Examples of top-down (TD) methods

- **Solar water heaters** (TD 1)
- **Modal shift for transport of goods** (TD 1)
- **New cars** (TD 2a)
- **Electricity end uses in services** (TD 2b)

evaluate energy savings EU

Original slides for the case methods by Enerdata and ADEME

Solar water heaters

market diffusion indicator

Top-down estimation of energy savings for solar heaters

- Indicator used to measure energy savings: diffusion of solar water heaters in terms of installed stock in m2

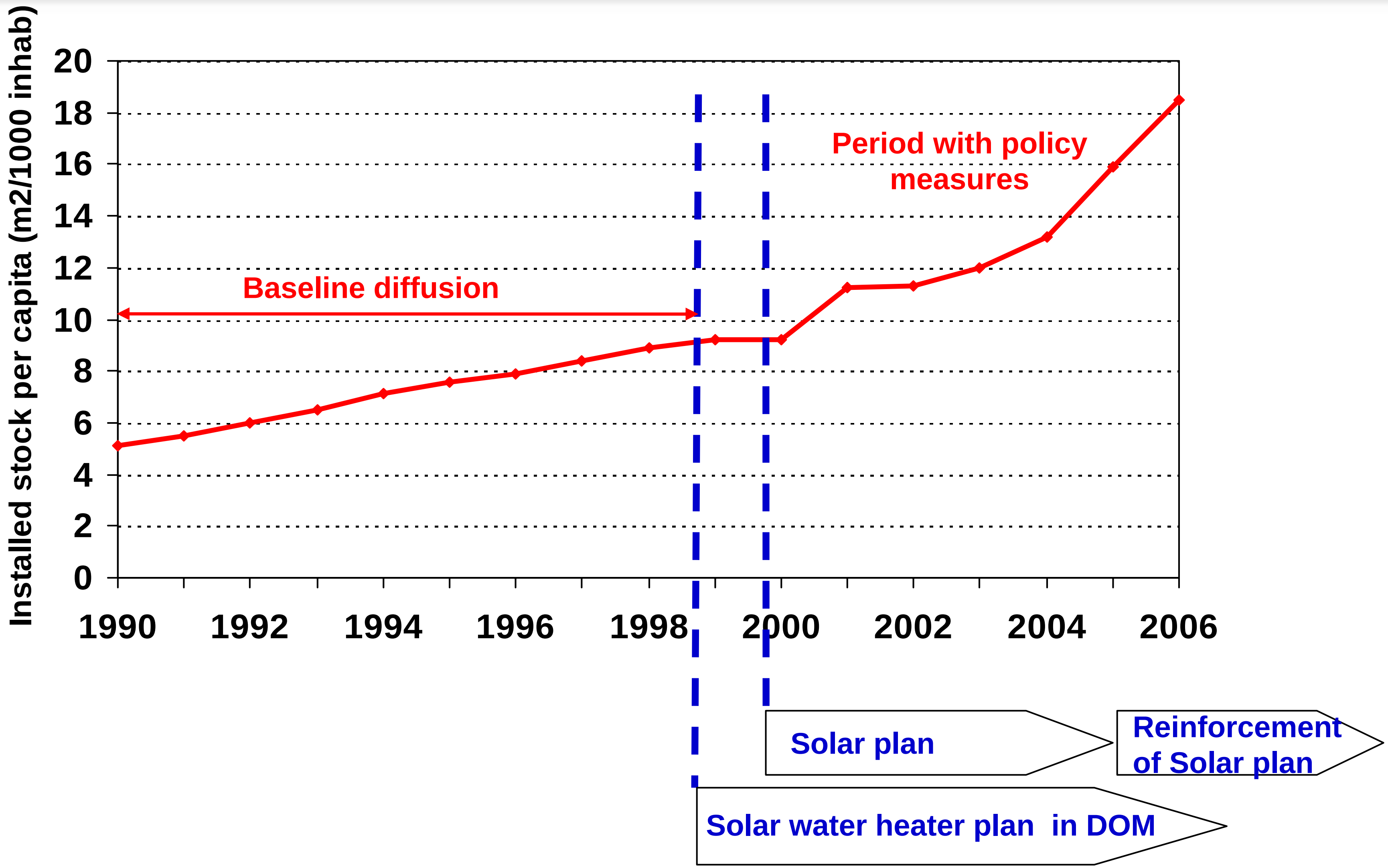
- The diffusion of solar water heaters can be generally explained by the following variables:
  - Autonomous trend
  - Energy price
  - Cost of solar water heaters
  - Energy policy measures (e.g., subsidies, tax credit) (After / before 1995)

  } **Defines the baseline**

- In practice, taking into account the data usually available, the diffusion of solar water heaters in the absence of policy measures (baseline) can be modelled with two main variables :
  - Time to capture the autonomous trend
  - Average price of energies used for water heating to measure the impact of prices

➔ The baseline diffusion is a function of an autonomous trend and a price effect; the energy savings from policies will be calculated from the difference between the actual diffusion and the baseline diffusion

Example: case of France
Solar water heaters



Modelling of the baseline diffusion of solar water heaters

- To capture the trend and price effect, the regression analysis has to be made over a period over which policy measures either are negligible or had a limited impact

- The autonomous trend and price elasticity are calculated over that period through a regression analysis with two variables:
  - Time to capture an autonomous trend
  - Average energy price to measure the impact of prices

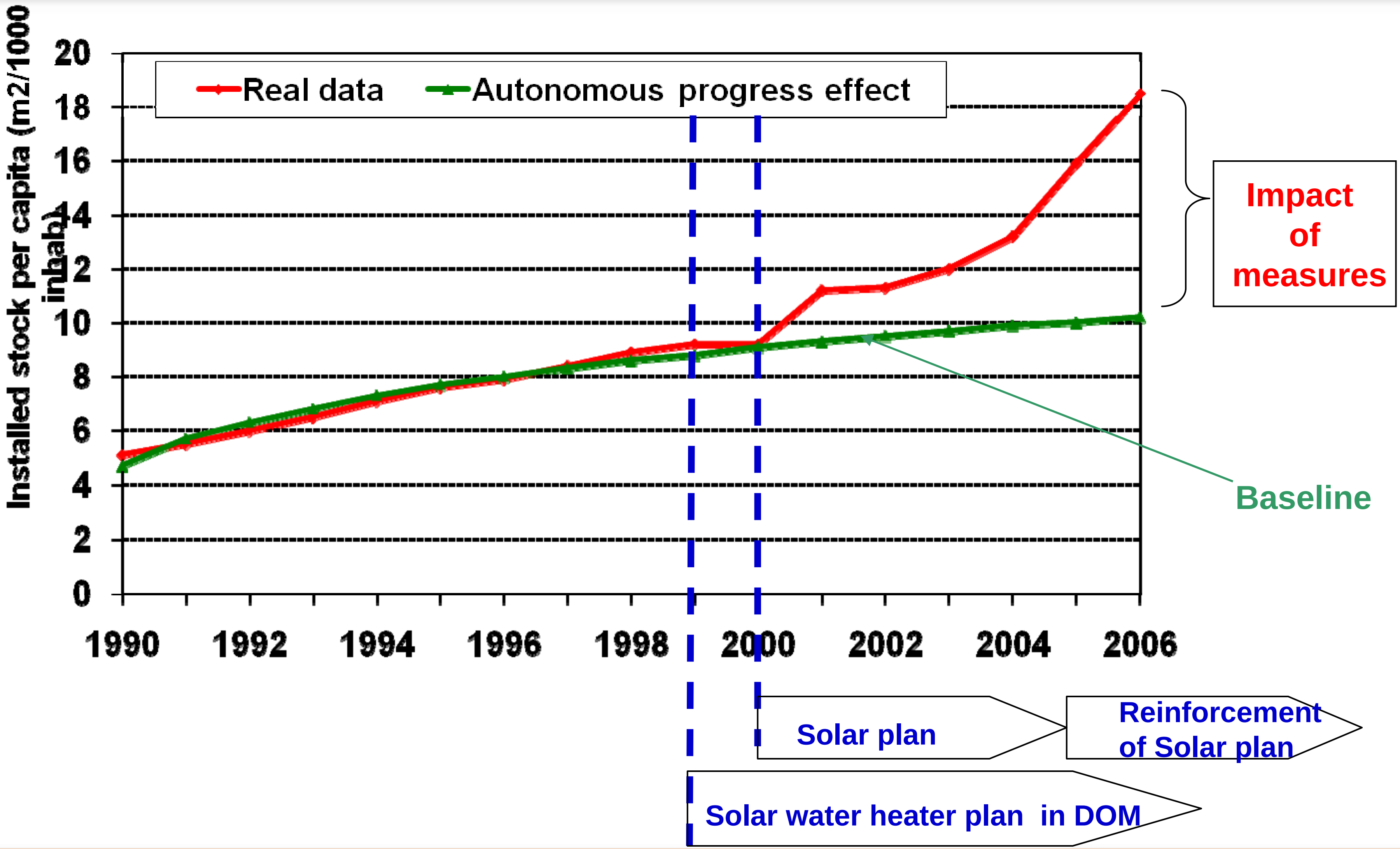
$$Ln\ (IC) = T \times ln\ (t) + A \times ln\ (P) + K$$

- ✓ T: trend
- ✓ A: price elasticity (>0 as price increase should increase penetration of solar water heaters)
- ✓ P: energy price

- The price effect was generally not validated by statistics test or was not really relevant from an economic viewpoint (price elasticity positive instead of negative or value too high)➔ may be neglected to define the baseline.

Example of France: modelling of the baseline

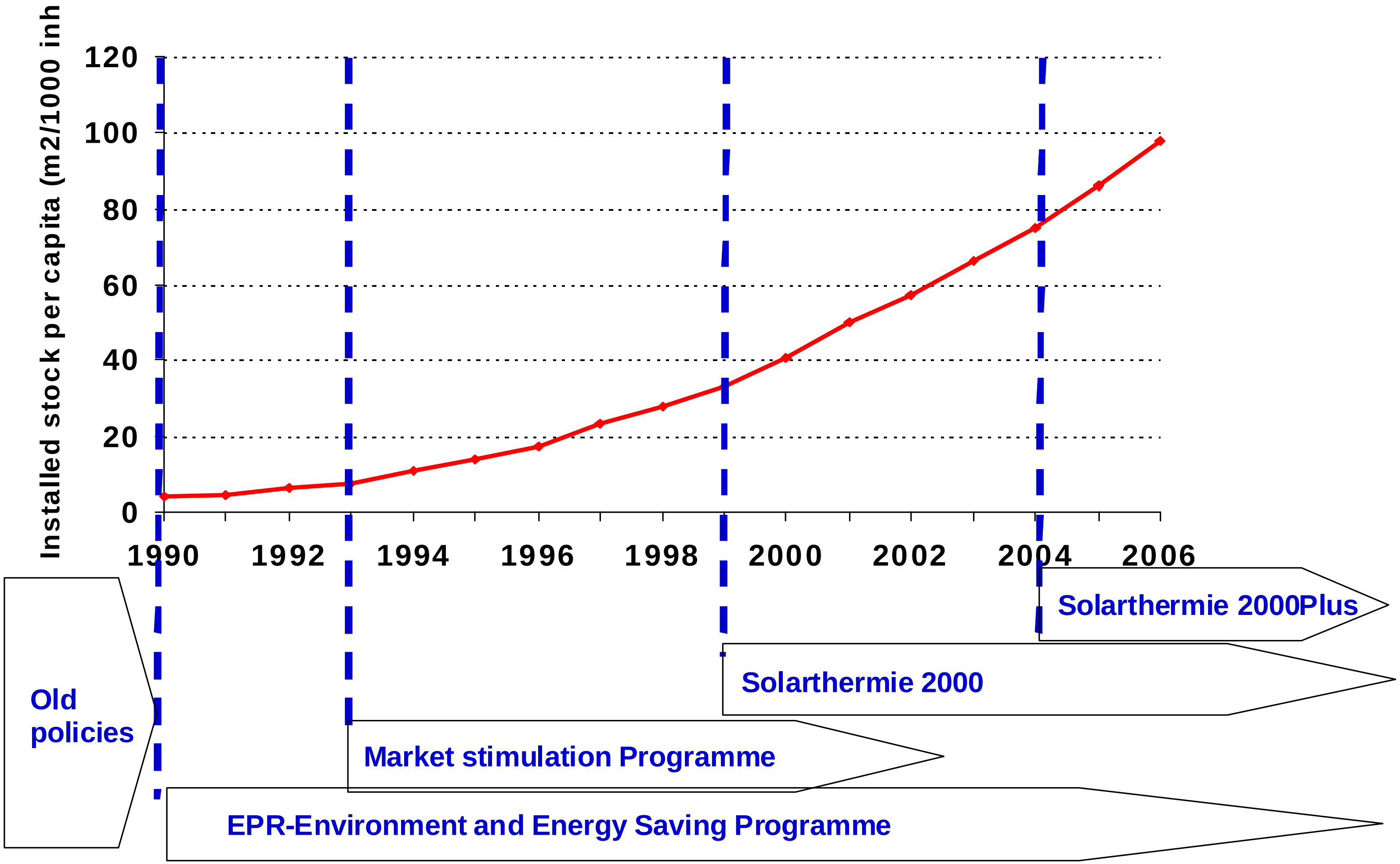
Solar water heaters



Case of a mature market: Germany (1/2)

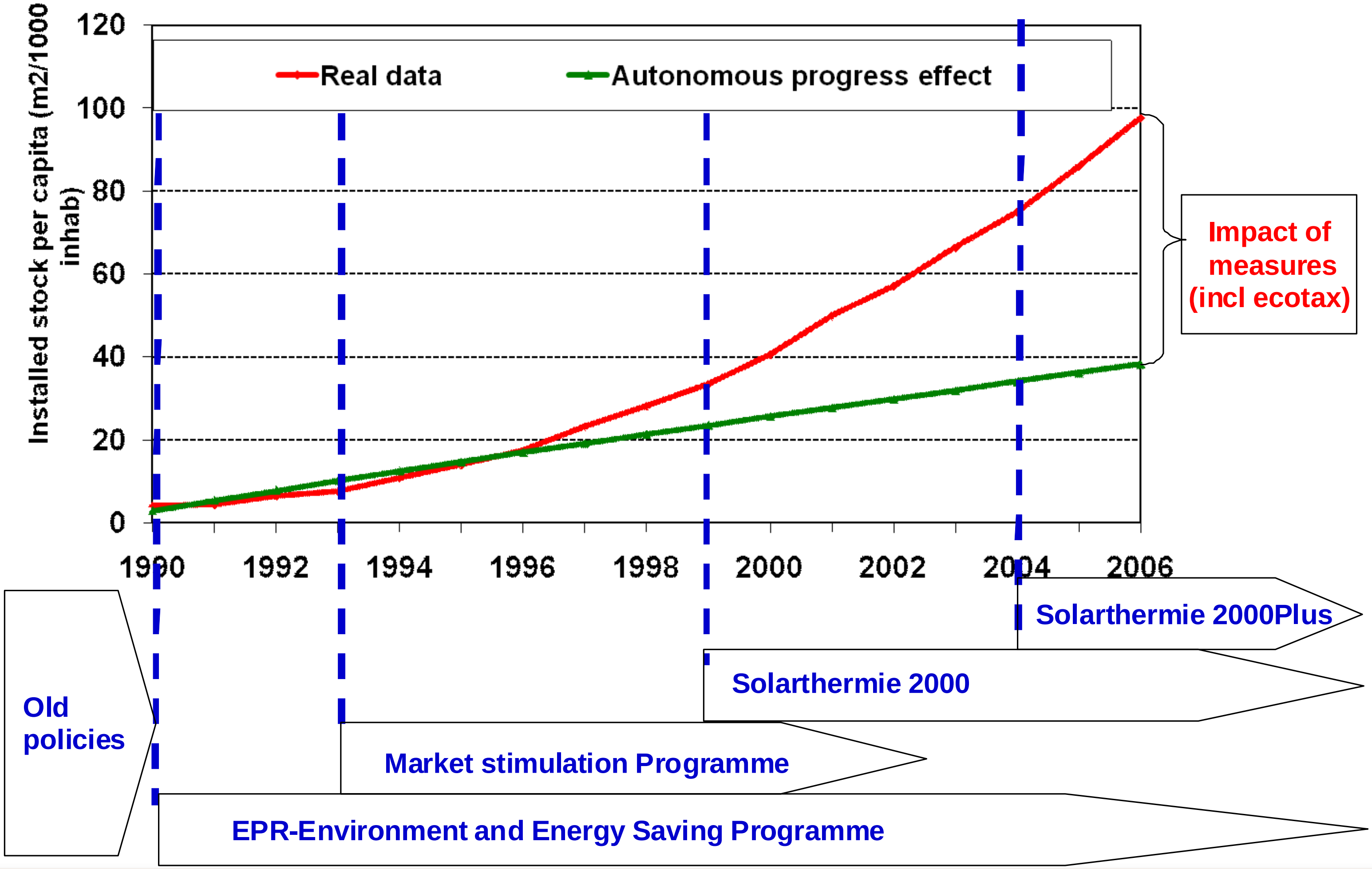
Historical development, solar water heaters

Several policies implemented for solar water heaters (1993, 1995, 1999), plus ecological tax in 1999. Over which period do we do the regression? The diffusion mainly significant since 1999.



