COST-BENEFIT ANALYSIS OF CARBON MITIGATION MEASURES IN EUROPEAN CITIES: THE IMPORTANCE OF CO-BENEFITS

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- European H2020 project
- 18 European Institutions and 9 cities in Europe involved
- Aiming at developing strategies towards the improvement of air quality and environment in urban settings in order to enhance citizens' health and wellbeing

This paper

- Cost-benefit analysis CBA of policy interventions proposed by the ICARUS cities
- Cost-effectiveness analysis CEA to examine costs of measures per outcome e.g. cost per ton of CO2eq saved.

	City	Description
Energy Efficiency	**Basel**	Replacement of 11,847 gas boilers and 4,468 fuel oil boilers with heating pumps and solar heating
	Brno	Replacement of 800 coal-fired boilers and stoves with biomass-fired boilers, natural gas-fired boilers, heat pumps, automatic coal fired boilers and solar thermal collectors
	Stuttgart	Replacement of heating system from oil to high efficiency gas boilers, district heating and heat pumps in the residential and commercial sector. Promotion of buildings insulation and renovation in residential and non-residential buildings
Active Transport	**Brno**	Promotion of walking, cycling and public transport
	Stuttgart	Promotion of walking, cycling and public transport
	Athens	Promotion of walking, cycling and public transport and eco-driving
Alternative Fuel vehicles	**Brno**	Increase in share of private car vkm done by electric vehicles to 7% in 2020 and 12.5% in 2030 through promotion of EV and development of charging infrastructure
	Stuttgart	Increase in share of vkm done by electric and hybrid vehicles to 7% in 2020 and 20% in 2030 (municipal fleet, promotion of willingness to switch to EV in taxi companies, construction of charging infrastructure, reduction of parking fees for EV)
	Milan	Conversion of the entire public bus fleet to an electric fleet by 2030 (purchase of 1200 electric buses and the development of the charging infrastructure).

Cost-Benefit Analysis - overview

- Comparison of total costs and benefits of a measure, expressed in a common metric, i.e. monetary values.
- Both financial costs and benefits and non-tangible impacts are taken into account
- Future costs and benefits to be discounted to adjust them to the opportunity cost of capital.
- Performance indicators:
  - Net Present Value (NPV) of total costs and benefits
  - Benefit/Cost Ratio.

Cost-Effectiveness Analysis - overview

- Cost effectiveness analysis computes the costs of measures per achieved outcomes.
- Performance indicators:
  - Financial cost per tC = total costs/tC saved
  - Full cost per tC = total costs-benefits/tC saved

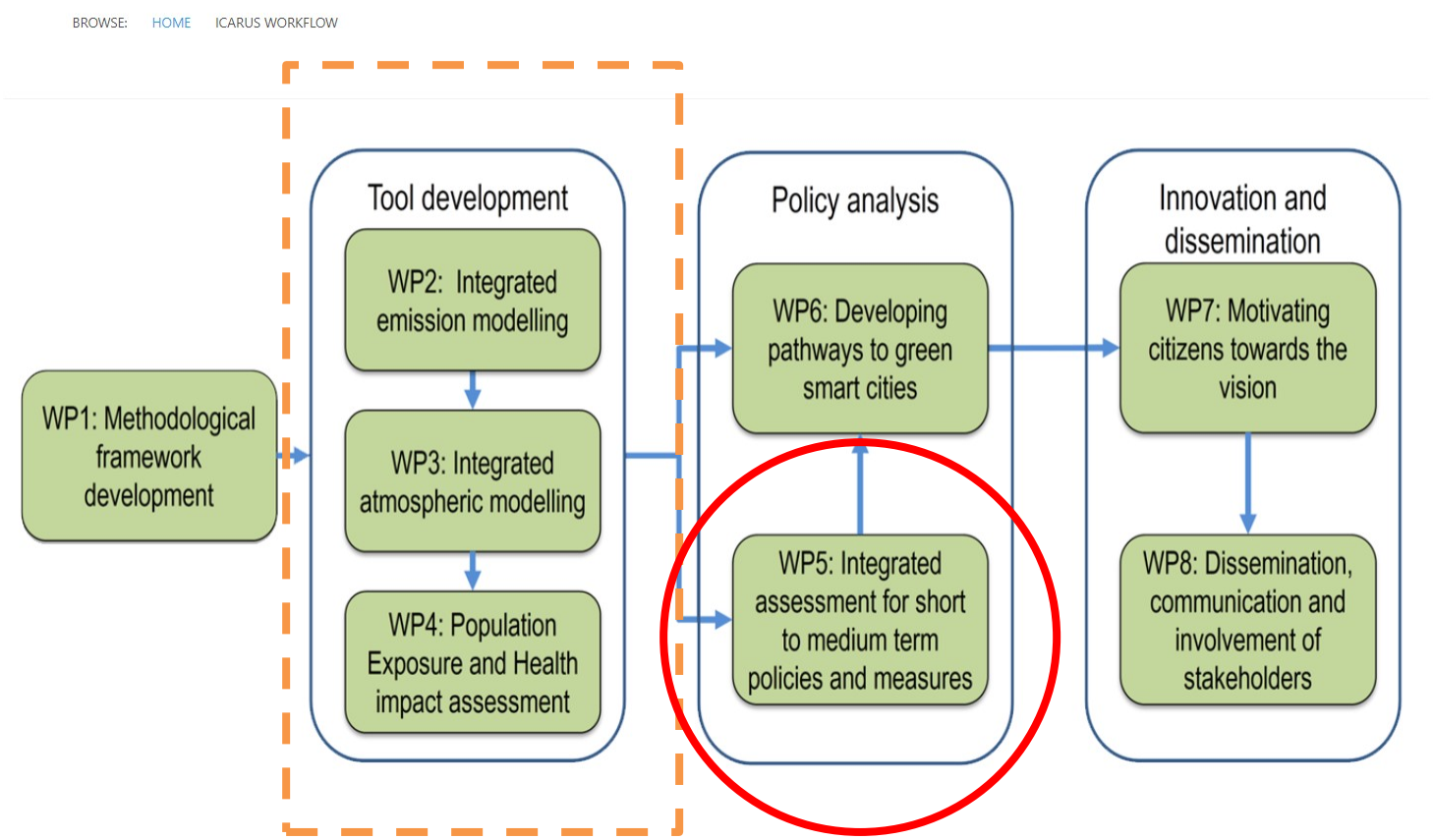
Cost & benefits included in the analysis

