Fraunhofer ISI

In the frame of the Project
Energy Savings 2030: on the 2050 Pathway

Analysis of a European Reference Target System for 2030

Report to the Coalition for Energy Savings

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1. Introduction

The project "Energy Savings 2030: on the 2050 Pathway", to which Fraunhofer ISI contributes for the Coalition for Energy Savings has as a major objective the identification of a 2030 target system for energy efficiency in the frame of a general target system comprising renewable and greenhouse gas reduction targets. **An important basis for such a target system are energy efficiency (EE) potentials. In fact, the central approach taken in this analysis is that setting up such a target system is about setting an energy efficiency target in final or primary energy metrics, using the share of renewable energy sources (RES) as a second important input parameter. Both parameters result in certain reductions of Greenhouse Gas (GHG) emissions, which are not to be confused with setting directly a target for GHG emissions.** Such a target may be realized by options beyond EE and RES, e.g. by fuel shift other than the shift to RES or by the reduction of non-CO_2-GHG, e.g. N_2O emissions from agriculture or industrial processes such as adipic or nitric acid.

The European Commission has raised the following questions related to a 2030 target system in the frame of its consultation process for the Green Paper "A 2030 framework for climate and energy policies" [COM(2013) 169][1]:

1. Which lessons from the 2020 framework and the present state of the EU energy system are most important when designing policies for 2030?
2. Which targets for 2030 would be most effective in driving the objectives of climate and energy policy? At what level should they apply (EU, Member States, or sectoral), and to what extent should they be legally binding?
3. Have there been inconsistencies in the current 2020 targets and if so how can the coherence of potential 2030 targets be better ensured?
4. Are targets for sub-sectors such as transport, agriculture, industry appropriate and, if so, which ones? For example, is a renewables target necessary for transport, given the targets for CO2 reductions for passenger cars and light commercial vehicles?
5. How can targets reflect better the economic viability and the changing degree of maturity of technologies in the 2030 framework?
6. How should progress be assessed for other aspects of EU energy policy, such as security of supply, which may notbe captured by the headline targets?

Further questions are posed by the European Commission concerning Instruments, Competitiveness and Security of Supply, Capacity and Distributional Aspects.

This analytical paper tries to make contributions to the questions 1-3 in particular.

[1] http://ec.europa.eu/energy/consultations/20130702_green_paper_2030_en.htm

2. Reference Target System

In this paper we will use the expression **"Reference Target System"**. By this we understand the combined set of targets covering in particular the two areas of energy efficiency improvement and renewable energy sources, while the reduction of GHG emissions is then resulting from the implementation of the two targets. In the past, such a reference target system was established with the "20-20-20" headline target system by the European Union. In that target system also GHG emissions are subject to a separate target which interacts with EE and RES targets.

Such a reference target system can be more or less complex: there can be a **single headline target** with the other targets being subordinated, there may be **several equal targets** (like in the 20-20-20 system) and there may be more levels like **sectoral targets** (the German target system up to 2050 is an example for a target system with several layers, see the box below).

Target system of German energy policy[2]

Climate-damaging greenhouse gas emissions are to be reduced by 40% by 2020, 55% by 2030, 70% by 2040 and by 80 to 95% by 2050, compared to reference year 1990.

Primary energy consumption is to fall by 20% by 2020 and by 50% by 2050.

Energy productivity is to rise by 2.1% per year compared to final energy consumption.

Electricity consumption is to fall by 10% by 2020 and by 25% by 2050, compared to 2008.

Compared to 2008, heat demand in buildings is to be reduced by 20% by 2020, while primary energy demand is to fall by 80% by 2050.

Renewable energies are to achieve an 18% share of gross final energy consumption by 2020, a 30% share by 2030, 45% by 2040 and 60% by 2050.

By 2020 renewables are to have a share of at least 35% in gross electricity consumption, a 50% share by 2030, 65% by 2040 and 80% by 2050.

A target system is typically derived from a projection of developments or from historic data. In most cases a reference target system is defined in a **static** manner that is, it is usually not revised frequently, if at all, and **does rarely contain dynamic elements**. The dynamics is usually included in the distance to target which may vary considerably over time with economic cycles and developments.

It is important to underline that in our approach GHG emissions are not defined as an independent target but are derived from the EE and RES targets in combination.

[2] Source. German Federal Ministry of the Environment BMU.

Strong changes in the distance to target occurred in the case of the 20-20-20 target system and we will first analysis this system and its failures in the following section.

3. The 2020 Reference Target System and its failures

The original European 2020 target system (20/20/20) was calculated based on the PRIMES 2007 projections[3]. The following overview (Table 1) shows that the target system which was originally set up with that set of projections **was coherent in itself**, that is a 20% renewable share and a 20% efficiency reduction (as compared to the PRIMES 2007 baseline) indeed provides for a reduction of GHG emissions in 2020 of 21% which is coherent with a 20% reduction in greenhouse gas emissions in 2020 (as compared to 1990). Further, sub-targets like for the EU emission trading sector (-21% in 2020 compared to 2005) and for the effort sharing sectors (-10% in 2020 compared to 2005) were coherent with the three main targets.

It is important to underline, however, that the 20% reduction target in GHG could already be entirely met by meeting the EE and RES targets. Therefore no additional reduction (beyond baseline development!) was required for GHG than those caused by EE and RES.