Example of Germany: modelling of the baseline
Solar water heaters

Regression until 1999: Ln (**IC**) = 0.92 X ln (**t**) + 1.05 + ε_t



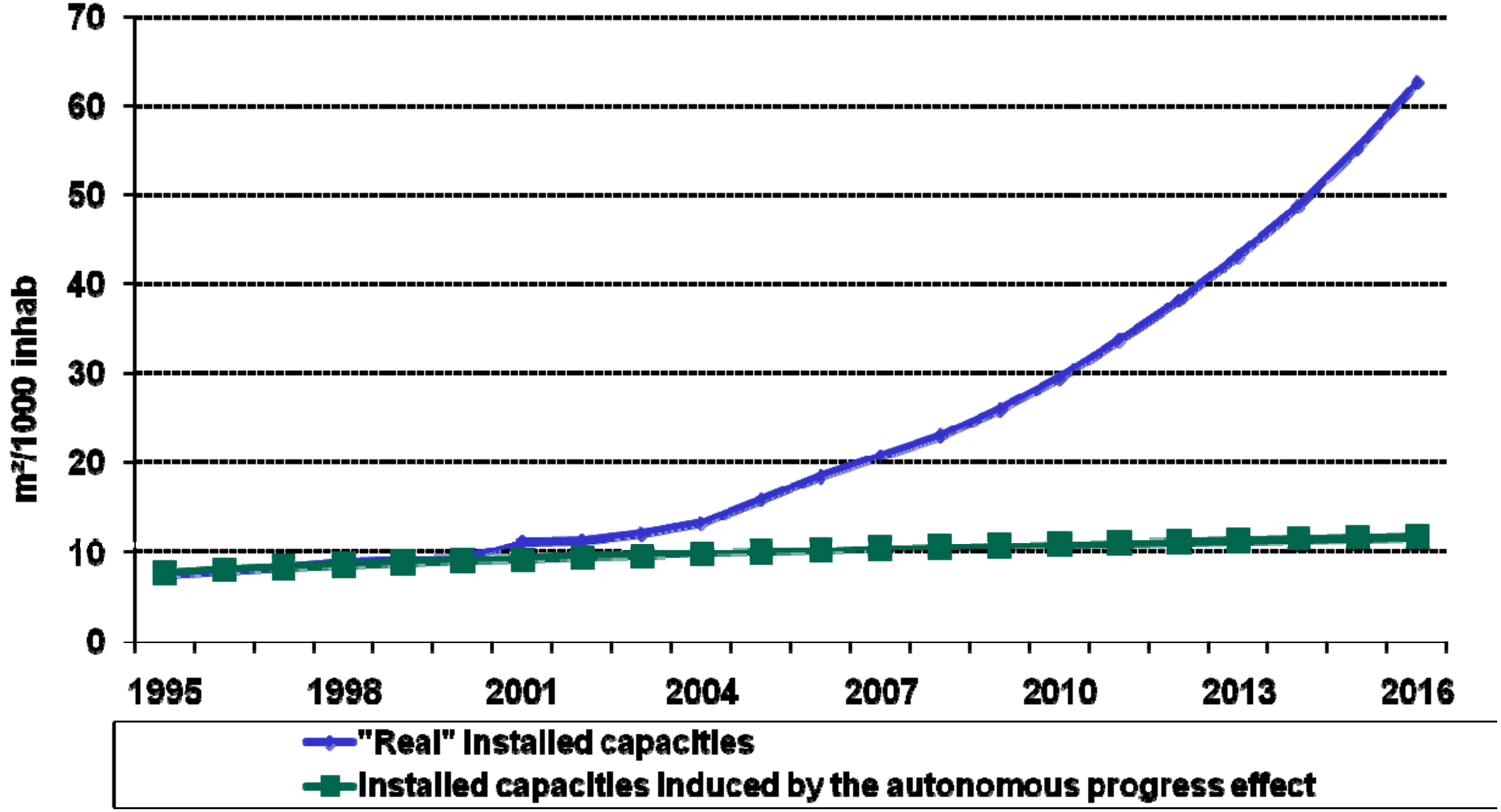
Calculation of ESD energy savings for solar water heaters 1/4

Calculation in 3 stages:

- **Stage 1 :** Estimation of the baseline installed capacities variation from autonomous trend based on econometric modelling (country specific trends)
- **Stage 2 :** Calculation of the total energy savings by multiplying the number of m^2 by an amount of energy saving per m^2 depending on the country
- **Stage 3 :** ESD energy savings calculated by difference: total savings minus trend related savings

Calculation of energy savings (example) 2/4
Installed capacities of solar water heaters

➢ **Stage 1** : Estimation of the evolution of the installed capacities induced by the autonomous trend

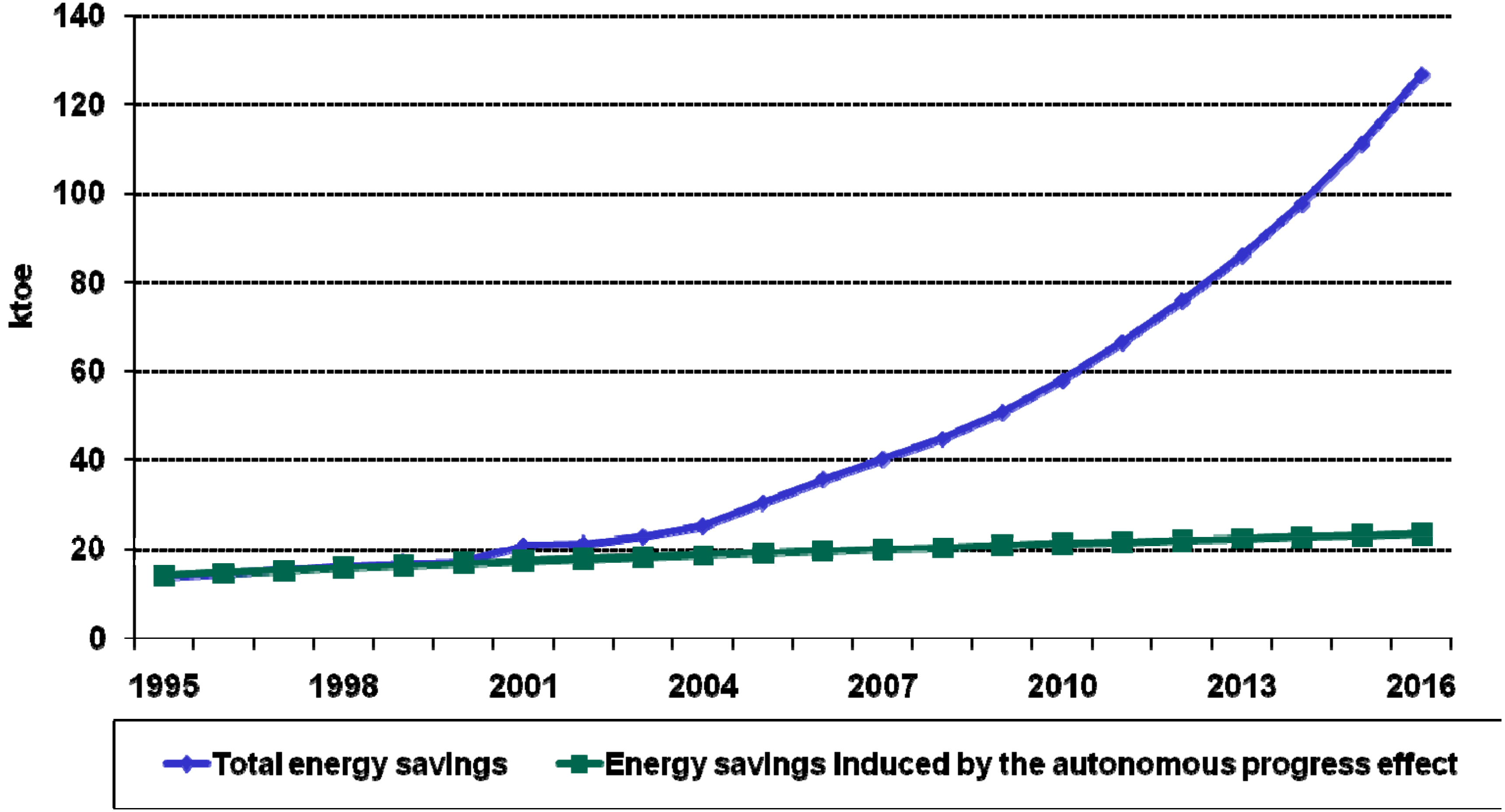


"Real" installed capacities are obtained by assuming a diffusion of solar water heaters at the same rhythm as over 2001-2006

Calculation of ESD savings (example) 3/4

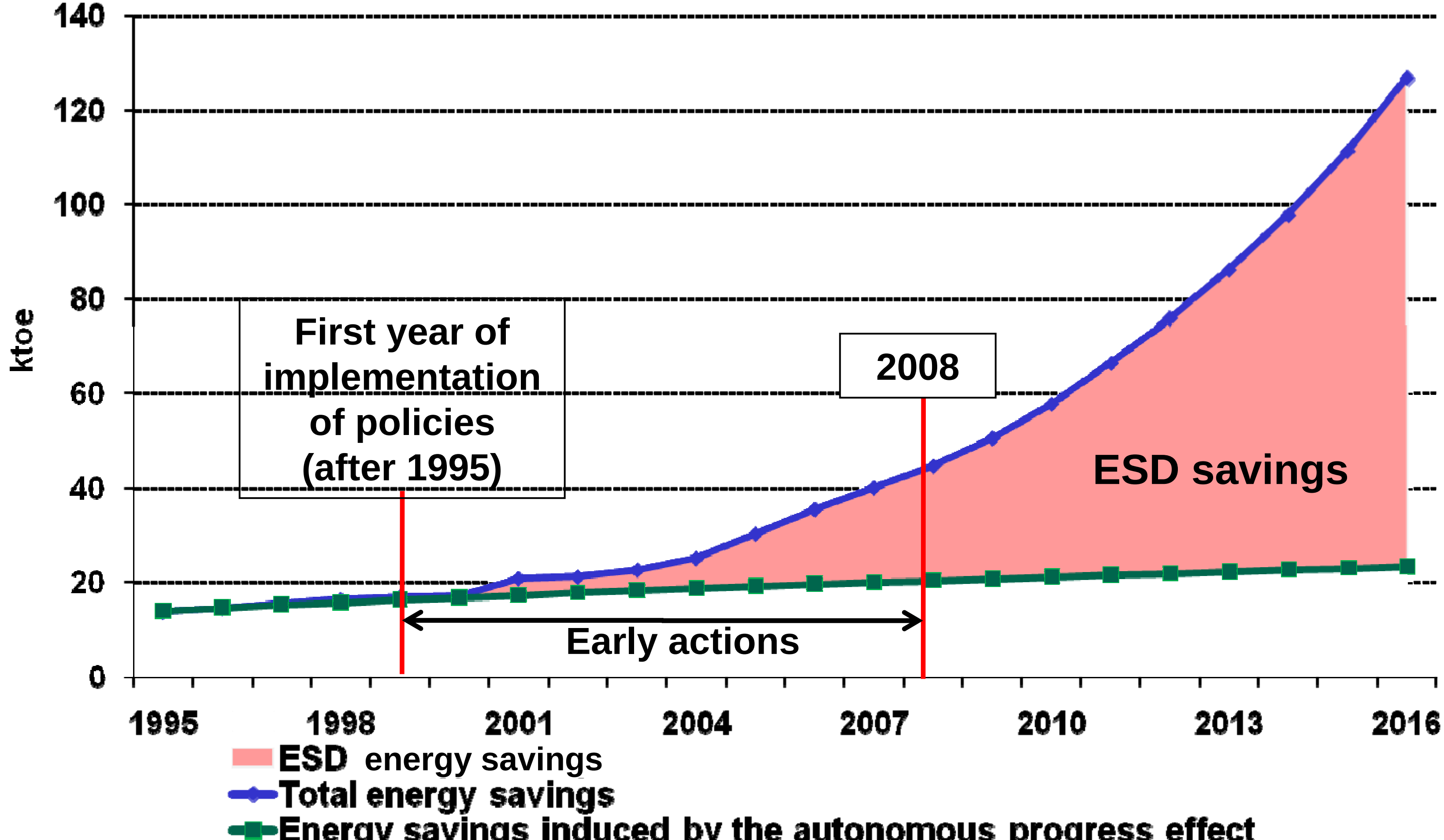
Total energy savings related to the diffusion of solar water heaters

- **Stage 2 :** Annual energy savings calculated from installed area of solar collectors and a coefficient in toe/m^2 (useful energy provided by the solar energy)



Calculation of ESD savings (example) 4/4
Solar water heaters

➢ **Stage 3**: ESD energy savings calculated by the gap between total energy savings and energy savings induces by the autonomous progress effect



Conclusion and issues for replication
Solar water heaters

- Definition of trends or baseline:
  - easy for countries with rapid take off following measures implementation
  - difficult for countries with mature markets
- Role of energy price from econometric analysis not significant econometrically or economically:
  - quality of the estimate of price elasticity questionable as short period and price not changing so much over the period of regression;
  - price effect to be neglected
- Need of country specific coefficient of energy saving to account for difference in solar flows (koe/m^2 or kWh/m^2 of solar panel)
- No need to account for the lifetime of energy savings: removal/ replacement of solar heaters at the end of their lifetime implicitly taken into account in the measurement of the installed solar area

