturbance and health		
	Hazardous waste generation	- -	-
	Solid waste generation (non-hazardous)	-	-
	Diet		
	Lifestyle (e.g. exercise)		
	Psycho social environment		
	Housing conditions (e.g. cold, damp, air quality)	-	+
	Geophysical factors (e.g. uv light, radon)		
	Water pollution	-	-
	Infection	-	-
vironment	Hazardous waste generation	- -	- -
	Solid waste generation (non-hazardous)	-	-
	Regional air pollutants (NH3, NOX, PM, SO2, VOCs)	- -	- -
	Heavy metals and other trace pollutants	-	-
	Materials damage from air pollution		-

Would inclusion of co-benefits and trade-offs change policy?

- Enable some non-technical measures to be brought into the analysis
- Change the ordering of measures
- Change whether costs of some measures are positive or negative
- Highlight interactions between policy areas
- Reveal important uncertainties
- Highlight opportunity to increase co-benefits
- Highlight presence of trade-offs that may require mitigation

Climate Change Committee Study*

- Focused on scenarios to 2030 addressing emissions from:
  - Power sector
  - Surface transport
  - Shipping and aviation
  - Energy use in industry, residential and non-residential buildings and heating
  - Agriculture and forestry
- Seeking a comprehensive overview of impacts, with quantification where possible

*Lead contractor, Ricardo AEA. To be completed April 2013. Short timescale study, developing framework, providing initial estimates. Outputs shown here are preliminary, yet to be approved by CCC.

Accounting Framework: Impacts considered

Generation stage: Human health	Major accident risk Occupational health Air pollution and health: UK Air pollution and health: outside UK Noise: disturbance and health Hazardous waste generation Solid waste generation (non-hazardous) Diet Lifestyle (e.g. exercise) Psycho social environment Housing conditions (e.g. cold, damp, air quality) Geophysical factors (e.g. uv light, radon) Water pollution Infection
Generation stage: Environment	Hazardous waste generation Solid waste generation (non-hazardous) Regional air pollutants (NH3, NOX, PM, SO2, VOCs) Heavy metals and other trace pollutants Materials damage from air pollution Landscape Land take Water abstraction Water pollution Bioversity and ecosystems Subsidence Congestion Soil erosion/fertility Resource use (metals/minerals)

Burdens from other life cycle stages	Major accident risk Occupational health Greenhouse gases Regional air pollutants (NH3, NOx, PM, SO2, VOCs) Heavy metals and other trace pollutants Hazardous waste generation Solid waste generation (non-hazardous) Diet Lifestyle (e.g. exercise) Psycho social environment Housing conditions (e.g. cold, damp, air quality) Geophysical factors (e.g. uv light, radon) Liquid effluents Transport (noise, congestion, accidents)
Economic	Fuel poverty Energy security Employment

Accounting framework: Presence or absence of impact

	Click on abatement options to move to worksheets containing full details	Nuclear	Coal	Natural gas CCGT	Natural gas OCGT	Coal with CCS	CCGT with CCS	Biomass	Onshore wind	Offshore wind	Marine	Other renewables
Generation stage: Human health	Major accident risk	- -	-	-	-	-	-					
	Occupational health	- -	-	-	-	-	-	-	-	-	-	-
	Air pollution and health: UK	- -	- -	- -	- -	- -	- -	- -				
	Air pollution and health: outside UK	- -	- -	- -	- -	- -	- -	- -				
	Noise: disturbance and health								-			
	Hazardous waste generation	- -	-			-		-				
	Solid waste generation (non-hazardous)	-	-			-		-				
	Diet											
	Lifestyle (e.g. exercise)											
	Psycho social environment								(-)			
	Housing conditions (e.g. cold, damp, air quality)	-	+	+	+	-	-	-	-	-	-	-
	Geophysical factors (e.g. uv light, radon)											
	Water pollution	-	-			-		-		-	-	
	Infection	-	-	-	-	-	-	-				
Generation stage: Environment	Hazardous waste generation	- -	- -	-	-	- -	-	- -				
	Solid waste generation (non-hazardous)	-	-	-	-	-	-	-				
	Regional air pollutants (NH3, NOX, PM, SO2, VOCs)	- -	- -	- -	- -	- -	- -	- -				
	Heavy metals and other trace pollutants	-	-	-	-	-	-	-				
	Materials damage from air pollution		-	-	-	-	-	-				
	Landscape	-	-			-		+ / -	- -	- -	- -	-
	Land take	-	-			-		- -	- -	- -	- -	-
	Water abstraction	- / - -	- / - -	- / - -	- / - -	- / - -	- / - -	- / - -				
	Water pollution	-	-	-	-	-	-	-				
	Bioversity and ecosystems											
	Subsidence	-	-	+ / -	+ / -	-	+ / -					
	Congestion											
	Soil erosion/fertility											
	Resource use (metals/minerals)	- -	- -	- -	- -	- -	- -					- -
Burdens from other life cycle stages	Major accident risk	-	- -	- -	- -	- -	- -					
	Occupational health	-	-	-	-	-	-	-	-	-	-	-
	Greenhouse gases	- -	-	-	-	-	-	-	-	-	-	-
	Regional air pollutants (NH3, NOx, PM, SO2, VOCs)	- -	-	-	-	-	-	-	-	-	-	-
	Heavy metals and other trace pollutants	- -	-			-		-				-
	Hazardous waste generation	- -	-	-	-	-	-	-				-
	Solid waste generation (non-hazardous)	-	-	-	-	-	-	-	-	-	-	-
	Diet											
	Lifestyle (e.g. exercise)											
	Psycho social environment											
	Housing conditions (e.g. cold, damp, air quality)											
	Geophysical factors (e.g. uv light, radon)		+ / -	+ / -	+ / -	+ / -	+ / -	+ / -				
	Liquid effluents	-	-	-	-	-	-	-	-	-	-	-
	Transport (noise, congestion, accidents)	-	-	-	-	-	-	-	-	-	-	-
Economic	Fuel poverty	-	+	+	+	-	-	-	-	-	-	-
	Energy security	+ / -	+	-	-	+	-	+	+	+	+	+
	Employment	+	+	+	+	+	+	+	+	+	+	+

