Measuring the Costs of *Un*sustainable Development

Some Case Studies from Cyprus

Theodoros Zachariadis

Department of Environmental Science & Technology

Cyprus University of Technology

E-mail: t.zachariadis@cut.ac.cy

November 2014

Outline

- Three issues of unsustainable development:
  - Low energy efficiency
  - Lack of public transport
  - Overexploitation of scarce water resources
- Assessment of costs in each case
- The future impact of climate change
- The importance of long term planning
- Policy implications

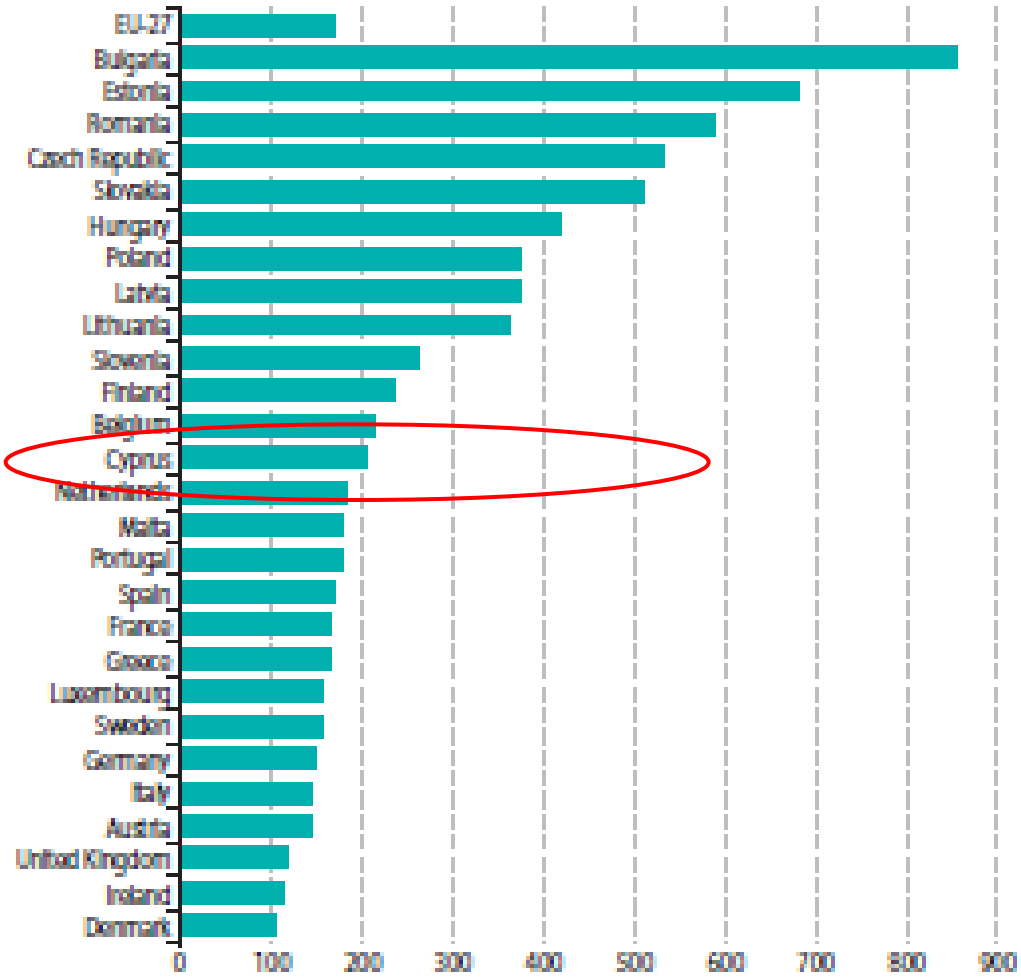
Issue #1: Cyprus has highest energy intensity among similar European countries

Energy Intensity = Energy consumption per unit of economic activity

Sometimes:
Sectoral energy intensity = Energy consumption per unit of final product (e.g. toe/tonne of steel)

Source: Eurostat Energy, Transport and Environment Indicators – 2012 Edition, Luxembourg, 2012

Figure 2.2.1: Energy intensity, 2010 (kgoe/1 000 EUR)



Reasons for low energy productivity

1. Energy inefficient buildings:
   - No thermal insulation of buildings before accession of Cyprus to EU
2. Energy intensive transport sector:
   - Dominance of cars (public transport < 2%)
   - Substantial share of air transport (no international connection by road or sea)
3. Inefficient power generation:
   - Almost entirely fossil-fuel-based, with outdated technologies; Combined Cycle Gas Turbine plants entered power generation only recently

Overview of climate change impacts in Europe

Climate change indicators	Northern Europe	Central and Eastern Europe	Mediterranean
Direct losses from weather disasters	M(-)	M(-)	H(-)
River flood disasters	M(-)	H(-)	L(-)
Coastal flooding	H(-)	M(-)	H(-)
Public water supply and drinking water	L(-)	L(-)	H(-)
Crop yields in agriculture	H(+)	M(-)	H(-)
Crop yields in forestry	M(+)	L(-)	H(-)
Biodiversity	M(+)	M(-)	H(-)
Energy for heating and cooling	M(+)	L(+)	M(-)
Hydropower and cooling for thermal plants	M(+)	M(-)	H(-)
Tourism and recreation	M(+)	L(+)	M(-)
Health	L(-)	M(-)	H(-)

