# Analysing the EU 2020 Package with an extended technology wedges approach

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# Analysing the EU 2020 Package with an extended technology wedges approach

**Abstract**

The ambitious energy and climate package decided by the European Council and the European Parliament in December 2008 has a twofold motivation: increasing the security of energy supply and combating climate change. These driving forces require a deliberate transition towards a low carbon economy.

With an extended technology wedges approach we analyze how Member Stated can develop restructuring paths for their energy systems that are compatible with these targets. In addition we demonstrate the accompanying economic impacts both for investments and operations.

**Keywords**

EU Energy and Climate Package

Technology wedges

Energy and climate policy

**JEL codes**

Q540 Q530

# 1 Introduction

„Humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century".

Pacala and Socolow (2004)

**The ambitious EU 2020 targets**

The EU 20 + 20 targets for greenhouse gas emissions and energy from renewable resources put forward for 2020 will fundamentally change the European economies:

- Never before did the EU set such ambitious policy targets for such a long period.
- These targets will require a profound restructuring of the EU energy system.
- Momentous consequences of these targets can be expected on the rest of the world.

The ambitious energy and climate package decided by the European Council and the European Parliament in December 2008 has a twofold motivation: increasing the security of energy supply and combating climate change. These driving forces require a deliberate transition towards a low carbon economy.

**The preparations for implementation**

The challenge for energy and climate policy over the next years is the design of restructuring paths that lead to the 2020 targets. This will require basically two activities:

- A thorough evaluation of available technologies and research and development for technologies that are expected to have a high potential for restructuring.
- The implementation of a corresponding incentive scheme that drives the markets towards the identified technologies for meeting the targets.

**An extended technology wedges approach**

This paper focuses on the first activity, the identification and evaluation of technologies that are compatible with the energy and climate targets for 2020.

Our approach will start with the technology wedges approach put forward by Pacala and Socolov (2004). We will extend this approach in two dimensions

- by embedding it into a structural analysis of the energy system and
- by judging the economic impacts both in the investment and the operating phase.

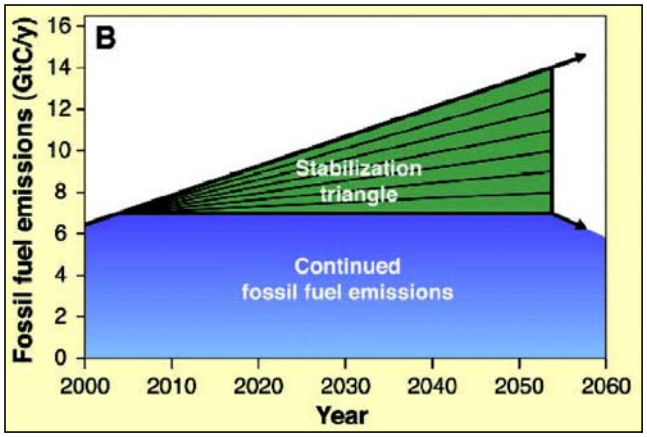
The analysis is based on data for Austria and can be extended to other Member States.

## 2 The technology wedges approach in a nutshell

**The origin of the technology wedges approach**

Pacala and Socolow (2004) offer a highly operational approach for analysing induced technological change. Concerned with technologies of the energy sector that have an impact on $CO_2$ emissions, they propose a restructuring of the global energy sector based on currently known and available technologies that would hold the current level of carbon at 7 billion tons of carbon per year (GtC/year) constant over the next five decades.

Graph 1: Stabilization of CO2 emissions by technology wedges




Source: Pacala and Socolow (2004)

**The global dimension**

Carbon emissions would double in the next 50 years if we extrapolate current trends. Keeping emissions constant would therefore require a technology shift that provided a total reduction in the emissions rate of 7 GtC/year by 2054. According to Graph 1, the “ramp” trajectory representing trend emissions and the “flat” trajectory representing stabilized emissions form a “stabilization” triangle that is divided into seven technology “wedges”, each of them representing a technological shift that cuts 1 GtC/year after five decades starting from zero today.

The projected emissions extrapolate the 1.5% carbon emissions growth over the past 30 years, which corresponded to a 2% growth in primary energy consumption and a 3% growth in economic activity as measured in gross world product. These figures indicate the historic declines of energy intensities and carbon intensities.