- Capital and O&M costs
- Avoided O&M and energy costs
- Health benefits from reduced air pollution
- Carbon savings
- Additional impacts for active travel measures: health benefits from increased walking and cycling; noise reduction; extra travel time

Methodology

- Discount rate: 3.5%
- All values expressed in € 2018
- Time horizon: from measure implementation until 2040

ICARUS Workflow



Health benefits: Health Impact Assessment

- Health impacts (compared to baseline) are based on AQ modelling for the following health endpoints
  - PM2.5: Mortality (>30)
  - PM10: Infant mortality
  - PM10: Incidence Chronic bronchitis
  - PM10: Cardiac Hospital Admissions
  - PM10: Respiratory Hospital Admissions
  - PM10: Incidence Chronic bronchitis children
  - NO2: Mortality (>30)
  - NO2: Incidence of bronchitis symptoms in asthmatic children

Health benefits valuation

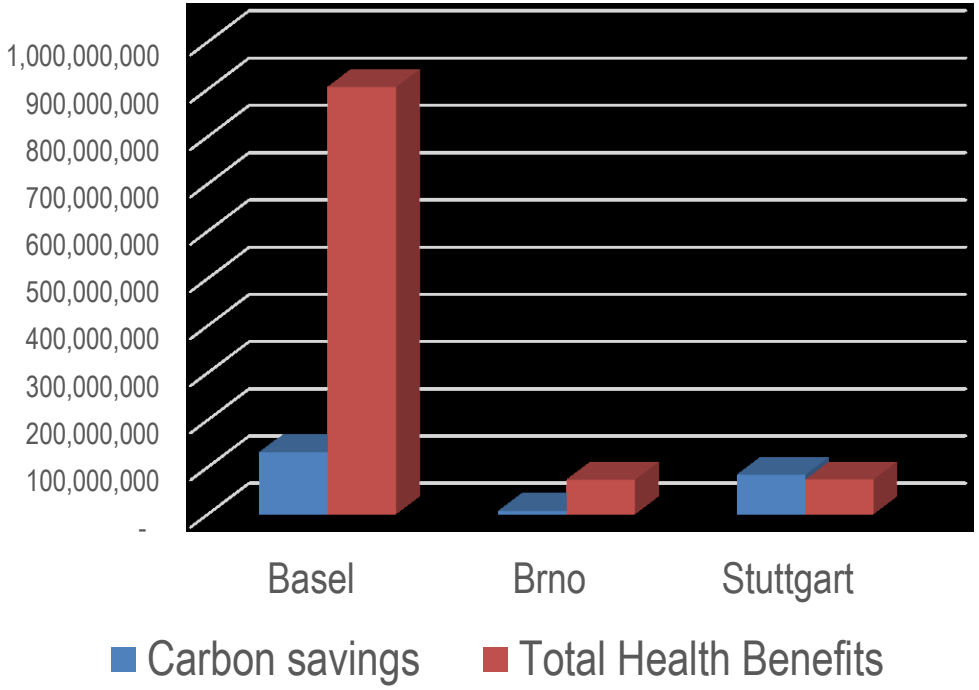
Valuation of health endpoints based on Hunt et al. (2011)