Notes: H: High; M: Medium; L: Low; (+): Positive impact; (-): Negative impact

Source: Future Impacts of Climate Change across Europe. Center for European Policy Studies (CEPS) Working Document No. 324/February 2010. www.ceps.eu/ceps/download/2972

Climate Change and Its Impacts in Cyprus

Recent region-specific projections:

(Hadjinicolaou et al., *Regional Environmental Change* (2011) 11: 441–457 and Zachariadis & Hadjinicolaou, *Energy* 76 (2014) 899–910

- Temperature increase of 2°C in summer, 1°C in winter by mid-21st century
- Slightly reduced rainfall levels (2–7%) + sea level rise

Effects:

Meeting most sustainable development objectives will become more challenging under climate change conditions

ity

- Higher energy needs for cooling (lower for heating)
- Risk of decreasing tourist flows
- Adverse impacts on public health

Analysis of Climate Effects on Energy Use

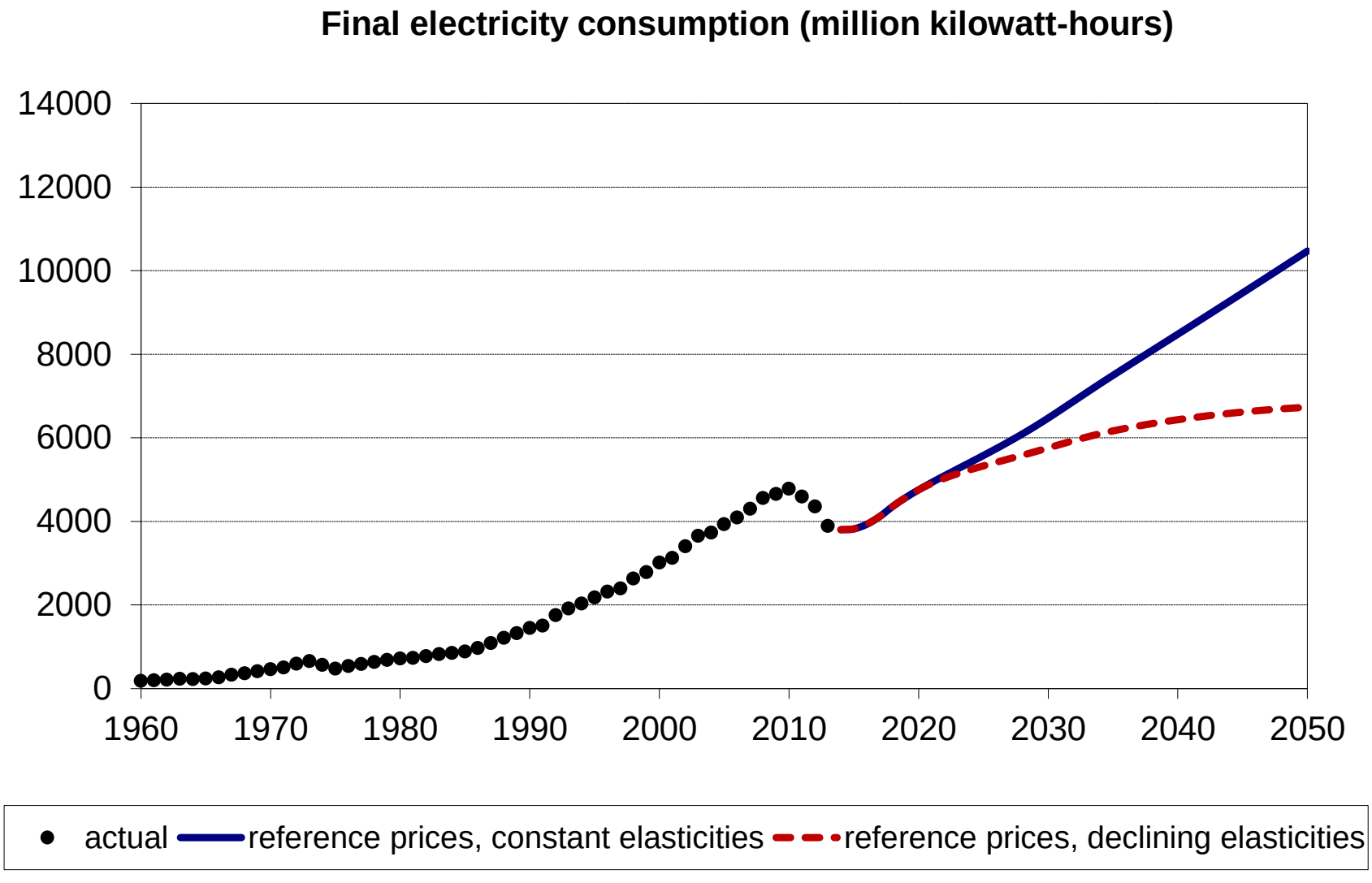
(Zachariadis & Hadjinicolaou, *Energy* 76 (2014) 899–910)

- Econometric time series analysis of energy use in Cyprus by sector and fuel, 1960-2010

➢ *Energy consumption = f (income/economic activity, energy prices, time trends, climate)*

- Climate effects captured by the variables of heating & cooling degree days (they express intensity + duration of cool & hot days respectively)
- Effect of climate statistically significant only for electricity consumption in households & tertiary sector
- Climate change leads to more degree-days ➔ higher electricity use ➔ higher energy expenditures for households and firms

Forecast of electricity consumption up to 2050 – without climate change



Forecast of electricity consumption up to 2050 with climate change – but without adaptation!