Modal shift for transport of goods

market diffusion indicator

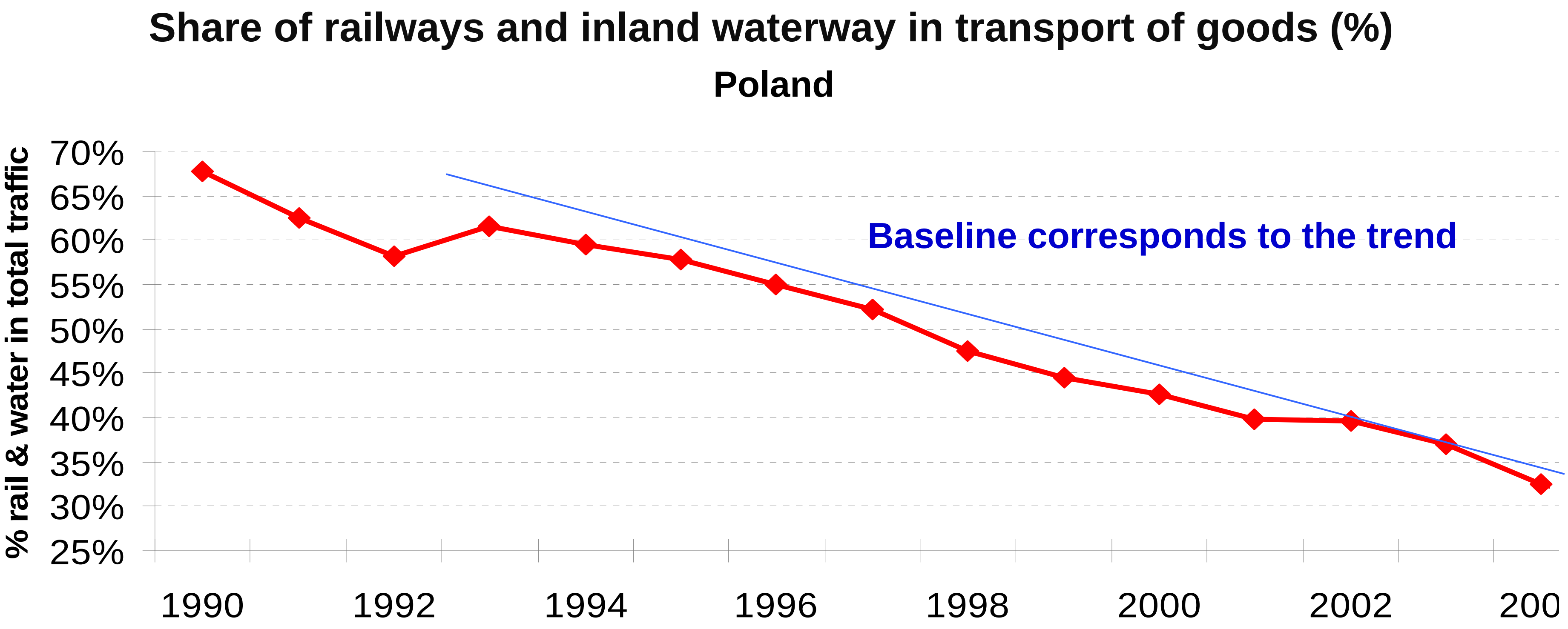
Top-down estimation of energy savings for modal shift

- Indicator used to measure energy savings: share of rail and water (non road transport).
- Change in modal shift can be generally explained by the following variables:
  - Autonomous trend
  - Cost difference by mode
  - Facilitating measures to promote modal shift (After / before 1995)
  - Other transport measures (relative investment in road/rail/water infrastructure)

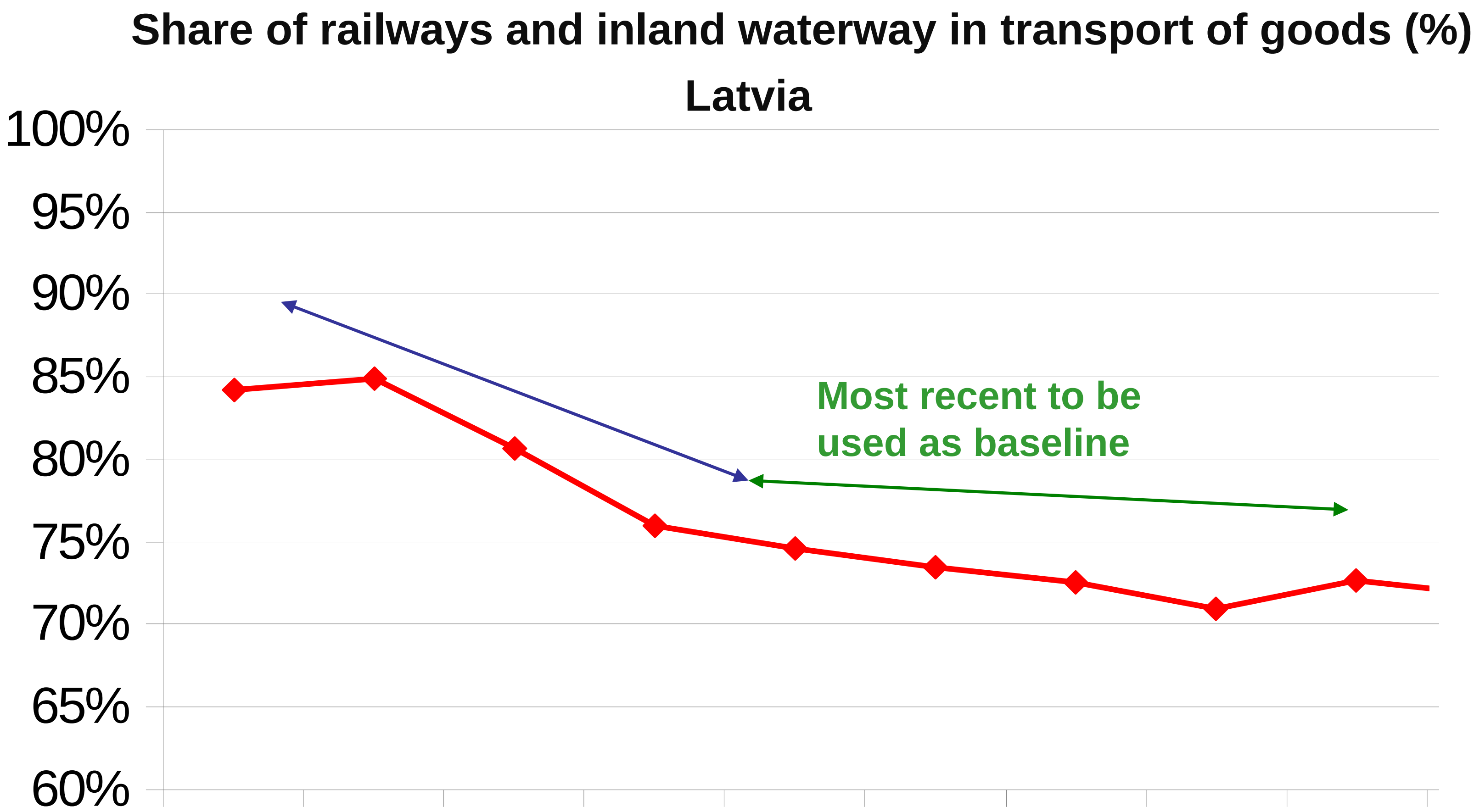
  } **Defines the baseline** (Autonomous trend; Cost difference by mode)

- In practice, taking into account the data usually available, modal shift in the absence of policy measures (baseline) can be modelled with two main variables :
  - Time to capture the autonomous trend
  - Average diesel price, as a proxy to measure change in relative costs
- Different situations among EU countries as to the trend in the share of rail and water transport for goods (see following typical cases)

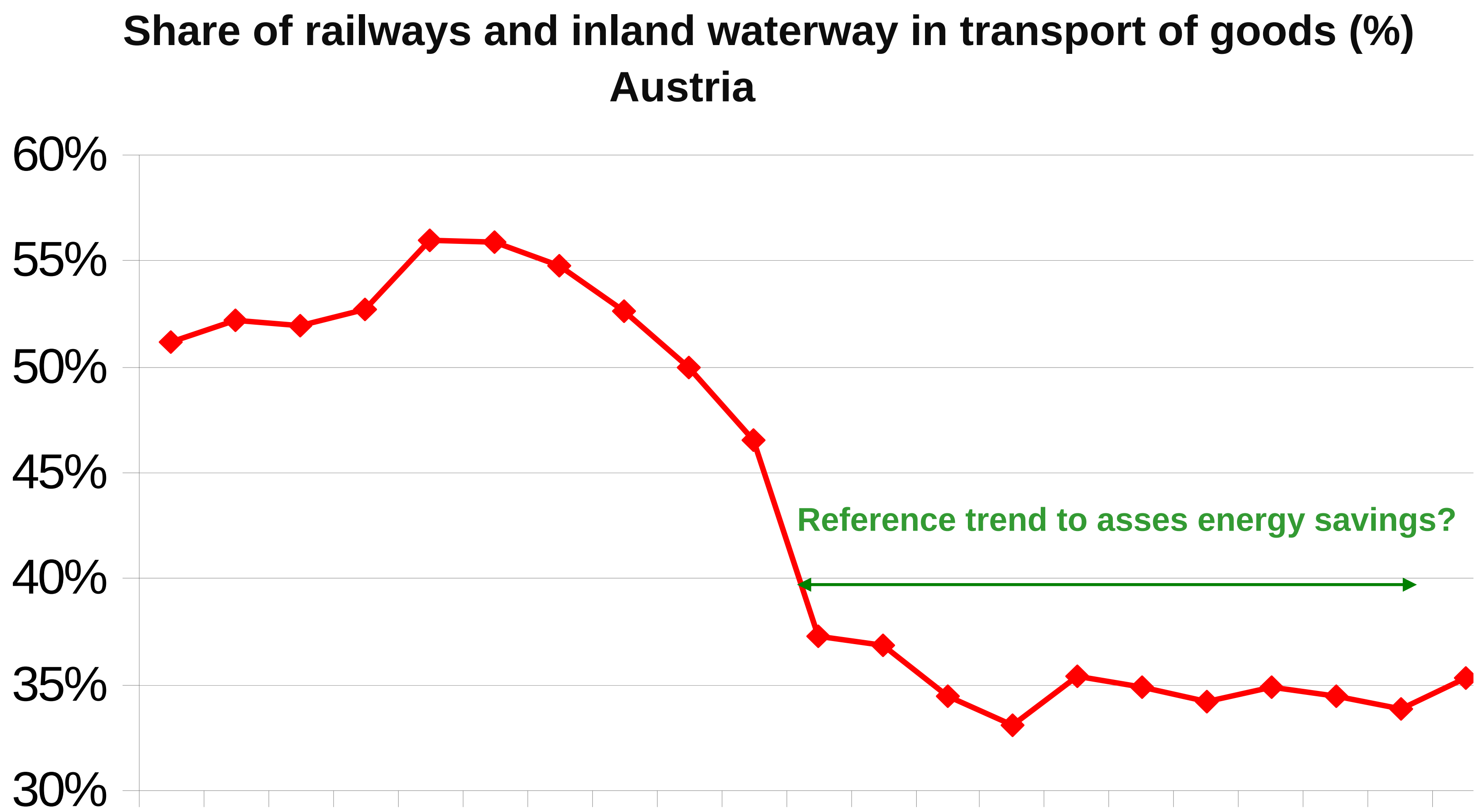
Case of a regular market share reduction for rail and water transport



Case of a slow down of the market share of rail and water transport

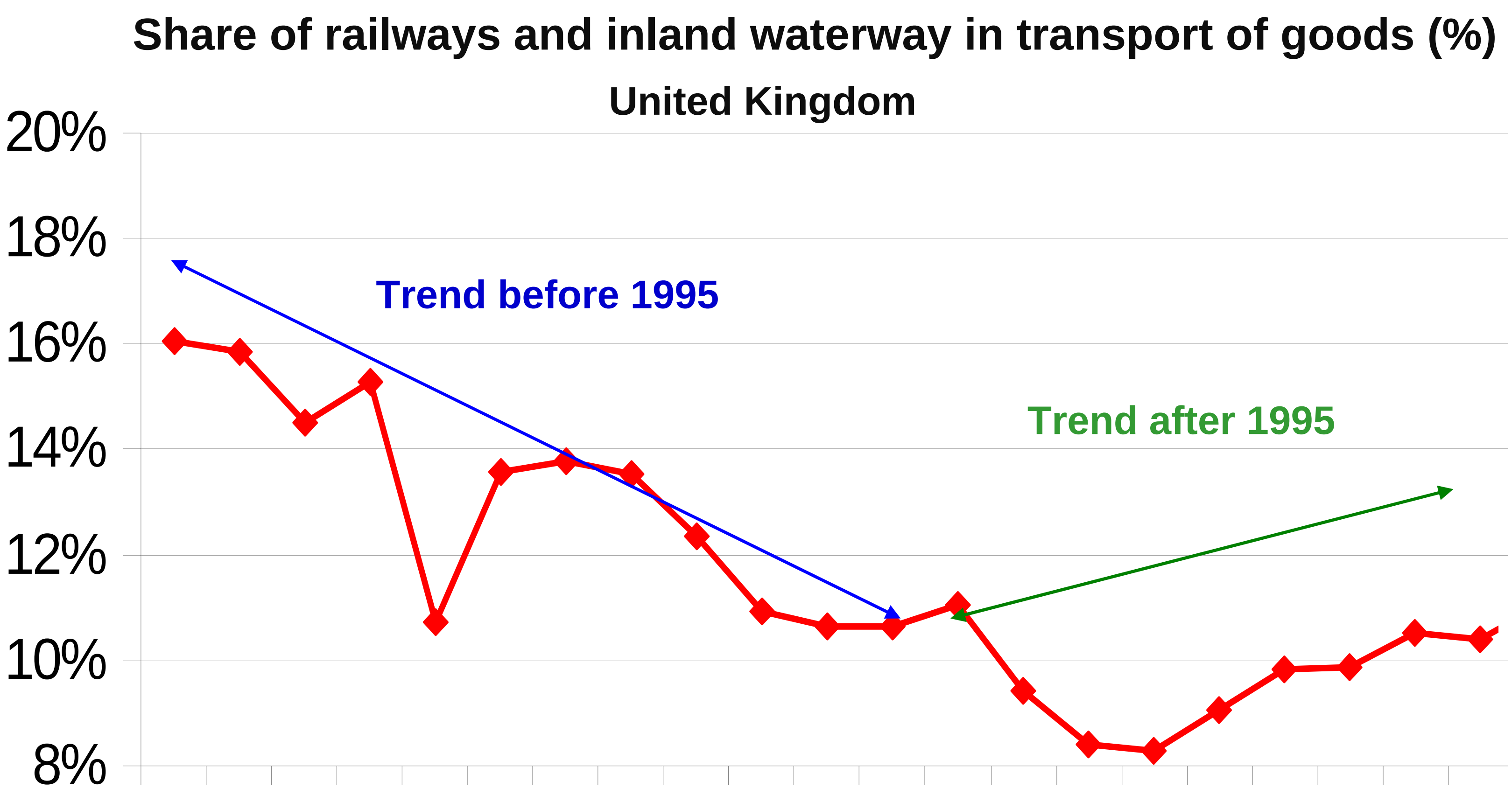


Case of a stabilisation of the market share of rail and water transport



Case of an increase of the market share of rail and water transport

- Why this trend inflexion? No link to price as same price increase in the other countries. No specific measure. What trend to take to assess savings?