Health End-Point	Low	Central	High	Unit (2010) per case	Reference
Sleep disturbance	480	1,240	1,570	Euro/year	Godet-Cayré et al. (2006); Ozminkowski et al. (2007)
Hypertension	880	950	1,110	Euro/year	Ramsey et al. (1997); Berto et al. (2002)
Acute myocardial infarction	4,675	86,200	436,200	Euro	Moïse et Jacobzone, 2003; Yasunga et al. (2006)
Increased mortality risk (infants)	1,120,000	2,475,000	11,200,000	Euro	Holland et. al. (2004)
Chronic bronchitis	43,000	60,000	100,000	Euro	Krupnick and Cropper (1992)
Severe COPD	70,000	120,000	260,000	Euro	Maca et al. (2011)
Increased mortality risk - Value Of Life Years acute	60,820	89,715	220,000	Euro	Alberini et. al. (2006)
Increased mortality risk - Value of Prevented Fatality acute	1,120,000	1,650,000	5,600,000	Euro	Alberini et. al. (2006)
Life expectancy reduction - Value of Life Years chronic	37,500	60,000	215,000	Euro	Alberini et. al. (2006); Desaigues et. al. (2011)
Respiratory hospital admissions	2,990	2,990	8,074	Euro	Navrud (2001); Holland et. al. (2004)
Cardiac hospital admissions	2,990	2,990	8,074	Euro	Navrud (2001); Holland et. al. (2004)
Work loss days (WLD)	441	441	441	Euro	Navrud (2001); Holland et. al. (2004)
Restricted activity days (RADs)	194	194	194	Euro	Navrud (2001); Holland et. al. (2004)
Minor restricted activity days (MRAD)	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
Lower respiratory symptoms	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
LRS excluding cough	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
Cough days	57	57	57	Euro	Navrud (2001); Holland et. al. (2004)
Medication use / bronchodilator use	74	80	96	Euro	Maca et al. (2011)
Lung cancer	70,000	720,000	4,200,000	Euro	Weissflog et al. (2001); Serup-Hansen et al. (2003); Scasny (2008); Jeanrenaud and Priez (1999); Aimola (1998)
Leukaemia	2,050,000	4,000,000	7,000,000	Euro	Aimola (1998)
Neuro-development disorders	4,500	15,000	33,000	Euro/year	Ščasný et. al. (2008)
Skin cancer	11,000	14,000	27,000	Euro	Aimola (1998)
Osteoporosis	3,000	5,700	8,100	Euro	Kudma and Krška (2005); Werner and Vered (2002)
Renal dysfunction	23,000	30,400	41,000	Euro	Bartaskova et al (2005); Sun-Mi et al. (2006)
Anaemia	750	750	750	Euro	Ossa et. al. (2007)

Other benefits: Carbon savings

- Carbon emission reductions for all measures compared to baseline (CH4, CO2, NO2)
- CO2eq computed according to GHG GWP Global warming potential
- Monetary valuation carried out following traded carbon values provided by the UK Department for Business, Energy & Industrial Strategy.

Carbon savings and health benefits from **Energy Efficiency measures**



	Basel	Brno	Stuttgart
NPV	1,099,028,950	76,430,727	-401,063,128
B/C Ratio	3.17	9.27	0.59
FICOSTEF	245.09	98.72	763.41
FUCOSTEF	- 468.00	- 751.72	375.43