- Electricity use in 2050 higher by 6% (compared to 'no climate change' scenario)
- Direct cost: 13-38 MEuros in 2030, 32-149 MEuros in 2050 (at constant prices of year 2010)
- Present value of total cost in period 2015-2050: 488-732 MEuros'2010
- Climate change will increase the imbalance between (low) winter and (high) summer electricity demand:
  - Earlier econometric analysis: > 100 extra MW required in 2050

  ➔ Increased requirements for extra reserve capacity

  ➔ Further increase in costs to society

➢ Costs underestimated because we do not account for non-linear extreme events (e.g. prolonged heat waves)

➢ Costs overestimated because we ignore adaptation

Issue #2: Lack of public transport
Costs from excessive car use

- The use of cars has several negative side effects, which lead to significant monetary costs (direct or indirect)
- **Private costs** are not of interest to policy makers as they are borne by car travellers themselves – private benefits outweigh costs
- **External costs** are important because they are generated -but not paid- by car travellers; they are borne by society

➢ Βλ. επίσης Ζαχαριάδης, Σχόλιο Οικονομικής Πολιτικής 20, ΚΟΕ, Παν/μιο Κύπρου, Ιανουάριος 2009, http://www.ucy.ac.cy/erc/documents/cars_comment.pdf

Objective of the study

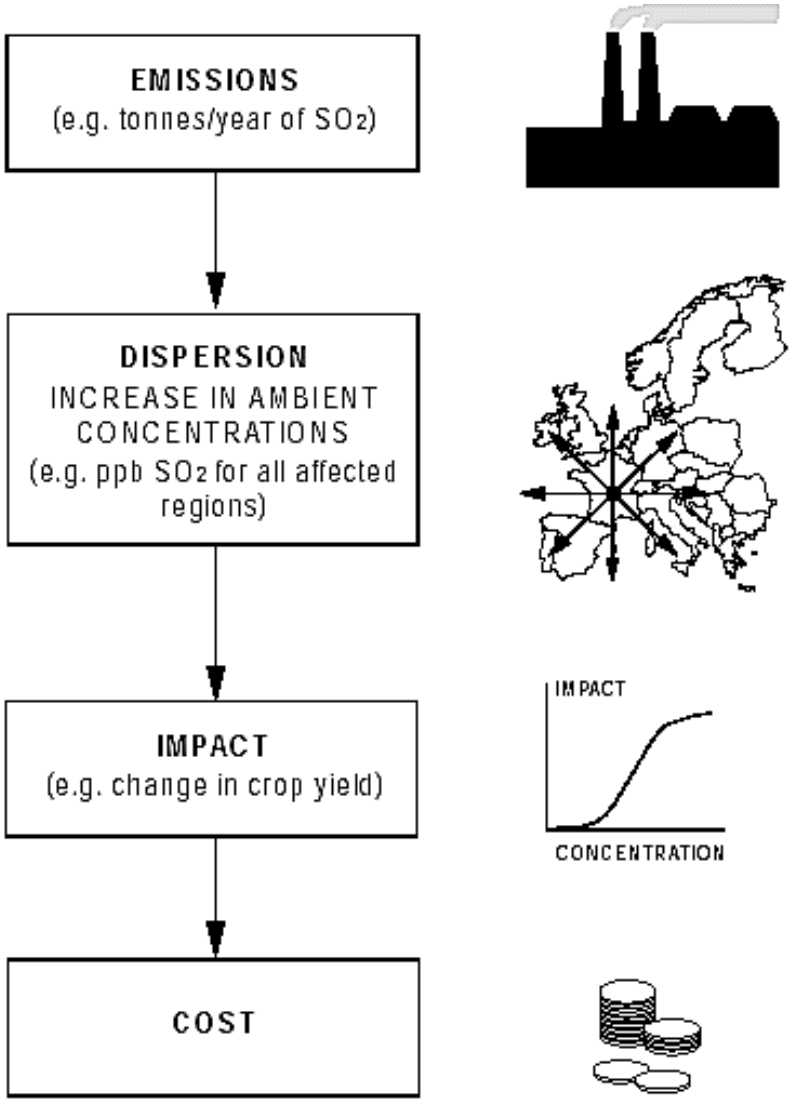
- **Calculation of marginal external costs of car use in cities of Cyprus by time of day**
- A European methodology was used (Handbook for estimation of external costs of transport), adjusted to national demographic and economic data
  [Maibach et al., http://ec.europa.eu/transport/themes/sustainable/doc/2008_costs_handbook.pdf]
- Detailed local data from Cypriot governmental authorities were used

  (Dept. of Public Works, Dept. of Labour Inspection, Environment Service)