Modelling of the baseline modal shift for transport of goods

- Modelling of the share of non road traffic through regression analysis with two variables:
  - Time to capture an autonomous trend
  - Average diesel price used to capture price differential

$$Ln (WRS) = T \times t + A \times \ln (P) + K$$

- ✓ T: trend
- ✓ A: price elasticity (>0)
- ✓ P: diesel price

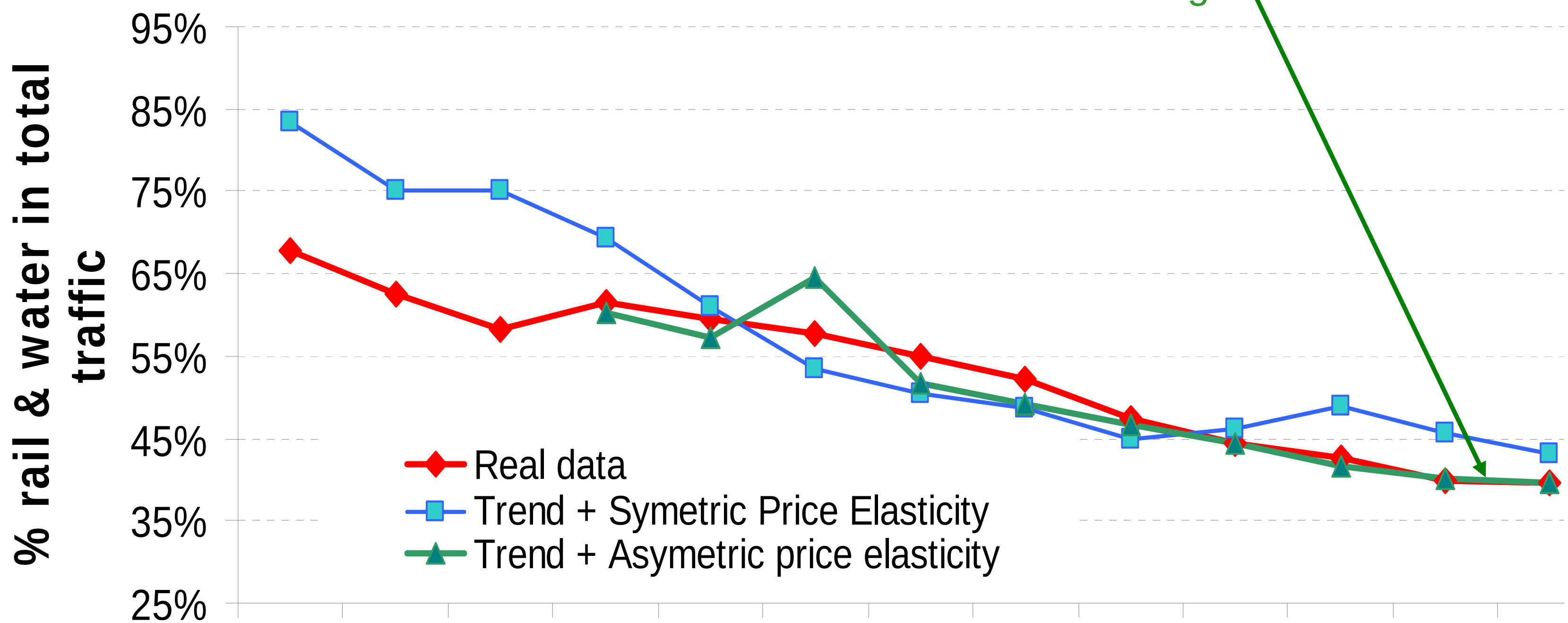
- Price elasticity calculated from regression not significant for most countries (e.g. <0 despite an important increase of diesel prices)

- It is proposed to use an exogenous and asymmetric price elasticity, with a lag of 3 years to well capture the impact of price :
  - ✓ 0.46 if prices increase (EU average between 2001 and 2005)
  - ✓ and 0 if prices decrease

Modelling of baseline modal share Poland

➢ **Asymmetric final regression :**
ln (WRS) = -0.05 X t + 0.46 x ln (P_{-3}) + 0.3 if prices increase
ln (WRS) = -0.05 X t - 0.3 if prices decrease

No energy saving in the past ➔ adjustment of a trend and price effect to get a reference from which to assess future saving



Calculation of energy savings 1/4
Modal shift for transport of goods

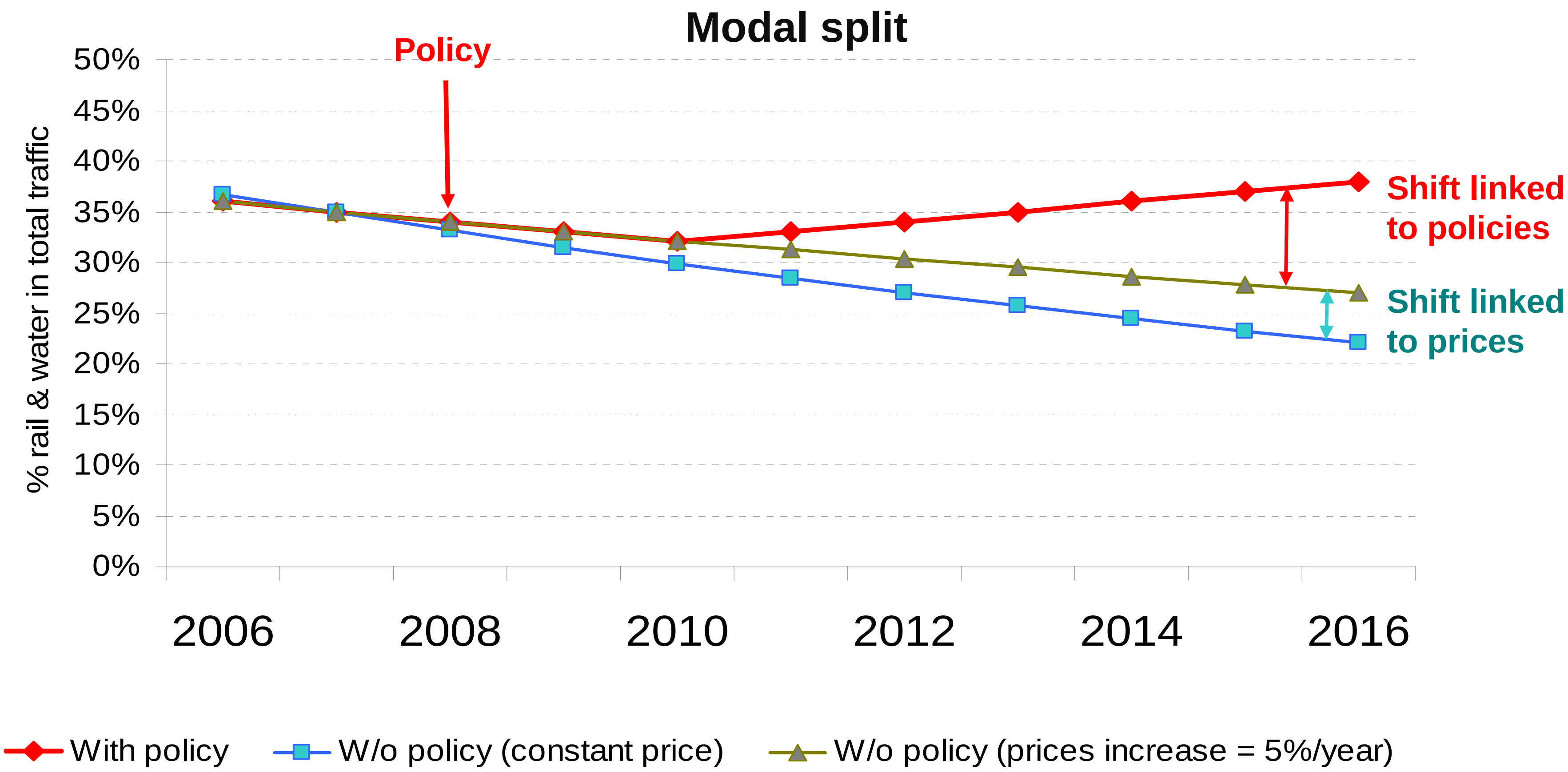
- Total energy savings at year t calculated from the variation in the share of rail and water between year t and reference year(t-1) multiplied by the total traffic of good transport at t (in tkm) and the difference in unit energy consumption between road and rail/water at t (toe/tkm)

- Calculation of ESD energy savings in 3 steps:
  1) Modelling of baseline modal split;
  2) Modelling of baseline energy consumption
  3) Modelling of baseline energy savings (can be negative!) and calculation of ESD savings as difference between total energy savings and baseline savings

Calculation of baseline modal split (example) 2/4

Modal shift for transport of goods

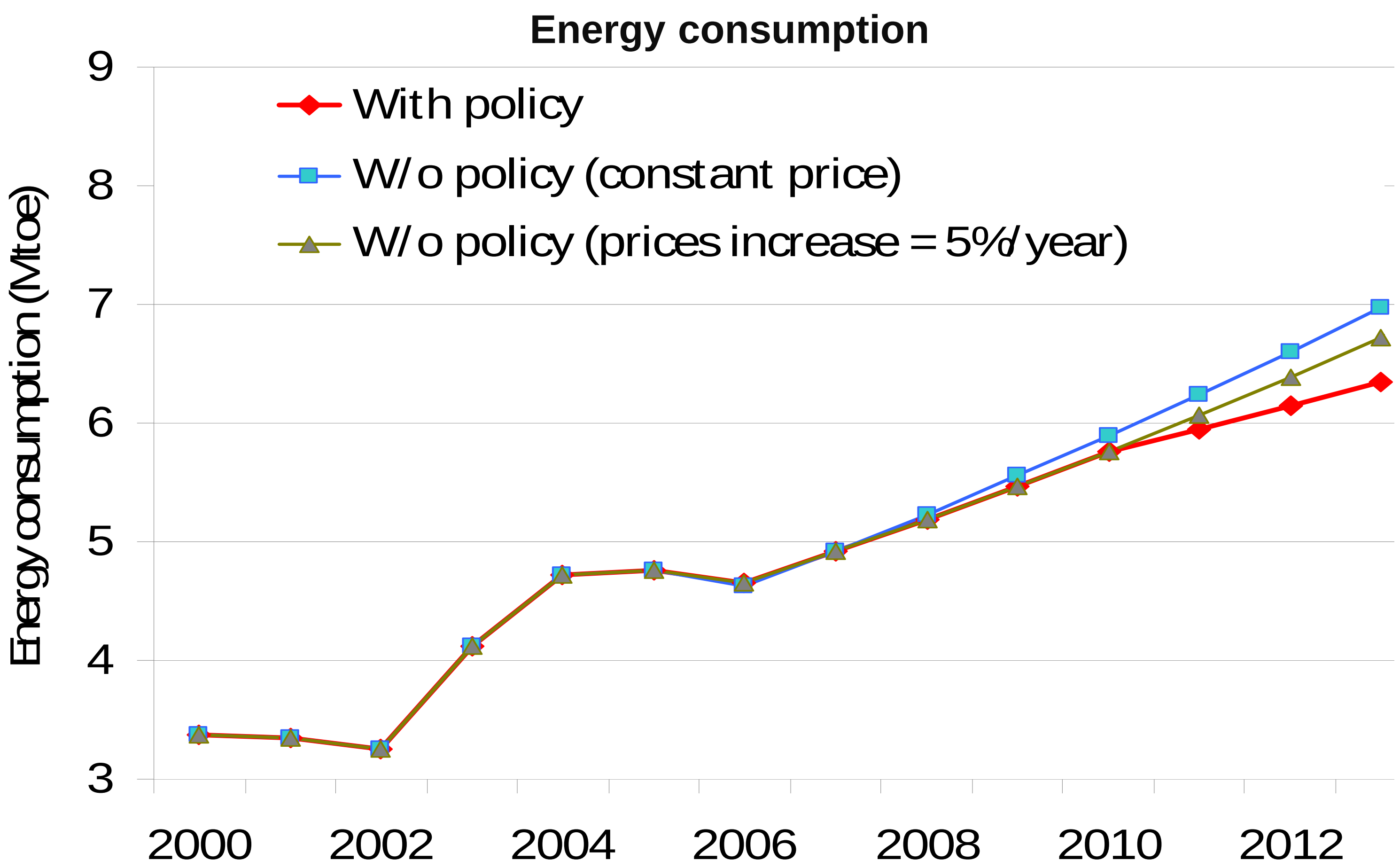
- Assumption of the implementation of a policy in 2008 with first impact in 2010 (rail and water traffic market share assumes to increase by 1% of each year)



Calculation of baseline energy consumption 3/4

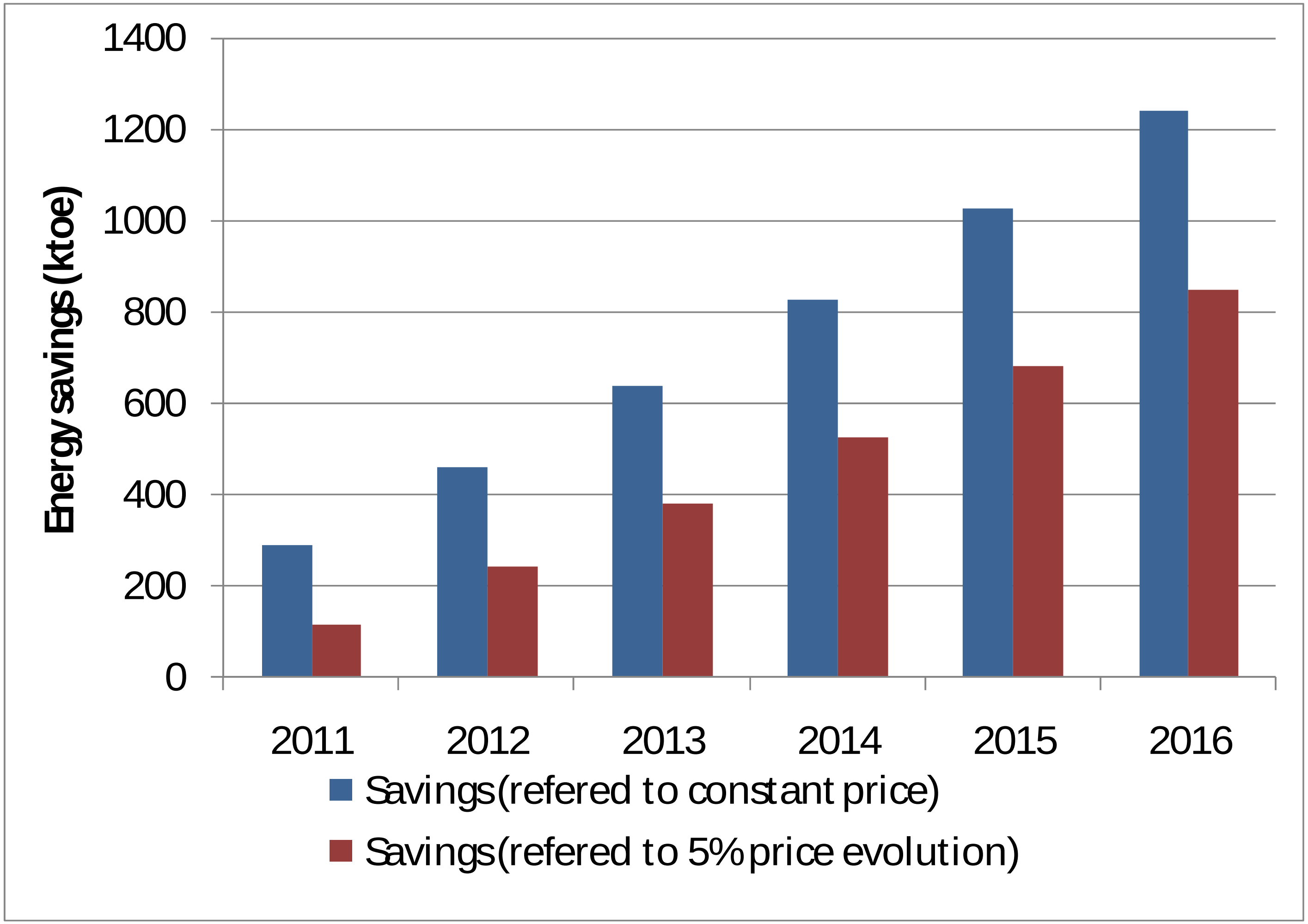
Modal shift for transport of goods

- Assumption implementation of a policy in 2008 and first impact of the policy in 2011



Calculation of energy savings 4/4

Modal shift for transport of goods



Conclusions and issues for replication on modal shift for transport of goods

- Validation of the methodology for price effect:
  - ✓ Same price elasticity
  - ✓ Asymmetric with lag (3 years, as a first estimate)

- Effect of policies negligible so far

- Selection of baseline trend to assess energy savings: most recent trend?