**A list of technology wedges**

Altogether, a menu of 15 technology wedges is presented, each scaled up to an emission reduction of 1 GtC/year 50 years from now. Thus the range of option is emphasized, since some wedges may not be acceptable, and because their scale may vary. Table 1 summarizes the proposed technology wedges

Table 1: Technology wedges

| | | |
|---|---|---|
| **Category 1:** | Improved fuel economy | Increasing the fuel efficiency of cars |
| **Efficiency and conservation** | Reduced reliance on cars | Reducing the annual distance travelled by cars |
| | More efficient buildings | Improving the energy efficiency of residential and commercial buildings |
| | Improved power plant efficiency | Increasing the fuel efficiency of power plants |
| **Category 2:** | Substituting natural gas for coal | Fuel shift in power plants |
| **Decarbonization of electricity and fuels** | Storage of carbon captured in power plants | Hydrogen for on-site electricity production |
| | Storage of carbon captured in hydrogen plants | Hydrogen for off-site use |
| | Storage of carbon captured in synfuel plants | Synthetic fuels from coal |
| | Nuclear fission | Doubling the current instalments for one wedge |
| | Wind electricity | 50 times today's deployment for one wedge |
| | Photovoltaic electricity | 2 $m^2$ per person for one wedge |
| | Renewable hydrogen | Hydrogen produced by windmills |
| | Biofuels | One-sixths of global croplands for one wedge |
| **Category 3:** | Forest management | Stopping clear-cutting of primary tropical forest, afforesting and reforesting |
| **Natural sinks** | Agricultural soils management | Conservation tillage practices |

Source: Based on Pacala and Socolow (2004)

**A portfolio of technology wedges**

Pacala and Socolow describe the dynamics of a portfolio of 15 technologies in terms of their impact on $CO_2$ reductions, starting from zero and reaching 1 GtC in 50 years.

Referring to the triangular shape of the area of emissions reductions that is created by such a reduction trajectory, the authors call the implementation of a particular technology a wedge.

Given current projections of economic activity, and extrapolating current technology trends, about 7 of the 15 technology wedges would be needed in order to stabilize global $CO_2$ emissions on a global scale.

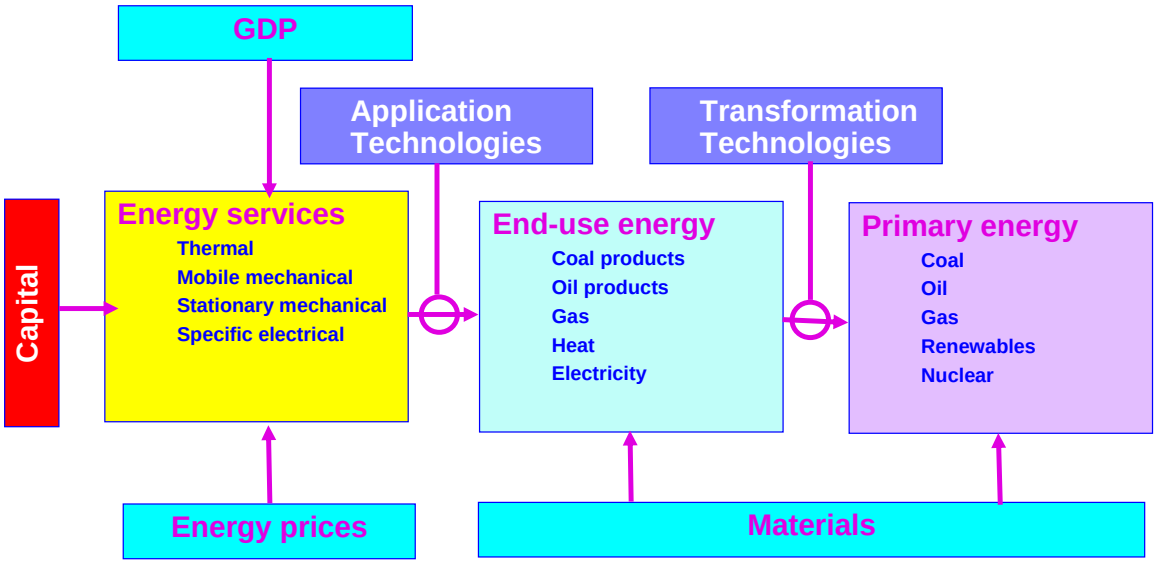
# 3 An extended technology wedges approach

**The missing economic evaluation**

Although the Pacala and Socolow paper focuses mainly on energy technologies and their impact on $CO_2$ emissions, the concept of technology wedges has a much broader relevance, since it deals with the dynamics of a technology from introduction up to a specific rate of implementation. It is a bottom-up analysis, and thus has the potential for revealing the detailed economic impacts of implementing a specific technology, both in the investment phase and in the operating phase.