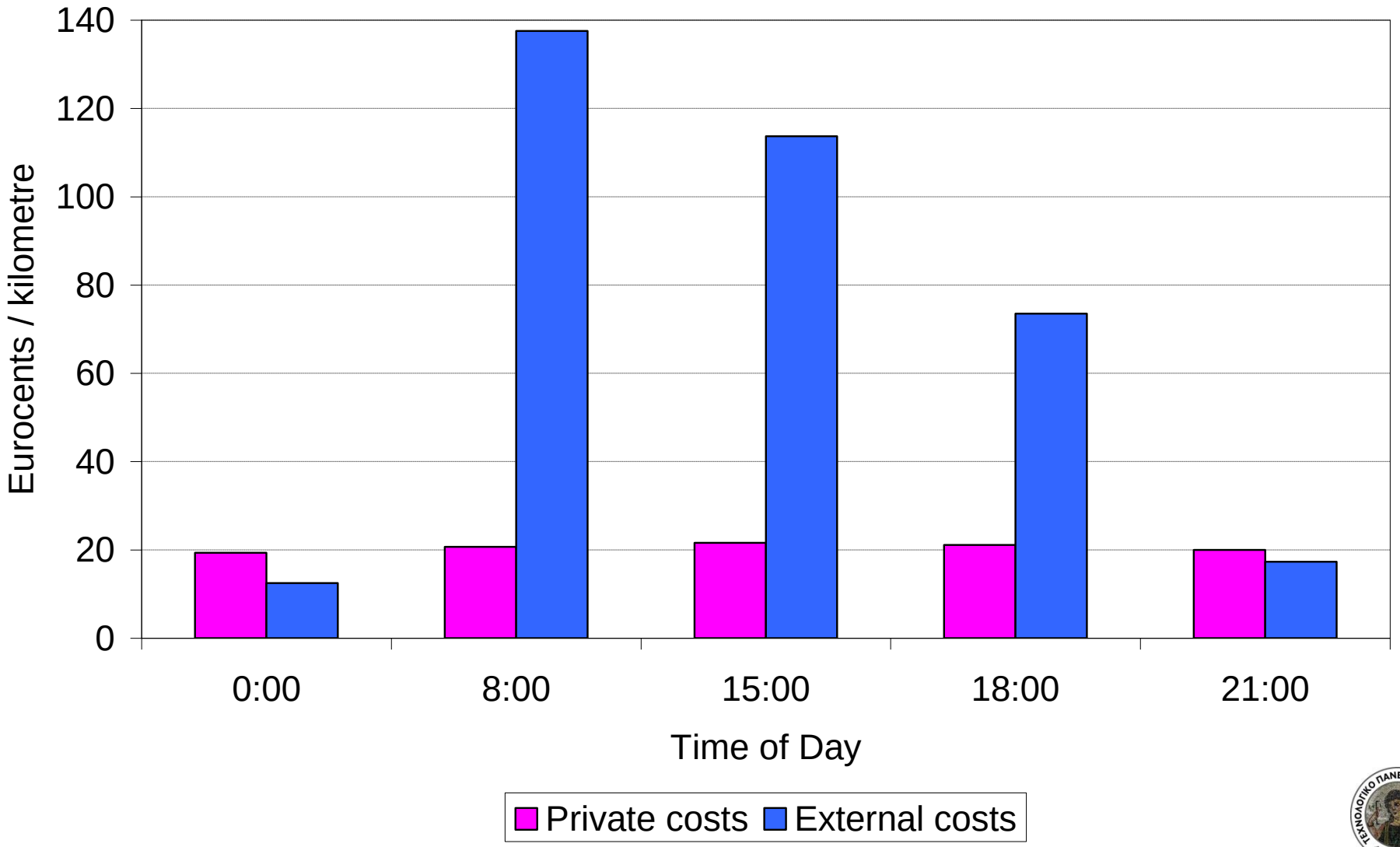
Types of externalities covered

- Congestion
- Road accidents
- Noise
- Air pollution
- Greenhouse gas emissions (CO_2, CH_4, N_2O)
- Other impacts