New cars

specific energy consumption indicator

Top-down estimation of energy savings for new cars

- Indicator used to measure energy savings: specific consumption of new cars sold every year in litres/100km (test values) (or litres/100km/kW if data on car horsepower are available)

- Change in specific consumption can be explained by the following variables:
  - Change in the average size of vehicles (in terms of weight, or horse power or engine size in cm^3) ("hidden structure effect") (towards larger or more powerful cars → energy savings are underestimated)
  - Autonomous trend (in technical efficiency)
  - Motor fuel price
  - EU policy (ACEA/JAMA/KAMA agreement) and national energy policies (tax on motor fuels, subsidies/ tax on vehicles): after 1995/ before 1995

  → Effect of change in the size of vehicles interesting to consider but limited in practice due to data availability; only tested for one or two countries

  → Direct rebound effect not taken into account at this stage

Modelling of the baseline specific energy consumption of new cars 1/2

- Modelling of the trend in the specific consumption of cars (SC) (by country) (in litre/100km/cm^3* or litre/100km) :
  - Time to capture an autonomous trend
  - Average price of gasoline and diesel

- To clean the impact of fuels substitution between gasoline and diesel, total energy savings will be calculated separately for gasoline and diesel vehicles as well for alternative fuels vehicles and then added together.

$$\text{Ln (SC)} = T \times \ln(t) + A \times \ln(P) + K$$

- ✓ T: trend
- ✓ A: price elasticity (<0)
- ✓ P: motor fuel price

- The energy savings associated to price changes will then be split into two components: energy savings linked to tax increase (policy related) and savings (>0 or <0 savings depending on the variation) linked to change in crude oil price (market related)

* or litre/100km/kW

Modelling of the baseline specific energy consumption of new cars 2/2

- Two approaches depending on the availability of the car size data
  - Countries without data on engine size:

    Ln (SC) = T X ln (t) + A X ln (P) + K
    - ✓ SC : Specific consumption of cars in litre/100km
    - ✓ T: trend
    - ✓ A: price elasticity (<0)
    - ✓ P: motor fuel price

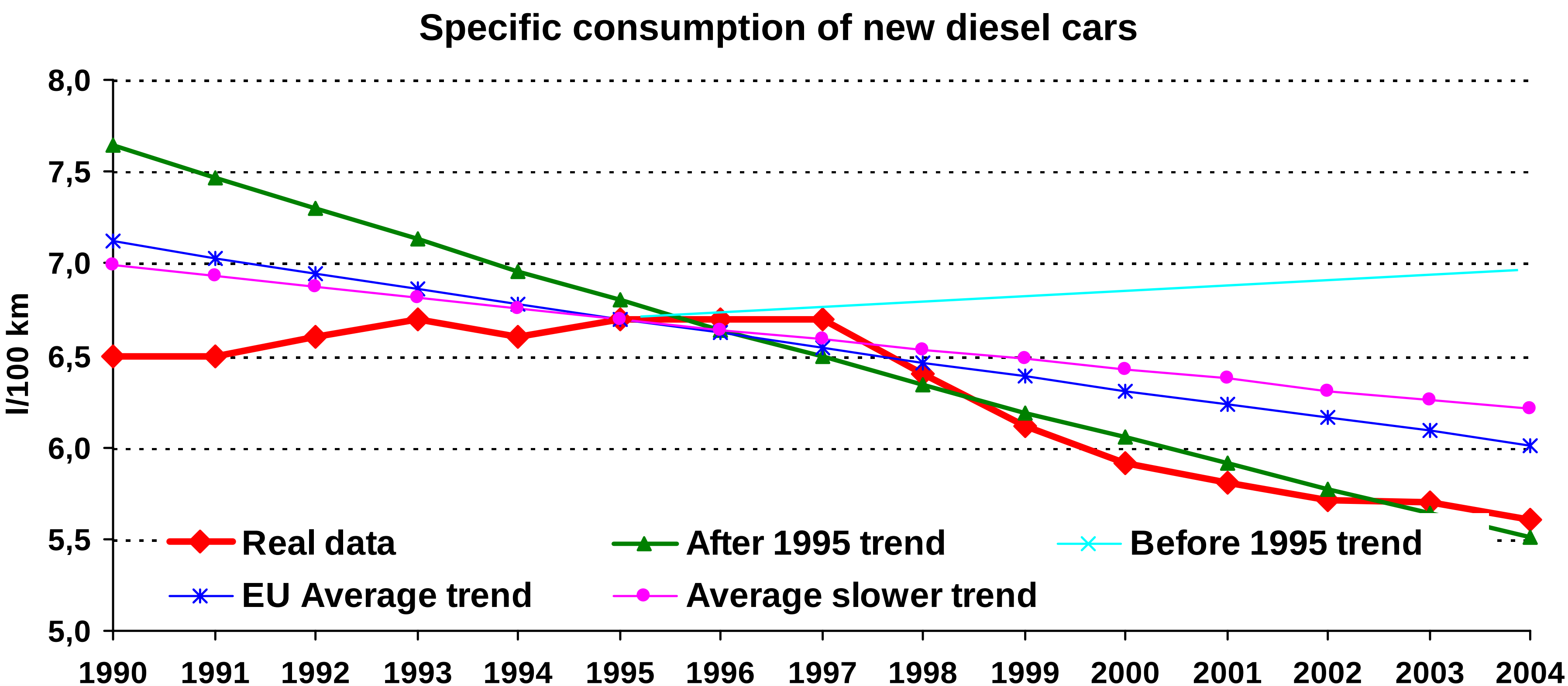
  - Countries with data on engine size:

    Ln (SC) = T X ln (t) + A X ln (P) + K
    - ✓ SC : Specific consumption of cars in litre/100km/cm^3 or in litre/100km/kW
    - ✓ T: trend
    - ✓ A: price elasticity (<0)
    - ✓ P: motor fuel price

- Whatever the approach two key questions
  - What autonomous trend to be considered?
  - Are motor fuel prices econometrically significant?

What autonomous trends to be considered?
case of France / diesel cars

- Trend before 1995 (i.e. before the ACEA/JAMA/KAMA agreement) ("before 1995 trend")
- Trend since 1995 ("after 1995 trend") ➔ reference used in the following case studies
- EU average trend = > -1.1%/year for diesel
- Trend of the average of the 3 countries with the lowest autonomous trend ("average slower trend")



Econometric analysis 1/3

Are motor fuel prices econometrically significant?

Case of Germany: gasoline cars (country without data on engine size)

- Motor fuel prices are generally not validated by statistics test (case of Germany, France, Belgium, Finland, Austria, etc).
- Example of econometric analysis for Germany for specific consumption of new gasoline cars
  - Regression with autonomous trend and motor fuel price between 1995 and 2003

    Ln (**SC**) = -0.008 X **t** – 0.02 X ln (**P**) + 2.13

    t-sta (3.1) (0.3)

    R^2 = 0.9 => Good correlation (R^2 near 1)

    F-stat = 26.8 => regression is globally significant (F-statistic is > 4.7)

    T-stat > 1.9 for time but <1.9 for prices => price effect not significant
  - Regression with autonomous trend only between 1995 and 2003

    Ln(SC) = -0.008 X **t** + 2.13

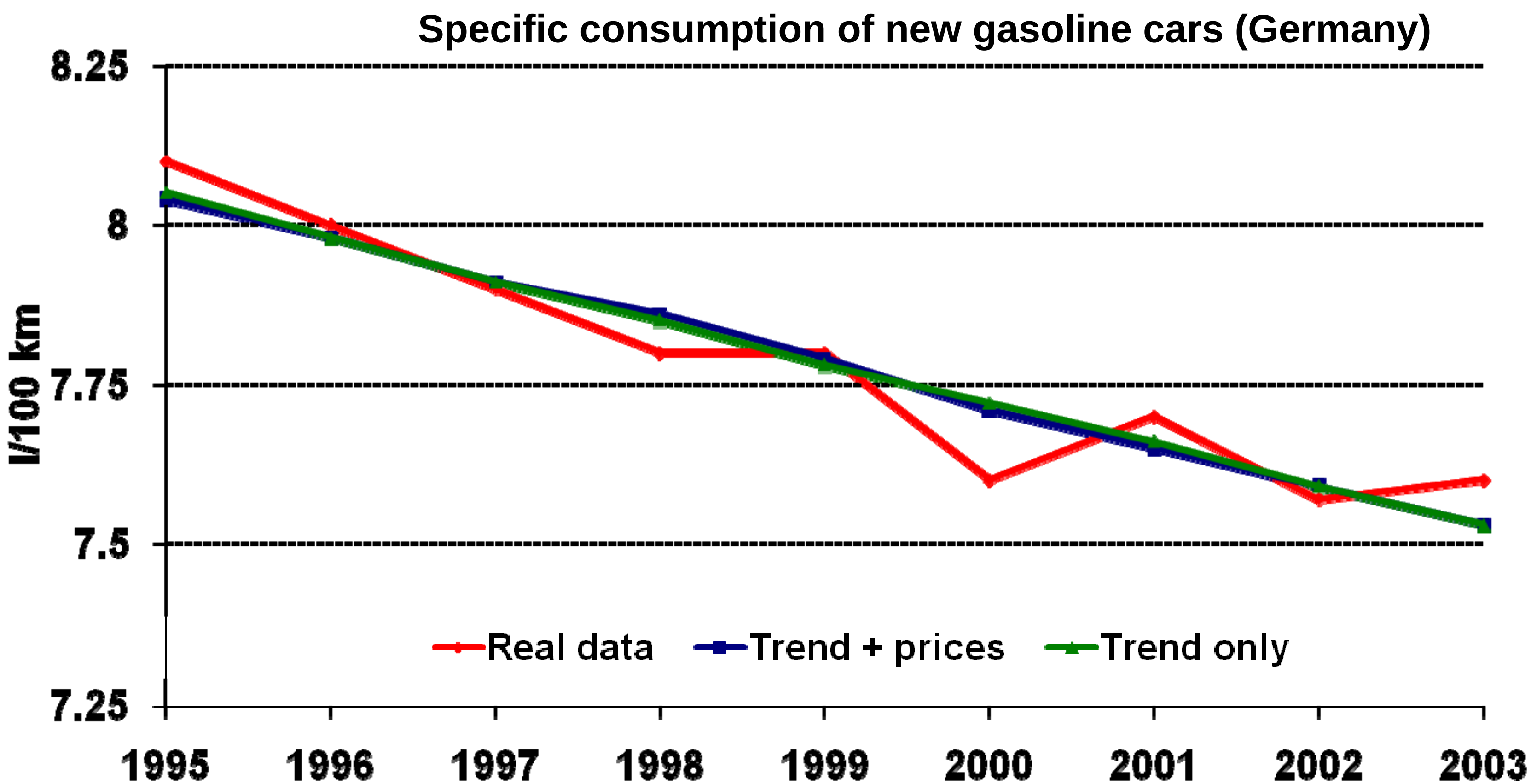
    t-stat = 7.9 , R^2 = 0.9, F-stat = 61.8

    Good correlation, regression globally significant

Econometric analysis 2/3

Are motor fuel prices econometrically significant?

Motor fuel prices are generally not validated by statistics test (case of Germany, France, Belgium, Finland, Austria, etc).



Econometric analysis 3/3

Accounting for the impact of motor fuel prices

- Although price elasticities are not econometrically significant, prices have certainly an effect and should be introduced

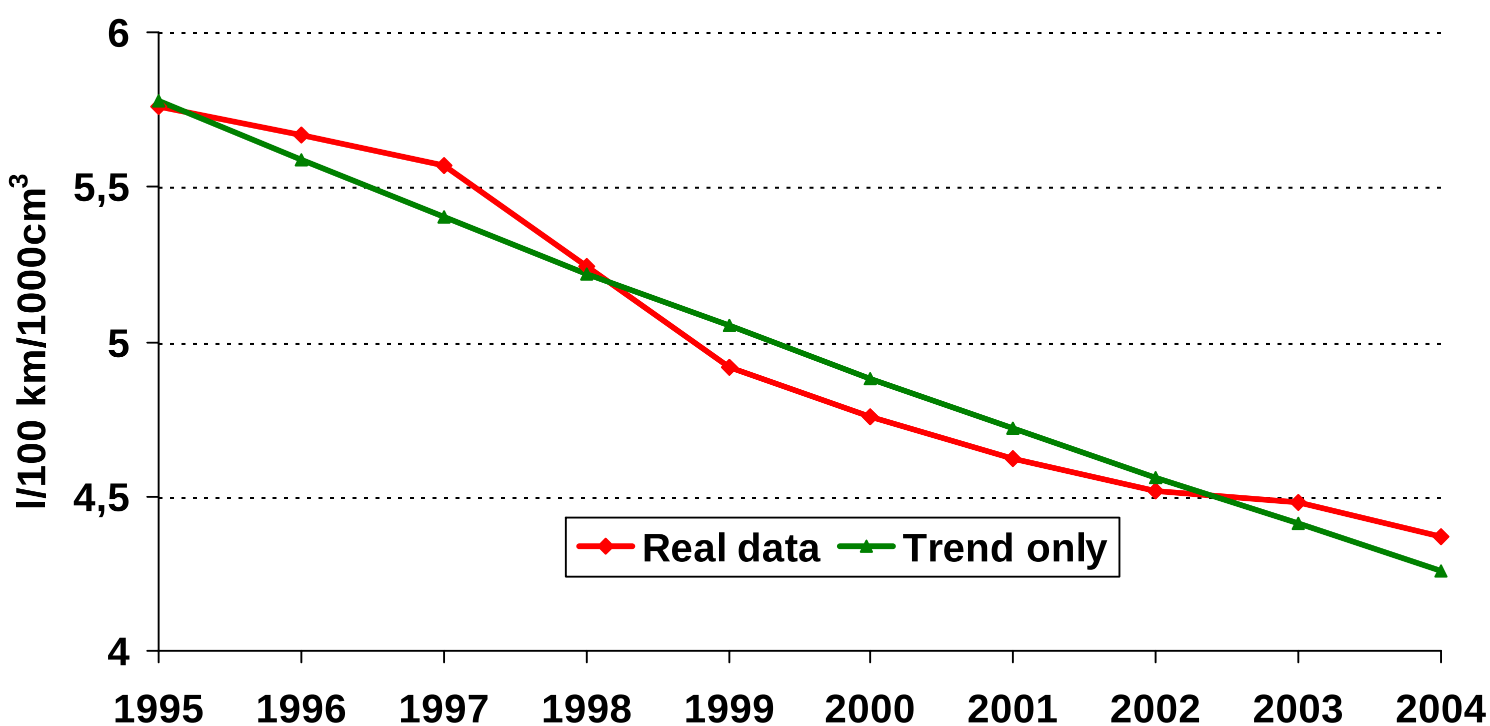
- Possibility to take into a price effect by considering a ‘default value” price-elasticity calculated with a pooling methodology or by taking an average value of EU countries with relevant data (“EU average”). In this case study the pooling methodology is not validated by econometrical tests. An EU average elasticity was used :
    - -0.35 for specific consumption of new diesel cars
    - -0.25 for specific consumption of new gasoline cars

Modelling of the baseline specific consumption of new cars

Case of countries with data on engine size

- The impact of change in average car size can be done if data are available ➔ engine size in cm³ seems to be the most relevant indicator
  - Trend of –3,4% (close to technical trend) instead of –2.3% (technical and non technical trend)
  - Better estimate of energy savings (underestimated if no correction of size)
  - Engine size data available ONLY for ACEA members

Specific consumption of new diesel cars per cm3 (France)



Calculation of ESD savings, 1/4
Methodology, New cars

- **Stage 1** : Calculation of the total energy savings over the 2008-2016 period for gasoline and diesel new cars separately

- **Stage 2 :** Calculation of the energy savings induced by the technological trend and prices effects for gasoline and diesel new cars separately with the same methodology as the total energy savings, based on the estimation of specific consumption induced by trend and prices

- **Stage 3** : Total energy savings for all cars obtained by summing total energy savings for gasoline car and for diesel cars; Energy savings induced by technological trend and price effect obtained by summing what is calculated for gasoline and diesel cars.