The main contribution of Pacala and Socolow is a procedure for opening the black box of technologies. This procedure, however, lacks an economic evaluation. We present in this paper a modelling approach that adds to the technology wedges approach an economic analysis.

Graph 2: Structure of the energy system




We provide several extensions of the technology wedges approach that embed this approach into the structure of the energy system and add an economic analysis.

**Embedding technology wedges into the energy system**

The first extension emphasises the structure of the energy system by emphasising the decisive role of energy services and the decisions about application and transformation technologies and finally the primary energy mix.

Thus our technology wedges are classified along the structure of an energy system as indicated in Graph 2 and listed in Table 2.

Table 2: Types of technology wedges in the energy system

| | | |
|---|---|---|
| **Category 1:**<br><br>**Energy services** | Eliminating redundant energy services<br><br>- thermal<br>- mobile mechanical<br>- stationary mechanical<br>- specific electrical | Temperature in building<br>Transport of passengers and goods<br>Lightening and electronic devices |
| **Category 2:**<br><br>**Application and transformation technologies** | Increasing the mass and exergy efficiency | Low energy efficiency in all application technologies<br>Using co- and poly-generation in thermal transformation processes |
| **Category 3:**<br><br>**Primary energy mix** | Switching to low carbon and zero carbon energy | Substituting fossil by renewable energy |

Source: Authors

**An economic analysis of a technology wedge**

The second extension analysis the economic consequences of the choice of a certain technology wedge. We deliberately differentiate between the investment and the operating phase for investigating the effects on flows, stocks, emissions and technology spillovers.

This information is collected in a technology information matrix as demnonstrated in Table 2.

Table 3: Technology evaluation matrix

| **Implementation of technology wedge of type x** | Direct and indirect effects | |
|---|---|---|
| | Investment phase | Operating phase |
| Flow effects<br>consumption, investment, imports, exports | | |
| Stock effects<br>by types of capital stock | | |
| Emission effects<br>greenhouse gases and others | | |
| Technology effects<br>learning, spillovers, security, competition | | |

# 4 Technology wedges for the EU 2020 Package

**The ambitious 2020 targets:**
**- minus 20 % GHG**
**- 20 % share of RES**

The European Council and the European Parliament decided in December 2008 on an ambitious reduction of greenhouse gas (GHG) emissions and an increasing share of renewable energy sources (RES) in Europe.

The unilateral target for the EU27 is a reduction of 20% GHG emissions until 2020 compared to 1990. In case of an international climate policy agreement this target will be extended to a 30% reduction.

For renewable energy an increase of the share of RES in overall EU final energy consumption from 8.5% today to 20% by 2020 was agreed. Moreover, the package also foresees to achieve at least a 10% biofuels component in vehicle fuel by 2020.

**The motivation:**
**- energy security**
**- climate change**
**- restructuring**

The motivation for this energy and climate package is threefold:

- *Energy security*
  In a business as usual development of energy demand the EU is facing a constantly increasing import share in energy resources making the EU economy vulnerable to interruptions in international energy markets.
- *Climate change*
  The irreversibility of climate change motivates the EU to take action in order to limit the risk of a temperature increase to less than 2 degrees by the end of this century (compared to pre-industrial levels).
- *Restructuring the economy towards a low carbon development path*
  The implementation of the energy and climate package is supposed to set incentives for innovative technologies in all sectors of the economy targeted at less energy demand and less fossil fuel use.

**The challenge for the Member States**

How these targets translate into targets for Member States is illustrated for Austria. Compared to the situation in 2005 the following targets need to be met:

- With the installations subject to the EU Emissions Trading Systems (ETS sector) contributing to the 21% reduction of greenhouse gas emissions.
- With the Non-ETS sector achieving a 16% reduction of greenhouse gas reductions.
- With the renewable energy sources (RES) increasing their share in gross final energy consumption from 23% to 34%.

**Applying the extended technology wedges approach**

For Austria the following analysis is performed for meeting the EU 2020 targets based on the extended technology wedges approach:

- Technology wedges are identified for the categories energy services, energy application and transformation, and energy mix.
- Alternative combinations of these wedges are presented which lead to the targets set for 2020.
- The direct and indirect effects of a chosen set of technology wedges is made visible in a macroeconomic framework that takes into ac-

count the impact of a technology wedge both in the investment and operating phase.

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