Quantitative assessment:

Phase 1: Unit impacts (e.g. per kWh) preliminary outputs

	Click on abatement options to move to worksheets containing full details	Increase in nuclear	Decrease in coal without CCS	Decrease in Closed Cycle Gas Turbine (CCGT) without CCS	Decrease in Open Cycle Gas Turbine (OCGT) without CCS	Increase in coal with CCS	Increase in CCGT with CCS	Increase in biomass	Increase in onshore wind	Increase in offshore wind	Increase in marine	Increase in other renewables
	Effect of scenario	Very large increase (8% to 40%)	Slight decrease (by <1%)	Very large decrease (61% to 6%)	Very little change (by <0.1%)	Slight increase (3% to 6%)	Large increase (2% to 10%)	Slight increase (by 0.3%)	Slight increase (by 1.8%)	Large increase (10% to 19%)	Slight increase (by 1.1%)	Slight increase (by 0.4%)
Generation stage: Human health	Major accident risk	0.02	negligible	negligible	negligible	negligible	negligible					
	Occupational health	0.033	0.009	0.0061	0.0061	0.009	0.0061	0.0005	0.19	0.19	0.19	0.19
	Air pollution and health: UK	0.079	Outside project scope									
	Air pollution and health: outside UK	Note 1	Outside project scope									
	Noise: disturbance and health		Outside project scope									
	Hazardous waste generation	0.025	negligible			negligible		negligible				
	Solid waste generation (non-hazardous)	negligible	negligible			negligible		negligible				
	Diet											
	Lifestyle (e.g. exercise)											
	Psycho social environment								0.07			
	Housing conditions (e.g. cold, damp, air quality)	Only likely to be affected through separate impact on fuel poverty										
	Geophysical factors (e.g. uv light, radon)		negligible	negligible	negligible	negligible	negligible	negligible				
	Water pollution	Note 1	negligible			negligible				negligible	negligible	
	Infection	negligible	negligible	negligible	negligible	negligible	negligible	negligible				
Generation stage: Environment	Hazardous waste generation											
	Solid waste generation (non-hazardous)											
	Regional air pollutants (NH_3, NO_X, PM, SO_2, VOCs)											
	Heavy metals and other trace pollutants											
	Materials damage from air pollution	Outside project scope										
	Landscape	negligible	negligible			negligible						
	Land take	negligible	negligible			negligible						
	Water abstraction	negligible	negligible	negligible	negligible	negligible	negligible	negligible				
	Water pollution											
	Bioversity and ecosystems											
	Subsidence	negligible	negligible	negligible	negligible	negligible	negligible					
	Congestion											
	Soil erosion/fertility											
	Resource use (metals/minerals)											
Burdens from other life cycle stages	Major accident risk	negligible	Note 1	0.05	0.05	Note 1	0.05					
	Occupational health	0.071	0.8	0.064	0.064	0.8	0.064	0.00025	0.16	0.16	0.16	-0.28
	Greenhouse gases	0.15	1.7	0.36	0.36	1.7	0.36	0.5	0.29	0.29	0.29	1.7
	Regional air pollutants (NH3, NOx, PM, SO2, VOCs)	0.6	0.018	negligible	negligible	0.018	negligible	2.13	0.7	0.7	0.7	1.26
	Heavy metals and other trace pollutants	Note 1						negligible				0.078
	Hazardous waste generation	2.0		negligible	negligible		negligible	negligible				
	Solid waste generation (non-hazardous)	negligible		negligible	negligible		negligible	negligible	negligible	negligible	negligible	
	Diet											
	Lifestyle (e.g. exercise)											
	Psycho social environment											
	Housing conditions (e.g. cold, damp, air quality)											
	Geophysical factors (e.g. uv light, radon)		negligible	negligible	negligible	negligible	negligible	negligible				
	Liquid effluents	Note 1	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	negligible	
	Transport (noise, congestion, accidents)	negligible	0.14	negligible	negligible	0.14	negligible	negligible	negligible	negligible	negligible	