- **Stage 4** : ESD energy savings for all cars calculated by difference for gasoline and diesel new cars separately: total savings minus trend and price-related savings

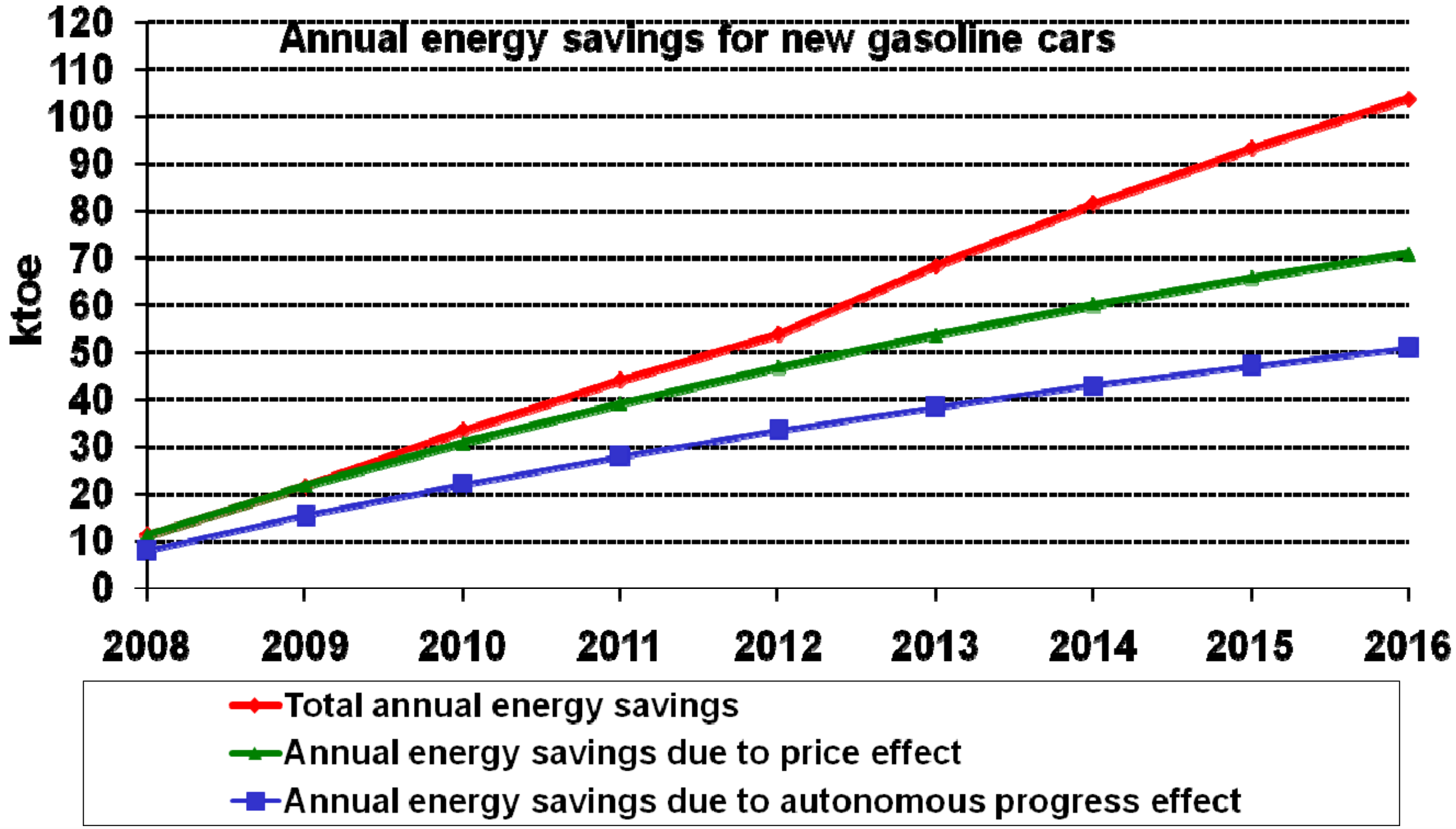
Calculation of ESD savings 2/4

New gasoline cars : stage 1 and 2 (example)

Evolution of total energy savings based on an impact of policies in 2009 and 2012 on the specific consumption of new cars

Evolution of energy savings due to technological progress effect based on a 0.8%/year trend

Evolution of energy savings due to market prices effect based on a -0.25 price elasticity



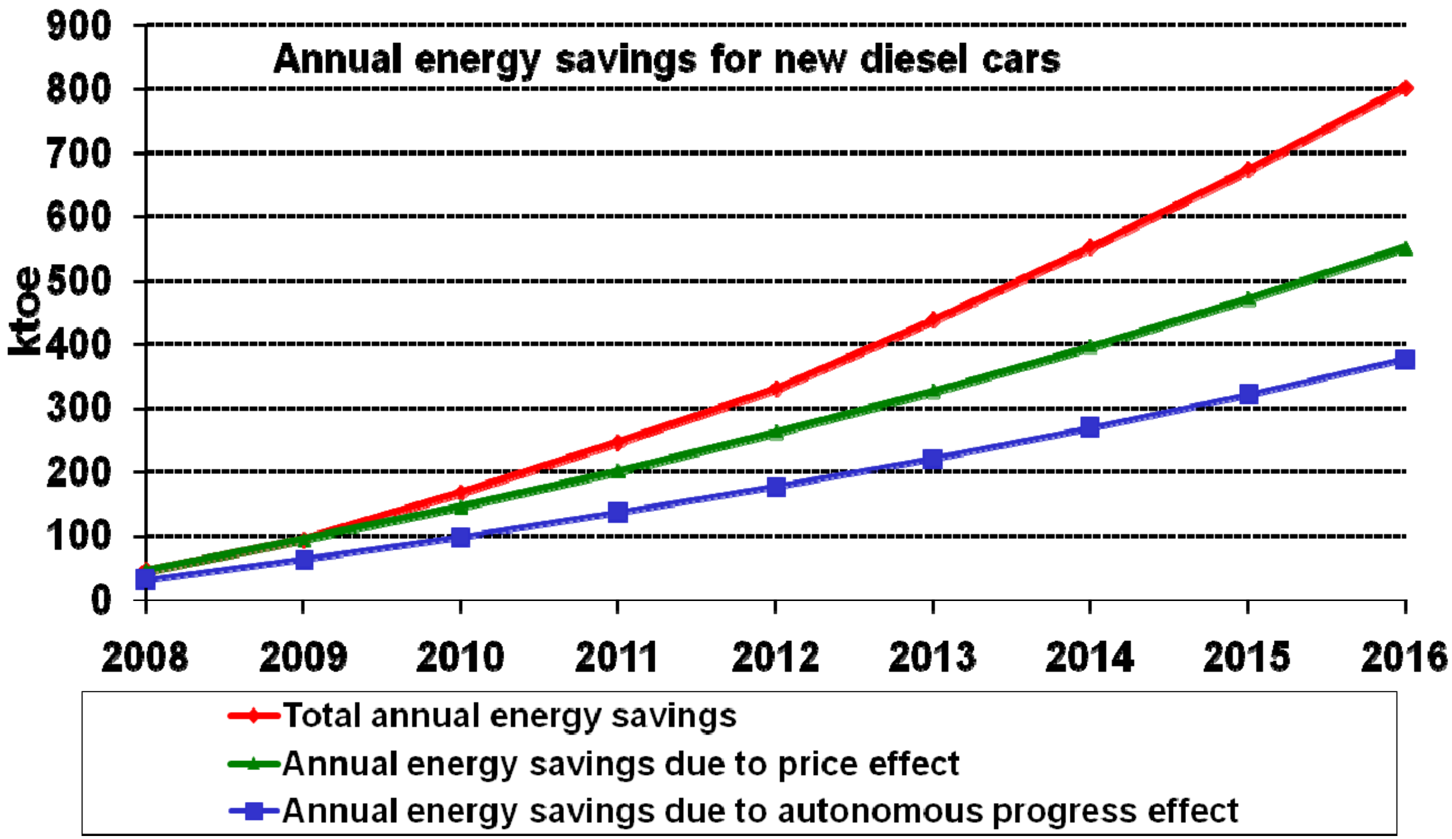
Calculation of ESD savings 3/4

New diesel cars : stage 1 and 2 (example)

Evolution of total energy savings based an impact of policies in 2009 and 2012 on the specific consumption of new cars

Evolution of energy savings due to technological progress effect based on a 1.2%/year trend

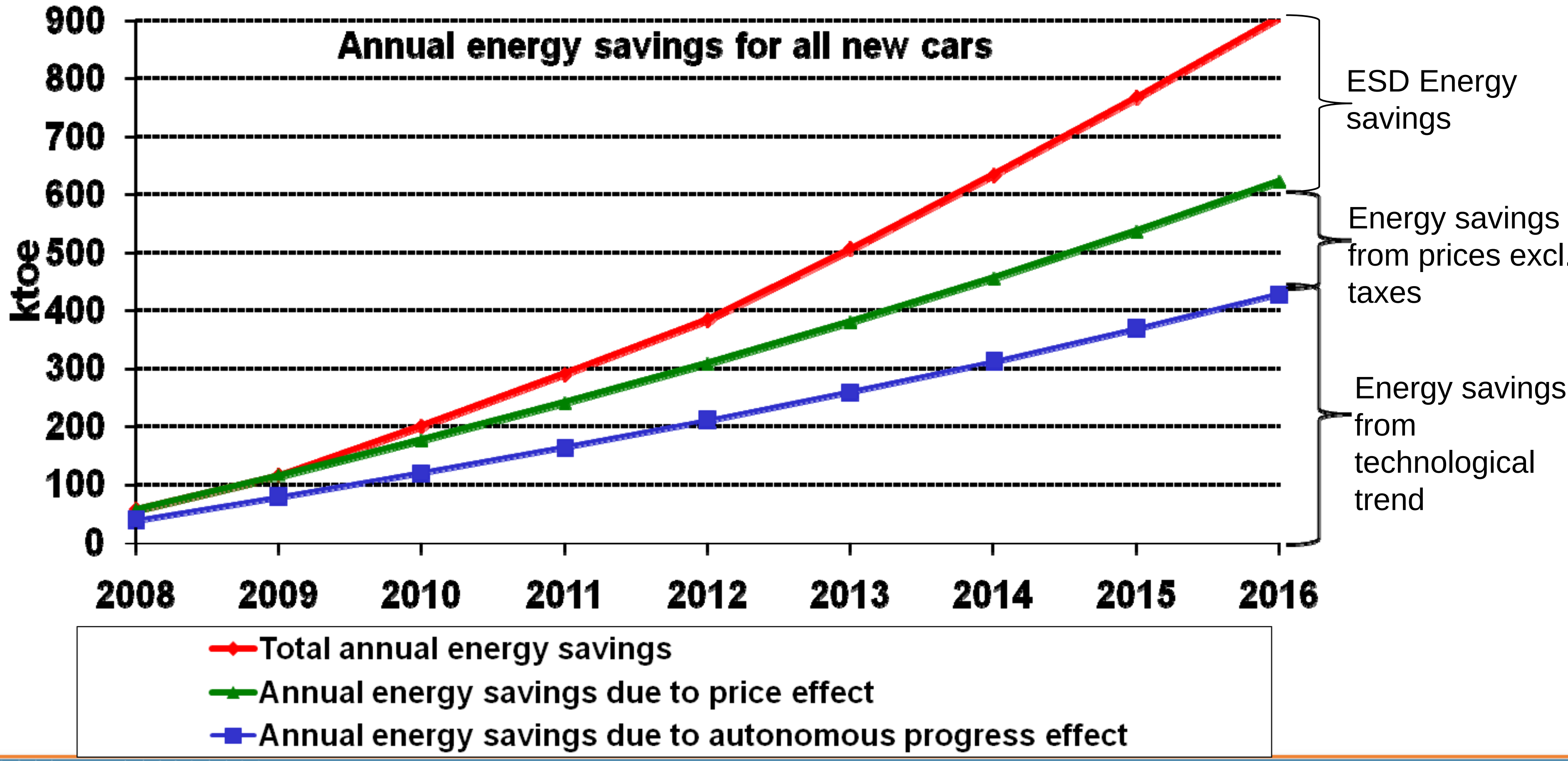
Evolution of energy savings due to market prices effect based on a -0.35 price elasticity



Calculation of ESD savings 4/4

All cars : Stage 3 and 4 (example)

The total energy savings over the 2008-2016 period are about **1000 ktoe/year in this example;** ESD energy savings are about **400 ktoe/year**



Conclusions and issues for replication on new cars

- Data limitations: no data for most EU New Member Countries (data not covered yet by the EU monitoring)
- Definition of trends or baseline to be decided :
  - A) Trend before 1995 (ie before the ACEA/JAMA/KAMA agreement) ("before 1995 trend") ***OR***
  - Trend since 1995 ("after 1995 trend")➔ reference used in the case studies
  - B) EU average trend ***OR***
  - Trend of the average of the 3 countries with the lowest autonomous trend ("average slower trend")
- Role of energy price negligible so far
- Need to define coefficient to account for difference between test values and actual values
- Similar approach seems applicable for other case studies with energy consumption indicators, although this case study may be simpler than other end-uses