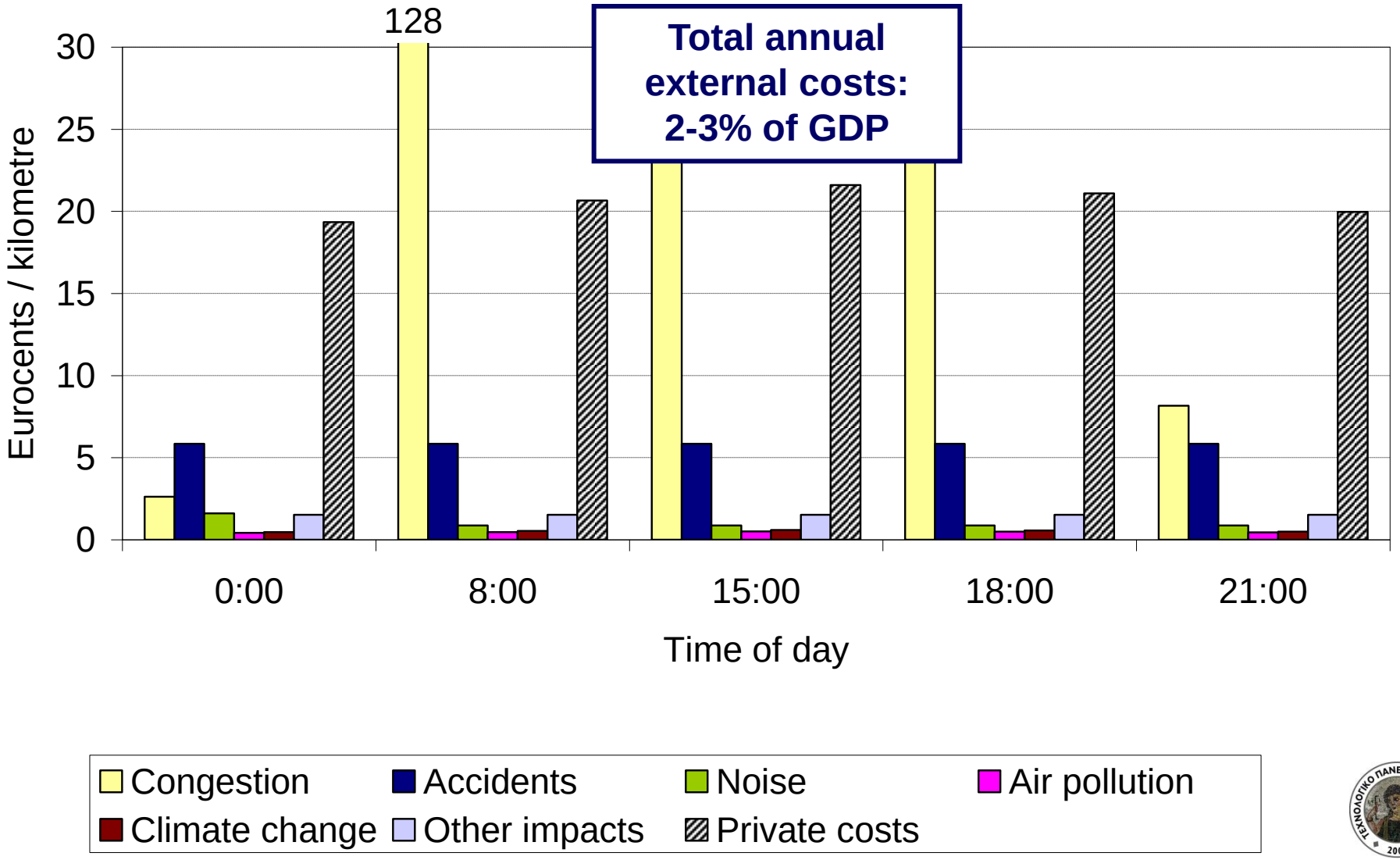
Example of external cost calculation: Air Pollution (www.externe.info)



Comparison of external and private costs of car use in Cypriot cities



External costs from the use of cars in Cypriot cities, by type



Policy recommendations

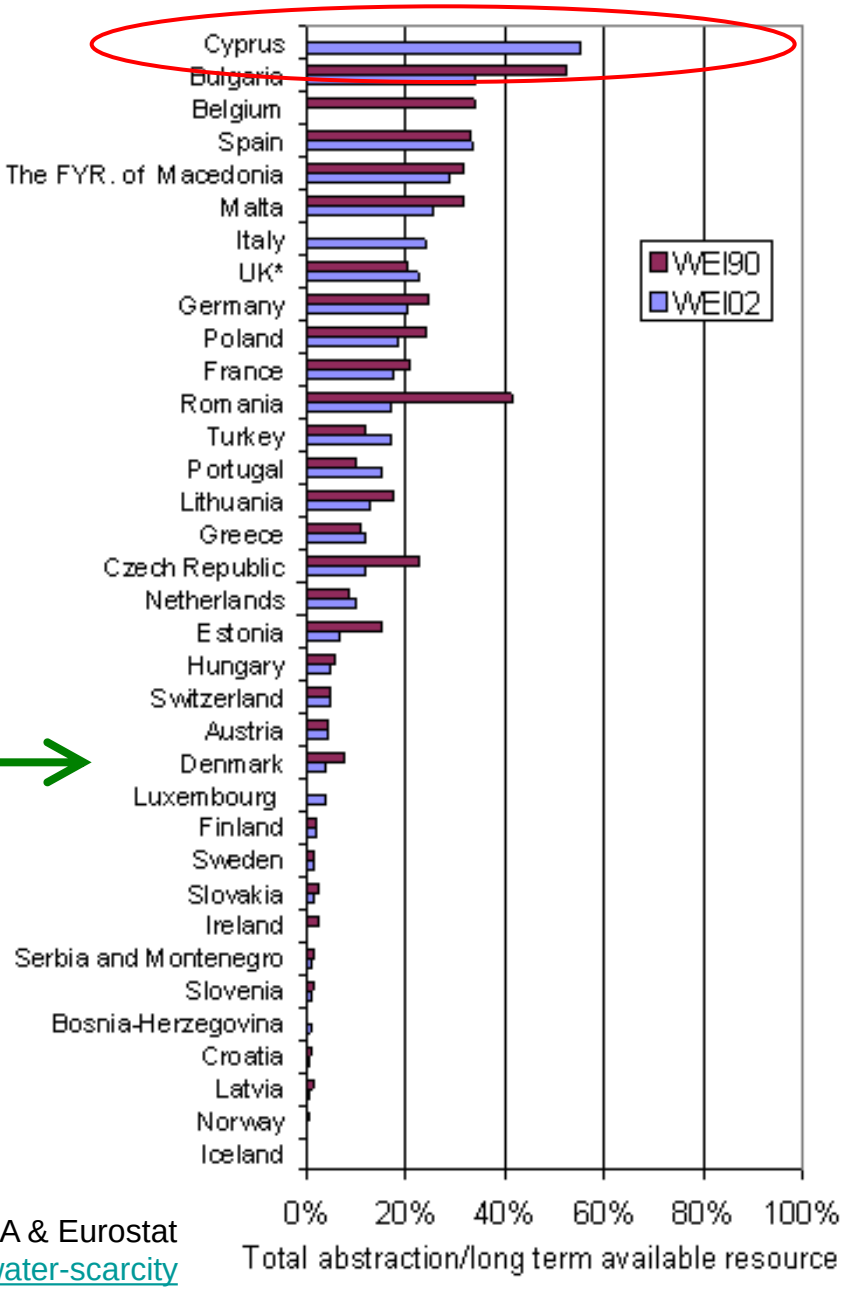
- Coherent long-term planning:
  - Rapid development of public transportation (comparison of external costs under different public transport scenarios is currently underway)
  - Charge use of cars (high parking fees, environmental taxation of cars and fuels)
  - Road charging maybe at a later stage