Important outstanding questions

- Nuclear accidents, high level waste management, proliferation risks
- Fossil fuel use and ecosystem effects
- Quantifying effects of fracking
- Landscape impacts of renewables
  - Onshore wind
  - Transmission lines of dispersed generation sites

TUBA: Treatment of uncertainty in benefit assessment

- Step 1: Monte Carlo of measurable uncertainty
- Step 2: Sensitivity analysis
- Step 3: Assessment of the effects of unquantified biases
- Step 4: Conclusions

Steps 1 and 2: Monte Carlo, Sensitivity analysis (illustrative case)

TUBA: Treatment of Uncertainty in Benefits Analysis

Quantitative assessment of uncertainty including sensitivity runs

Figures below highlighted green show where benefits>costs. Pink shading where costs>benefits.

Scenario: 2020, All countries

Abatement costs for scenario: 56

€M/year Benefits	10%ile	25%ile	33%ile	50%ile	67%ile	75%ile	90%ile	Case name
125	73	90	99	115	135	149	191	Median VOLY
252	146	181	199	232	272	300	386	Mean VOLY
203	118	146	160	187	219	242	311	Median VSL
380	220	274	300	350	410	452	581	Mean VSL
96	56	69	76	88	104	114	147	Desaigues VOLY
471	273	339	372	433	509	560	721	OECD VSL

Scenario: 2030, EU27

Abatement costs for scenario: 41

€M/year Benefits	10%ile	25%ile	33%ile	50%ile	67%ile	75%ile	90%ile	Case name
59	34	42	47	54	64	70	90	Median VOLY
115	67	83	91	106	124	137	176	Mean VOLY
109	63	78	86	100	118	130	167	Median VSL
202	117	145	160	186	218	240	309	Mean VSL
46	27	33	36	42	50	55	70	Desaigues VOLY
251	146	181	198	231	271	299	384	OECD VSL

Step 3: Unquantified biases (illustrative case)

Bias assessment for unquantified uncertainties

The views expressed here are those of the author.

	Direction of bias			
	Costs up or impacts down?	Costs down or impacts up?	Weight	Comments
Impacts				
Health	1	0	50%	Believed that some health impacts are excluded, moderated by concern over some valuations possibly being too high, e.g. for chronic bronchitis.
Materials	0	0	0%	Utilitarian material damage makes minimal contribution to overall effects
Materials in cultural heritage	1	0	20%	Low urban SO2 levels suggest this is of limited importance
Crops	0	0	0%	Accounted for in the modelling
Other agriculture	0	0	0%	Considered unimportant
Ecosystems	1	0	100%	Not included. Extent of exceedance of eutrophication in particular suggests that this effect is significant.
Cobenefits and trade offs				
Greenhouse gas emissions	1	0	10%	Small effect on GHG emissions unaccounted for
Discharge to water (not for treatment)	0	1	10%	Considered unimportant as plant will operate within discharge consents. However, linked with solid waste arisings (see below)

Step 4: Conclusions (illustrative case)

Conclusions

The analysis of uncertainties has quantified the possible consequences of variability with respect to data used for (e.g.) response functions and valuation, and sensitivity to key assumptions. It has also sought to provide a comprehensive overview of unquantified biases that affect the results, focusing on the likelihood that the benefits of action will exceed costs. By accounting for these various elements the analysis of uncertainties provides a comprehensive overview of the robustness of results.

Results of the quantitative uncertainty analysis indicate that in all cases where analysis considers all European countries, there is at most a 10% probability that benefits would not exceed costs. In all cases using a VOLY higher than from Desaigues et al (2011) or using the VSL, the probability of costs exceeding benefits is less than 10%. Restricting analysis to the EU27 reveals a slightly different pattern. There is around a 10% probability of costs exceeding benefits when mortality is valued with the median VOLY and a 25 to 40% probability when the Desaigues et al VOLY is applied. Again, there is substantially less than a 10% probability of a net cost when applying the VSL. Overall, results consistently indicate that the move to the MFR scenario would be beneficial to society on economic grounds*. [Leaving aside the non-marginal nature of the scenario comparison, for the purposes of illustration.]*

The bias analysis indicates that (in the opinion of the author) there are more biases that either reduce estimates of benefits or increase estimates of cost than vice versa; in other words the biases overall appear likely to act against any package of measures passing a cost-benefit test. The weighted equivalent (again, here based on the author's views, rather than, e.g. an expert panel though there is no reason that such a panel could not be convened in the future) provides a very similar outcome. Accepting the views expressed in the bias analysis as a reasonable representation of reality would

The Cornish Question

- What is the air quality problem in Cornwall?