Carbon savings and health benefits from **Active Transport measures**

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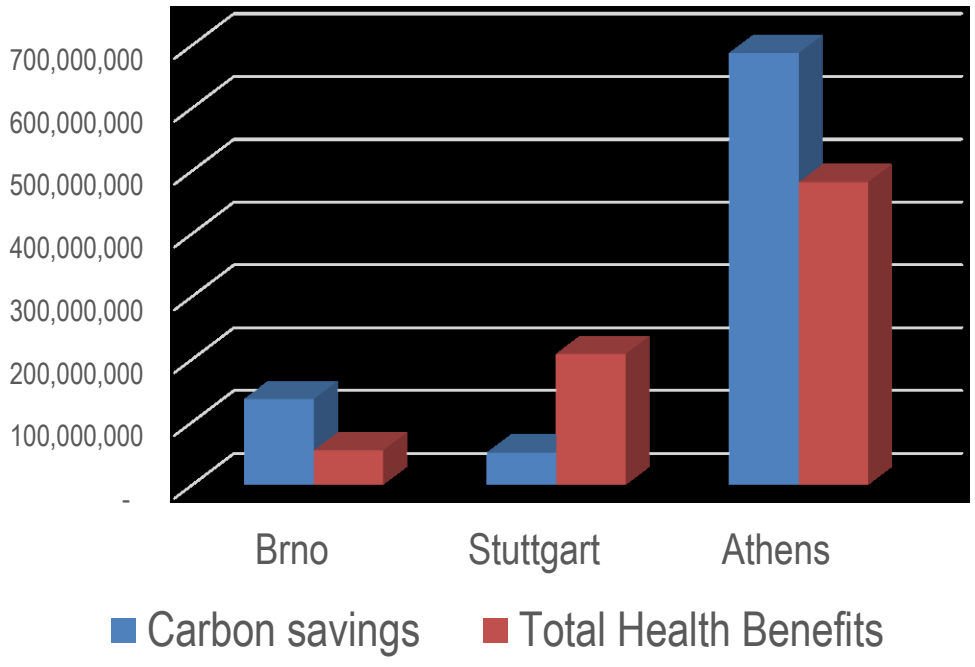
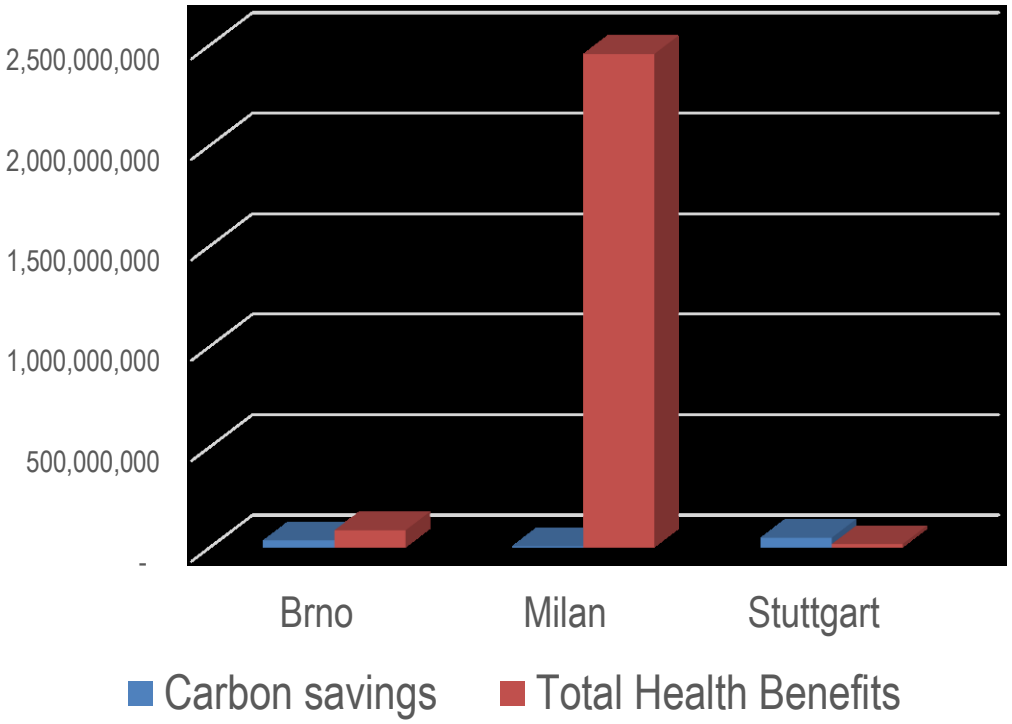


	Brno	Stuttgart	Athens
NPV	2,562,315,651	202,230,268	1,098,864,834
B/C Ratio	18.59	2.65	1.38
FICOSTEF	65.23	151.41	277.20
FUCOSTEF	-1,086.52	-187.40	-39.02

Carbon savings and health benefits from **Alternative fuel vehicles**



	Brno	Milan	Stuttgart
NPV	176,723,313	2,382,376,451	42,618,205
B/C Ratio	2.38	3.61	1.26
FICOSTEF	221.04	11,019.24	216.03
FUCOSTEF	-255.51	-28,719.75	6.55

Conclusions

- Importance of gathering good cost data
- Options that may appear costly in terms of the financial cost per tonne of carbon reduced become viable in many cases when co-benefits are considered

Thank you!

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