➢ Citizens respond to economic incentives

➢ Strong political willingness is required because this is a long-term investment

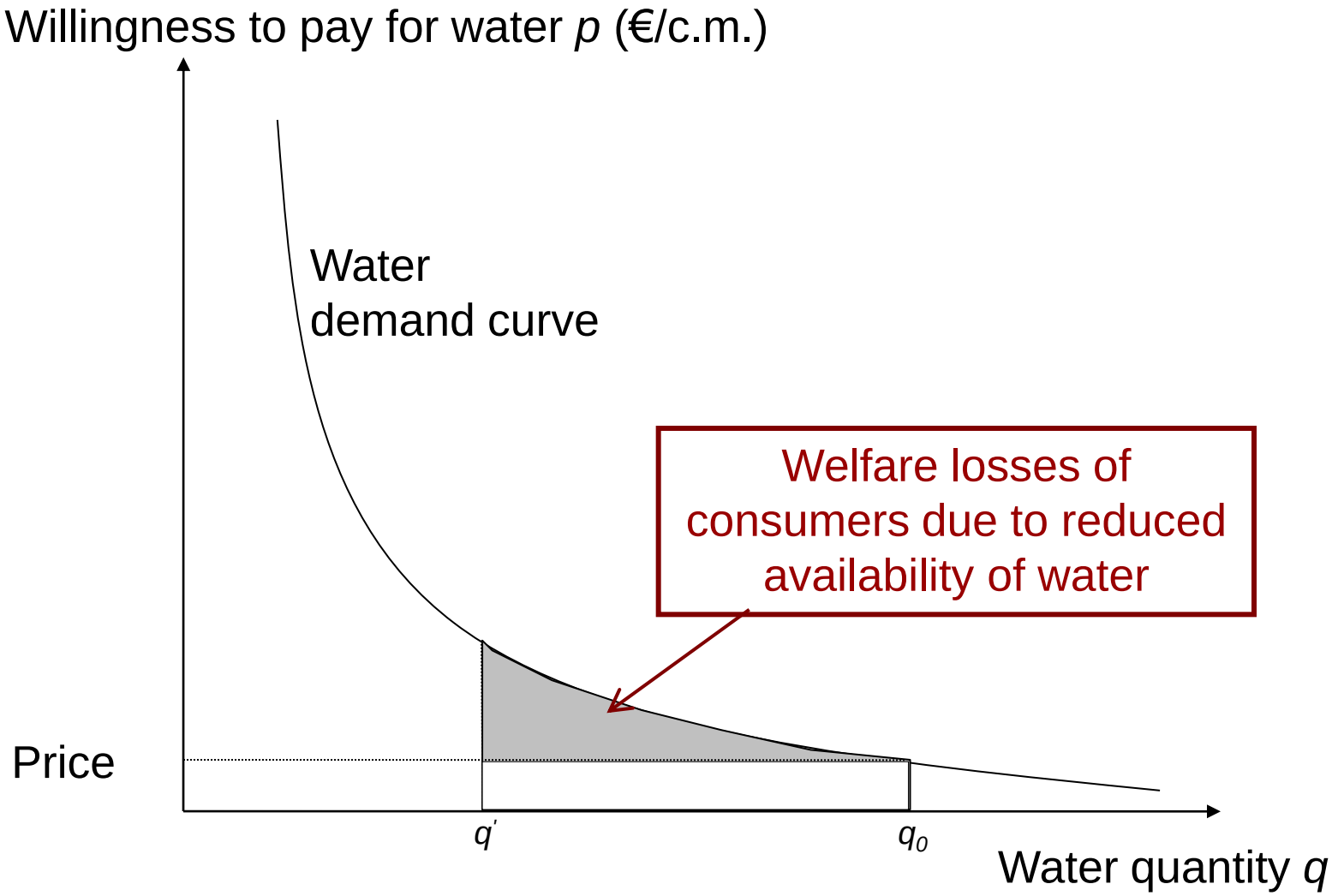
Issue #3: Overexploitation of already scarce water resources

'Water Exploitation Index' expresses water scarcity (annual water abstraction divided by long-term annual average of available water)



Source: EEA & Eurostat
http://www.eea.europa.eu/themes/water/featured-articles/water-scarcity

Methodology to assess costs of water shortages in non-agricultural sectors



Estimating Residential Water Demand in Cyprus

(Zachariadis T., *Water* Vol. 2, pp. 788–814 (2010) and
Polycarpou & Zachariadis, *Water Resources Management* 27 (2013) 309–317)