Electricity end uses in services

unit energy consumption indicator of a sub-sector

Top-down estimation of energy savings for electricity end uses in services

- Indicators to measure savings : unit electricity consumption per employee (excluding electricity for thermal uses when data available) measured :
  - from the sum of unit electricity consumption by activity subsector (detailed approach) to clean the changes in the structure of service sector activities ("hidden structure effect") ➔ the best approach but data available only for few countries
  - from the total unit electricity consumption for service sector (aggregative approach) if data by subsector are unavailable.
- Use of unit electricity consumption per employee because
  - Physical indicators used and not economical indicators: energy needs related more to work conditions than to production
  - Employment data more robust than building surface data
- Change in unit electricity consumption can generally be explained by the following variables:
  - Autonomous trend
  - Electricity price

  } **Defines the baseline**
  - Energy efficiency facilitating measures (subsidies, fiscal incentives, VA, taxes) (after / before 1995)

Modelling of the baseline unit electricity consumption of services

- Identification by country of a period over which policy measures either are negligible or have a limited impact → over that period changes in unit electricity consumption mainly linked to autonomous trend, electricity prices

- Modelling over that period of the indicator through regression analysis with two variables:
  - Time to capture an autonomous trend
  - Electricity price

$$\ln(UC) = T \times t + A \times \ln(P) + K$$

- ✓ T: trend
- ✓ A: price elasticity (<0)
- ✓ P: electricity price

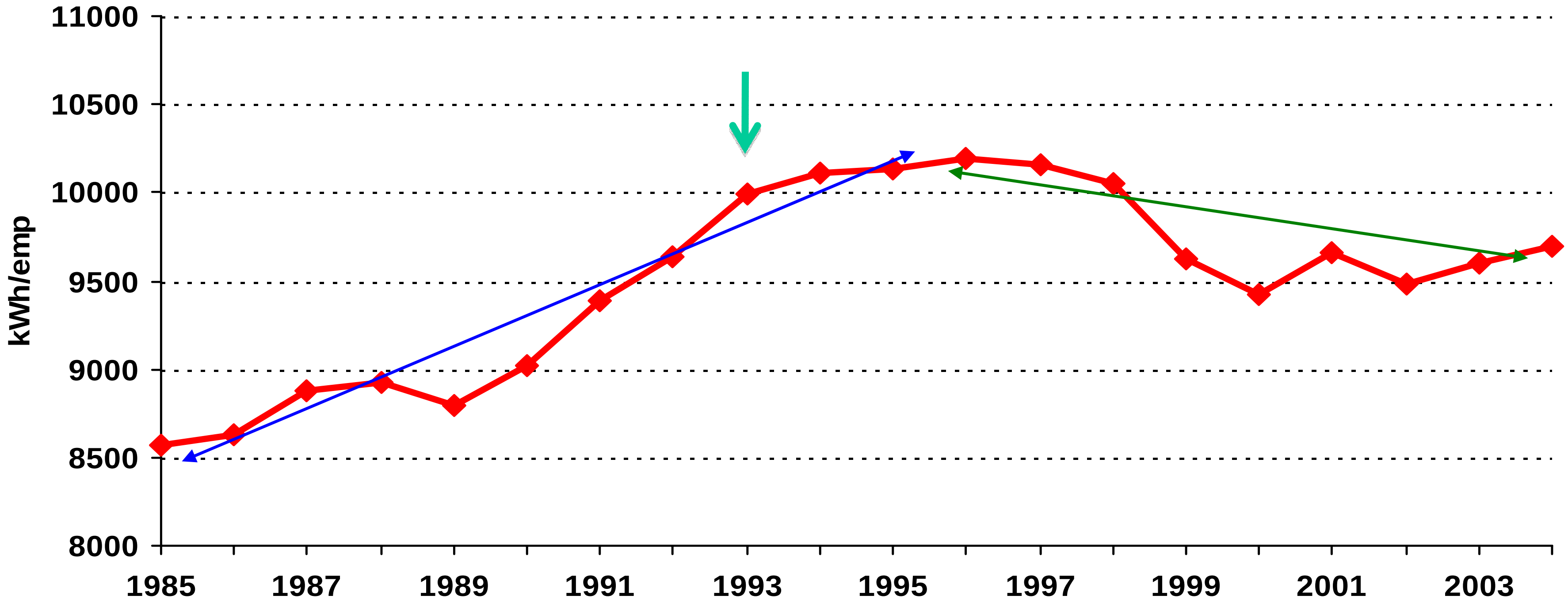
- The price effect was generally not validated by statistics test as electricity prices did not change enough in the past

Unit electricity consumption of services 1/4

Countries with national measures and slower increase, stabilisation or decrease of the unit consumption after measures implementation

Case of Sweden

- Implementation of voluntary agreements in 1993. Which trend to take? Before 1993? Or after 1993? Or somewhere in between (saturation of autonomous change?)?

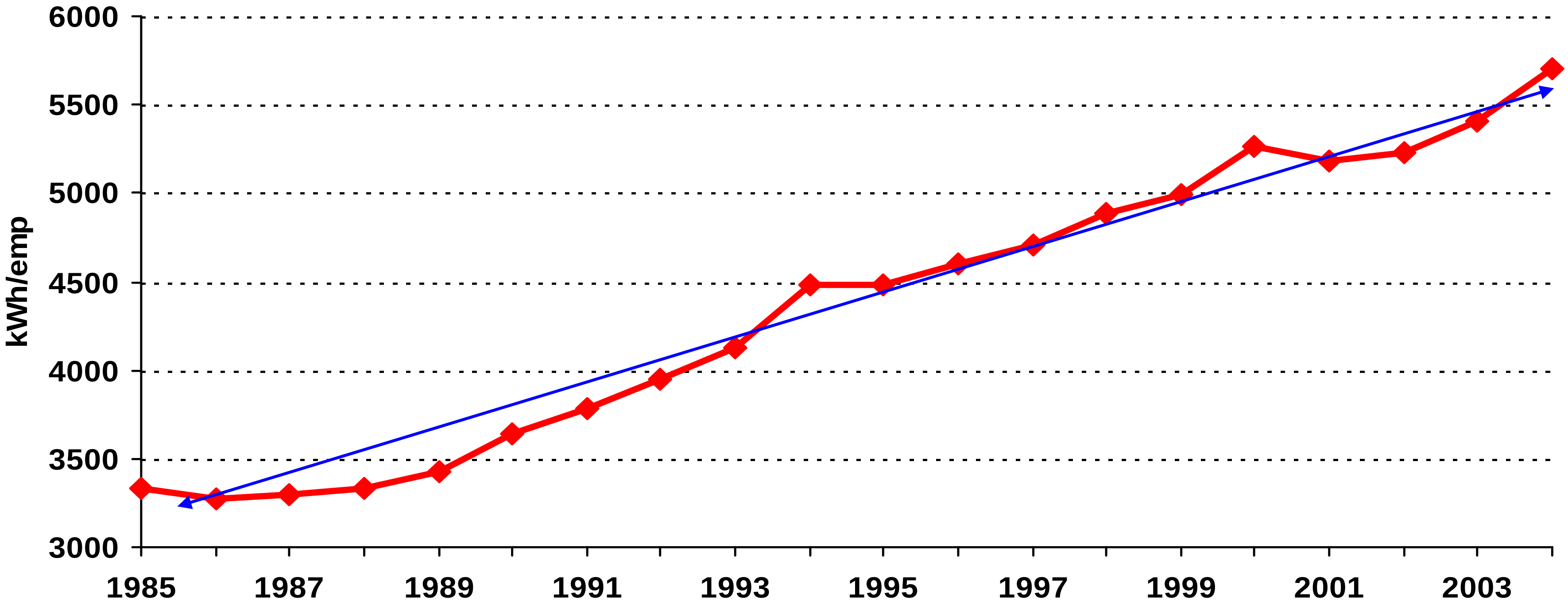


Unit electricity consumption of services 2/4

Countries with national measures and steady increase of the unit consumption despite measures implementation

Case of Spain

- Trend easy to measure. Impact of measures not visible, probably measures with low impact ➔ any deviation in the future compared to the trend can be linked to measure

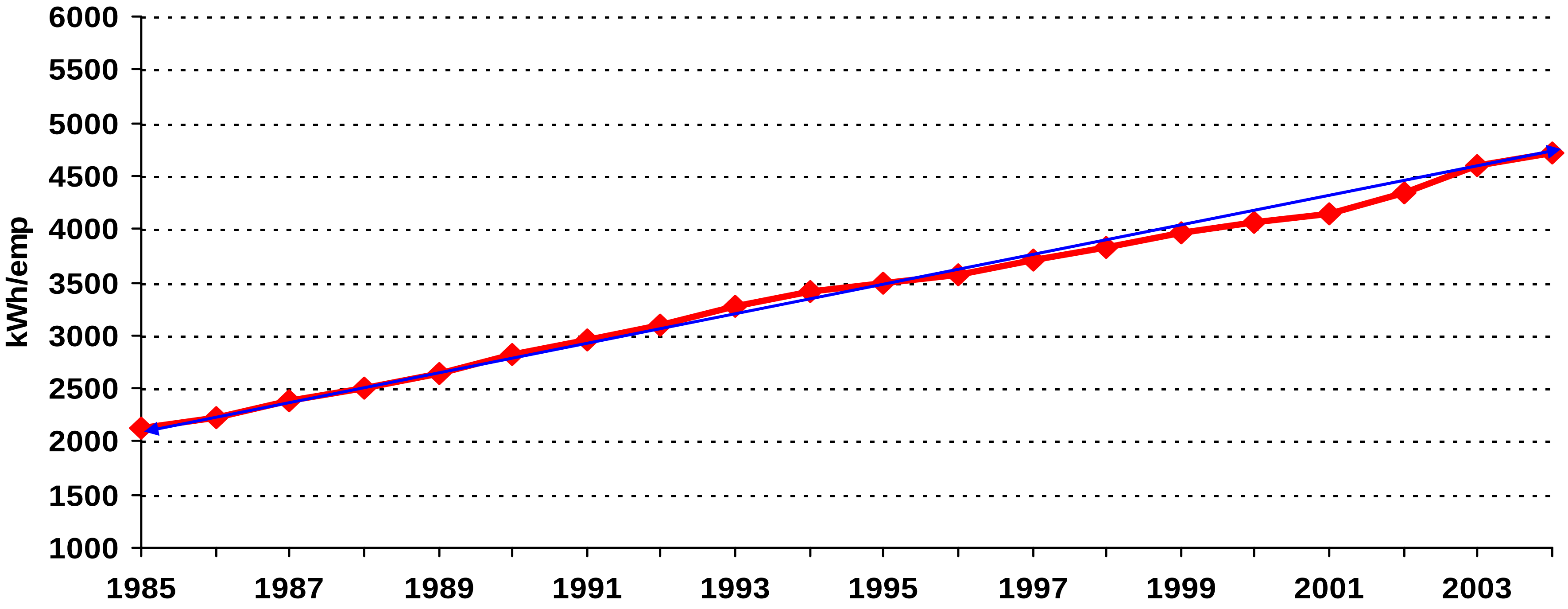


Unit electricity consumption of services 3/4

Countries without national measures and steady increase of the unit consumption

Case of Italy

- ➢Trend easy to measure ➔ any deviation compared to the trend in the future can be linked to measure



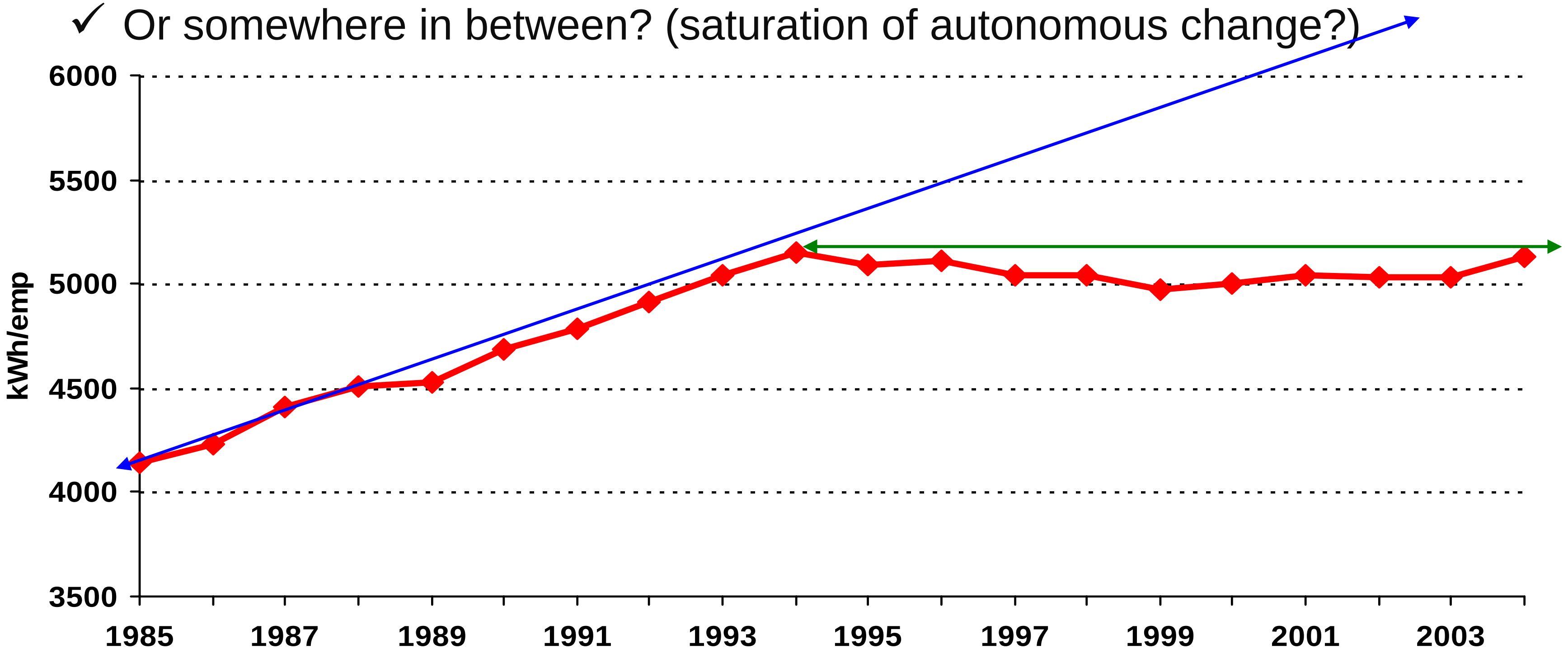
Unit electricity consumption of services 4/4

Countries with national measures and rupture in the trend of the unit consumption

Case of Denmark: (DSM since 1995 and Elec. Saving Trust since 1996)