- Data from the three Water Boards of Cyprus serving the main cities (Nicosia, Limassol, Larnaca):
  - Billed water consumption per consumer type
  - No. of consumers by type
  - Water tariffs (fixed prices & prices per consumption block)
  - Fraction of consumers in each consumption block
  - Revenues and expenditures (from Board financial accounts)
  - Period: 1980-2009 (annual data), 2000-2009 (data available per billing period – 2/3/4 months)
- Other data:
  - Monthly temperature and rainfall (from Met. Service)
  - Quarterly GDP & population (from Statistical Service)
  - Household income by district of Cyprus (Family Expenditure Surveys conducted by Statistical Service)

Cyprus:
Costs of Water Shortages up to 2030

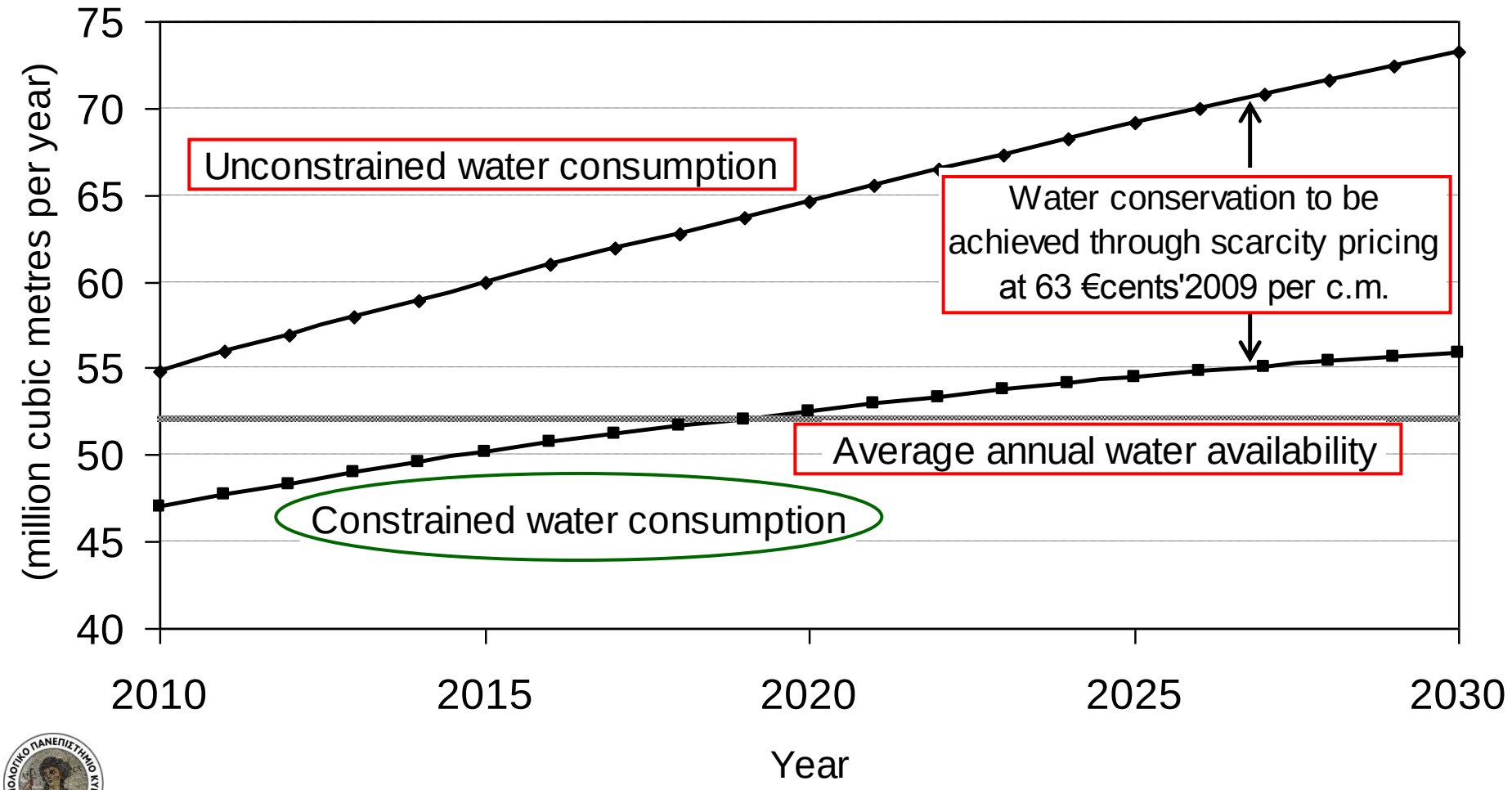
	Scenario 1: Constant per capita water use		*Scenario 2: Per capita water use grows 1% p.a.*		*Scenario 3: Per capita water use grows 2% p.a.*	
Year	Water consumption (mio c.m.)	Cost (mio Euros'2009)	Water consumption (mio c.m.)	Cost (mio Euros'2009)	Water consumption (mio c.m.)	Cost (mio Euros'2009)
2010	54.8	0.21	54.8	0.21	54.8	0.21
2015	57.0	0.75	60.0	1.95	63.0	3.84
2020	58.5	1.27	64.6	5.15	71.3	12.81
2025	59.5	1.73	69.1	9.86	80.1	29.12
2030	60.1	2.01	73.3	15.84	89.3	54.80
Total economic loss, 2010-30		**25.57**		**130.69**		**381.97**
Present value of economic loss, 2010-30		**15.20**		**71.96**		**204.21**

New desalination plants cost 400 MEuros!

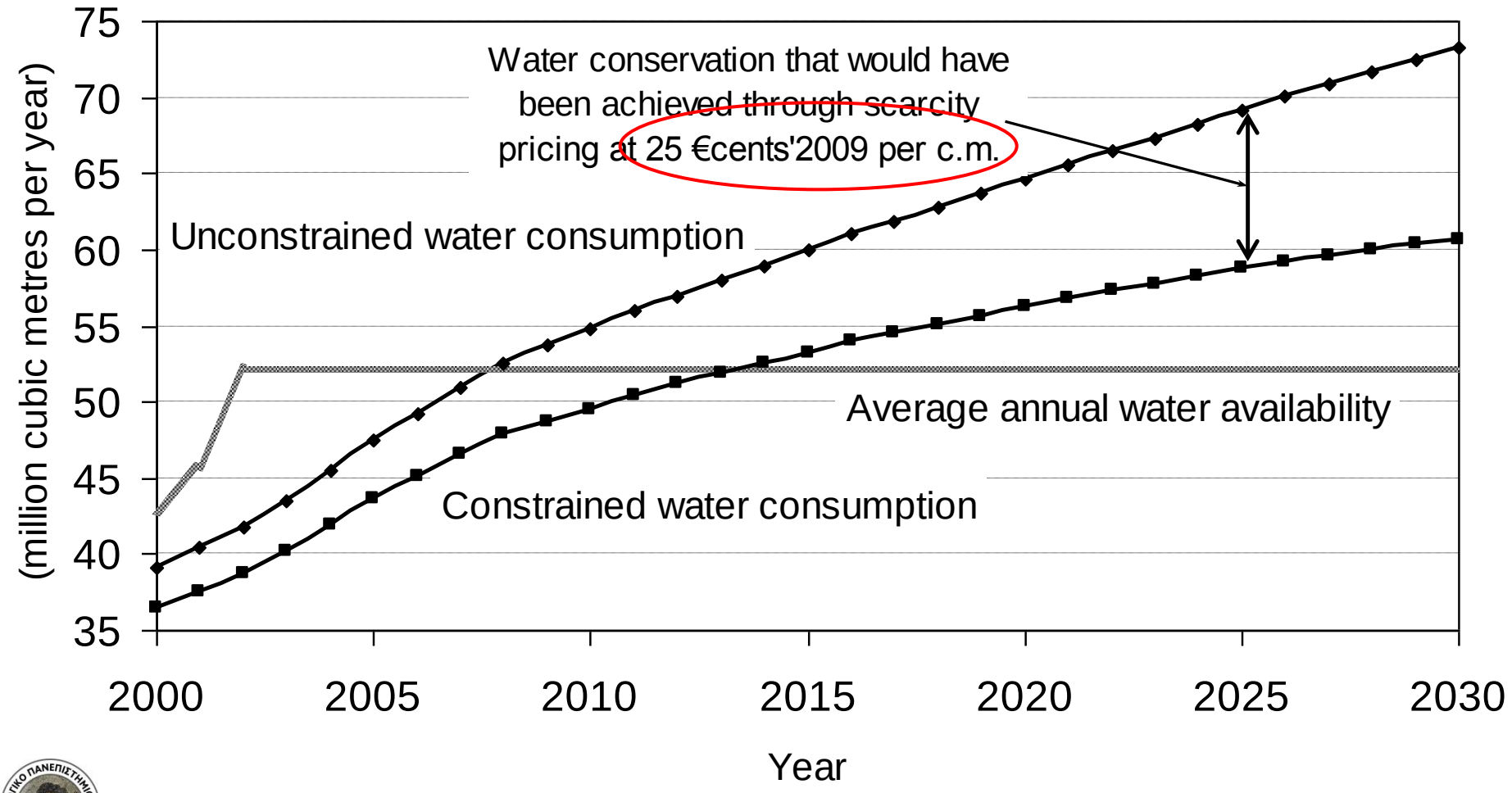
		Additional scarcity cost due to climate change (mio Euros'2009)		
Year	Difference in water availability due to climate change	*Scenario 1: Constant per capita water use*	*Scenario 2: Per capita water use grows 1% p.a.*	*Scenario 3: Per capita water use grows 2% p.a.*
2010	0.0%	0.00	0.00	0.00
2015	-0.9%	0.17	0.28	0.41
2020	-1.9%	0.46	1.00	1.74
2025	-2.8%	0.85	2.27	4.58
2030	-3.7%	1.28	4.17	9.72
Total additional economic loss, 2010-30		**11.11**	**29.42**	**60.19**
Present value of economic loss, 2010-30		**6.12**	**15.69**	**31.49**

15–20% higher costs due to climate changed induced water scarcity

An adaptation measure: Effects of 'efficient' household water pricing



Benefits of long-term planning: What if we had 'efficient' prices already in 2000?



To summarize…

- Three cases of unsustainable development
- Common causes:
  - Absence of long-term planning
  - Insufficient understanding of the issues by policy makers
  - Institutional problems & poor governance
  - Weak political will and weak pressure by citizens
- EU membership greatly helped change path – but policy makers often follow sustainability strategies half-heartedly
- Assessment of costs is very important;
  shows that long-term planning has tangible benefits
- Messages have to be conveyed to decision makers

- Βλ. επίσης Ζαχαριάδης, Σχόλιο Οικονομικής Πολιτικής 21, ΚΟΕ, Παν/μιο Κύπρου, Μάιος 2010, http://www.ucy.ac.cy/erc/documents/water_comment.pdf