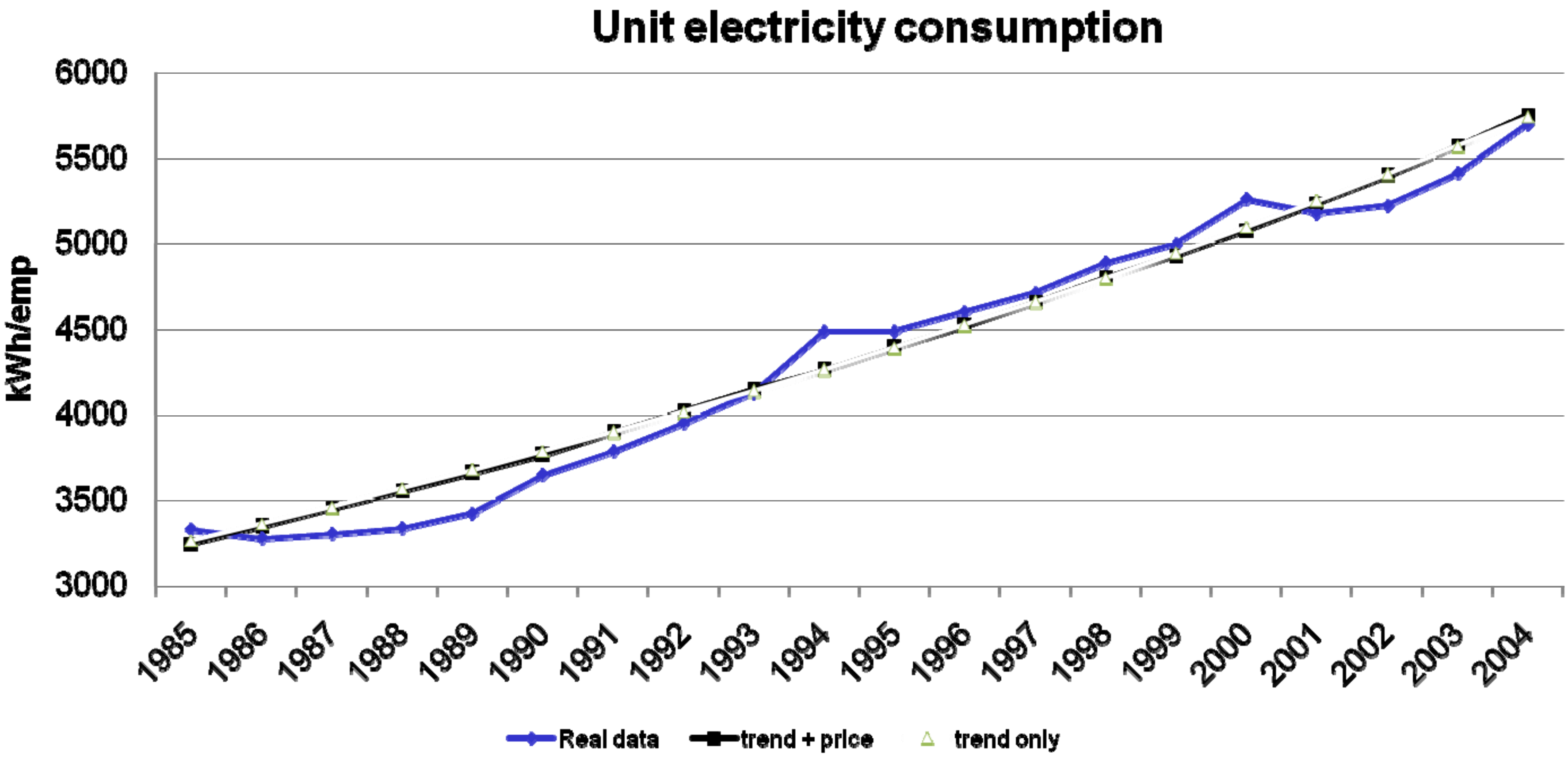
➢ Which trend considered to calculate energy savings? :

- ✓ 1985-1994
- ✓ Or 1994-2004?
- ✓ Or somewhere in between? (saturation of autonomous change?)



Modelling of the baseline unit electricity consumption of services : case of Spain

- ln (UC) = 0.03 X t + 8.06 (regression over the 1995-2004 period)
- Prices not validated by econometric tests



Calculation of ESD savings 1/4

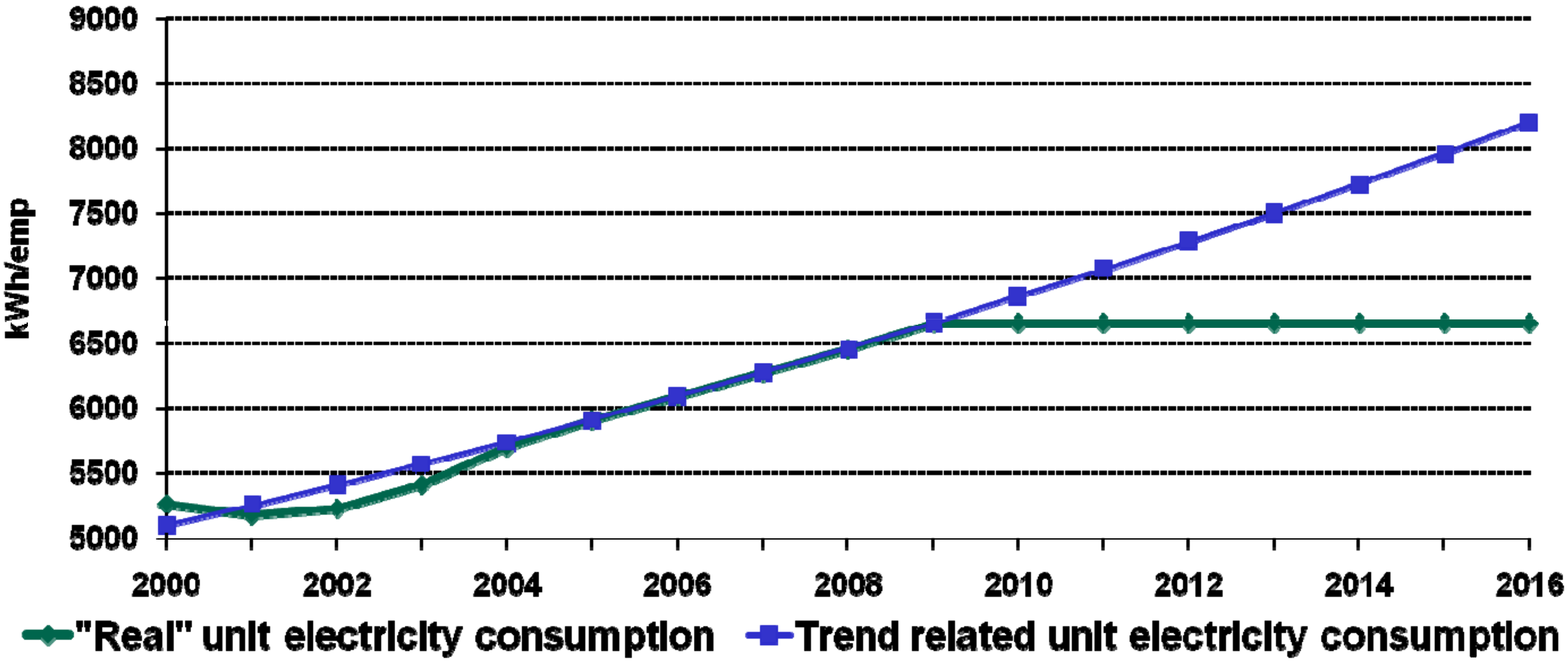
Electricity end uses in services

- **Aggregative approach**
  - **Stage 1 :** Calculation of the trend-related electricity consumption per employee
  - **Stage 2** : Calculation of the trend-related total electricity consumption
  - **Stage 3 :** ESD energy savings calculated by difference between the actual total electricity consumption and the trend-related total electricity consumption
- **Detailed approach**
  - **Stage 1 :** Calculation of the trend-related electricity consumption per employee for each activity subsector
  - **Stage 2** : Calculation of the trend-related electricity consumption of each subsector
  - **Stage 3** : Calculation of the trend-related total electricity consumption by summing the subsectors
  - **Stage 4 :** ESD energy savings calculated by difference between the actual total electricity consumption and the trend-related total electricity consumption

Calculation of ESD savings 2/4
Electricity end uses in services

Aggregative approach (example)

➢**Stage 1 :** Calculation of the trend-related electricity consumption per employee

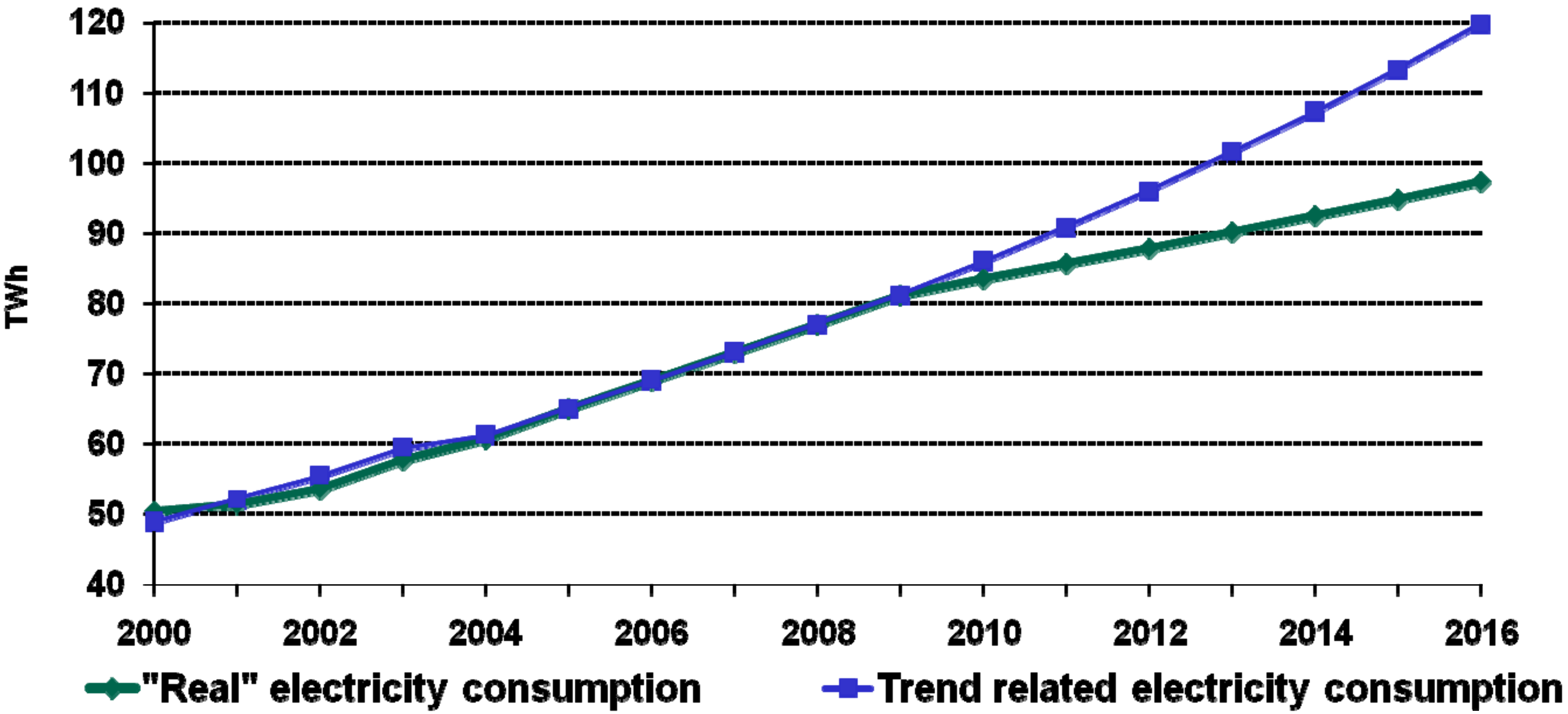


"Real" unit electricity consumption are obtained by assuming the implementation of a first policy in 2008 with first impact in 2010 (stabilisation of the unit consumption)

Calculation of ESD savings 3/4
Electricity end uses in services

Aggregative approach (example)

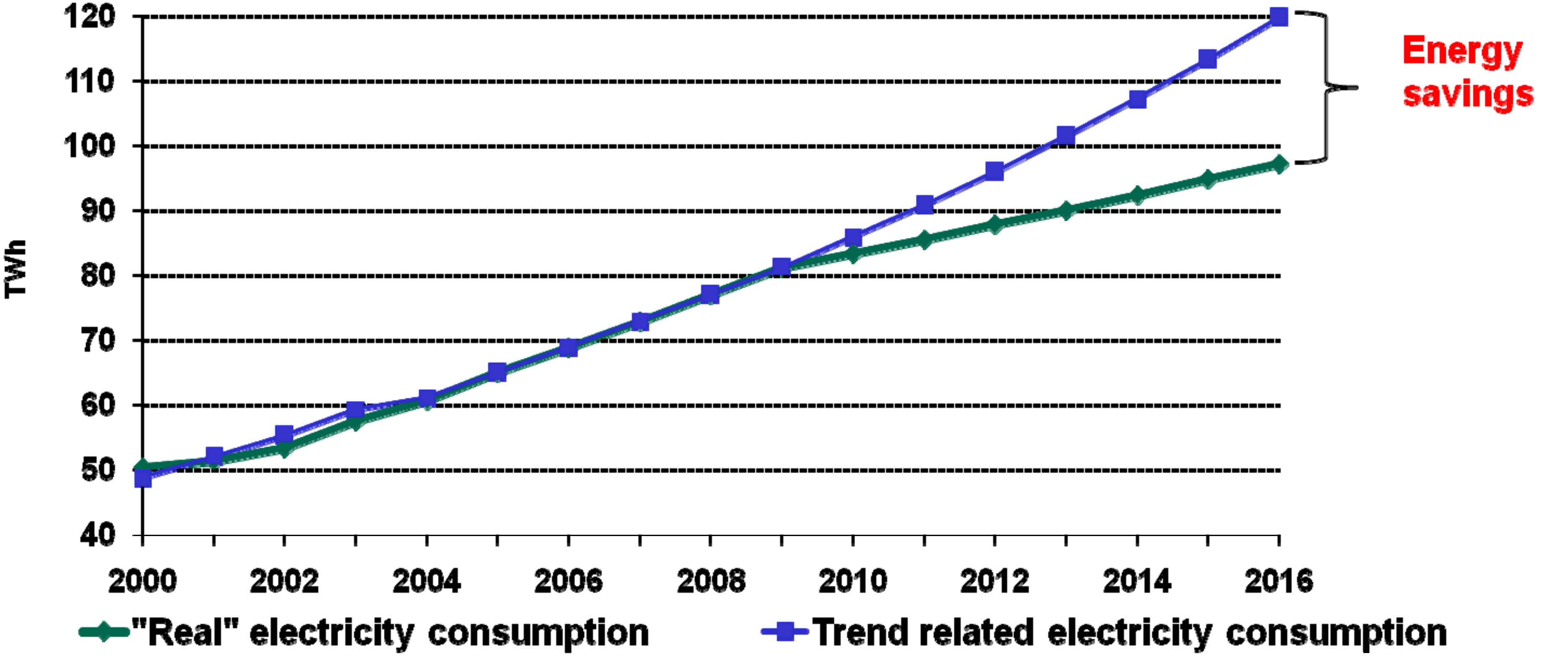
➤ **Stage 2 :** Calculation of the trend-related total electricity consumption



Calculation of ESD savings 4/4
Electricity end uses in services

Aggregative approach (example)

➢**Stage 3 :** ESD energy savings calculated by difference between the actual ("real") total electricity consumption and the trend-related total electricity consumption



Conclusions and issues for replication on electricity end uses in services

- The detailed approach is the best one, but can be implemented only for few countries
- Price effect generally difficult to measure, as electricity prices did not change enough in the past
- Selection of baseline trend to assess energy savings:
  - ✓ Most recent trend?