The ETS can contribute to realize EE and RES implementation measures. Given the fact that EE and RES targets already sufficiently covered the GHG target, additional GHG reduction measures beyond EE and RES would have lead to an over-fulfillment of the GHG target.

Table 1 shows also sectoral targets both based on potentials and as a “flat” target that is a target equally distributed across all sectors and fuels without consideration of potentials. The latter is added for comparison purposes but does not provide a realistic view on the potentials and possible sectoral targets for individual sectors and fuels. The table further shows the distance to target and the considerable effort to be made.

The table also shows the distance to target. For that purpose the targets are assumed to be fixed once for all (targets fixed by the PRIMES 2007 reference system), and the distance to target is the distance from the baseline development to the targets but the economic development could deviate from the development expected in the baseline. If it does not, the distance to target would be the one expected and for example for primary energy consumption 368 Mtoe are to be saved. In that case the table specifies that the distance to target is given by the PRIMES 2007 development.

Table 2 shows the changes in the distance to target, if the reference target system based on PRIMES 2007 were maintained but the baseline were adapted according to the PRIMES 2009

[3] PRIMES (2007): European Energy and Transport – Trends to 2030 - Update 2007, Luxembourg: Publications Office of the European Union, 2008 http://www.e3mlab.ntua.gr/reports/energy_transport_trends_2030_update_2007_en.pdf

projections[4] (PRIMES 2007 target system + PRIMES 2009 development to measure the distance to target. The table also shows a variant with an even lower economic growth as compared to the PRIMES 2009 projections which could be the case of the forthcoming EU projections to be published this year. In the PRIMES 2007 projections the economic growth was projected to be around 2.22%/year from 1990 to 2020. In the PRIMES 2009 projections the same figure was 1.86%/year. Cumulative GDP was around 11% lower in 2020 in the PRIMES 2009 projections. The low growth case assumes an average growth of 1.49%/year up to 2020 with a further decrease of GDP of 12% compared to PRIMES 2009. So it is at a similar distance to the PRIMES 2009 projections as those were to the PRIMES 2007. As the economic growth since the start of the financial and economic crises in 2008 was well below of even the level of the low economic growth case considered here, this case does not seem to be overly pessimistic. It can also be expected that the new PRIMES projections to be published this year may also be below the PRIMES 2009 growth levels. In that case we would say the reference target system is fixed from the PRIMES 2007 projection but distance to target is measured from a "lower than PRIMES 2009 economic development".

The distance to target is measured with the following comparison:

- **Consumption target** (absolute final/primary energy target): distance between target and baseline
- **Intensity target** (relative final/primary energy target): distance between target intensity and baseline intensity
- **Energy saving target** (final/primary saving target): distance between target savings and baseline saving
- **RES target:** distance between the RES share in the target reference system and the RES share in the baseline development
- **GHG emissions:** distance between the GHG emissions as resulting in the target reference system and the GHG emissions as resulting from the baseline development. In relative terms the distance is expressed referring to 1990 levels (which is the principal base year for Kyoto)
- **ETS/Effort sharing sector emissions**: distance between the emissions from thos sectors as resulting in the target reference system and the emissions as resulting from the baseline development. In relative terms the distance is expressed referring to 2005 levels (which is the base year relevant for those sectors).

[4] PRIMES (2009): EU energy trends to 2030 – Update 2009, Luxembourg: Publications Office of the European Union, 2010
http://ec.europa.eu/clima/policies/package/docs/trends_to_2030_update_2009_en.pdf

Table 1: Reference Target System 2020 (based on PRIMES2007 projections)

Reference Target System 2020 (based on PRIMES2007)									Distance to target		
									Target fixed on PRIMES2007		
1) Final Energy									+ PRIMES2007 development		
Absolute final energy target	Mtoe	1.078	-20%	compared to reference					270	20%	
Sectoral targets:		Potential-based			Flat						
Industry	*Mtoe*				*294*	*-20%*	*compared to reference*				
Residential	*Mtoe*				*269*	*-20%*	*compared to reference*				
Tertiary	*Mtoe*				*164*	*-20%*	*compared to reference*				
Transport	*Mtoe*				*351*	*-20%*	*compared to reference*				
Final energy intensity target	toe/MEuro'05	69	-20%	compared to reference					17	20%	
Final energy saving target	Mtoe	270	-20%	compared to reference					270	20%	
	Mtoe	89	-8%	compared to 2005					89	8%	
2) Primary Energy											
Absolute primary energy target	Mtoe	1.474	-20%	compared to reference					368	20%	
Primary energy intensity target	toe/MEuro'05	94	-20%	compared to reference					23	20%	
Primary energy saving target	Mtoe	368	-20%	compared to reference					368	20%	
							RES production absolute in 2020 reference development				
3) Renewable energy								Mtoe	164		
							RES production absolute in 2020 target system				
								Mtoe	224		
RES production	Mtoe	224	20%	RES share in gross final energy demand					60	5%	RES share in Gross Fina
										8%	Percentage diff. Ref.-Targ
RES-H	*Mtoe*			*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*							
RES-E	*Mtoe*			*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*							
RES-T	*Mtoe*			*RES-T share in transport (as defined by Directive 2009/28/EC)*							
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	4.388	-21%	compared to 1990					871	16%	compared to 1990
Absolute GHG emissions	Mt CO2eq	4.388	-14%	compared to 2005							
Absolute CO2 emissions (energy-related)	Mt CO2eq	3.382	-14%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1816	-21%	compared to 2005					476	21%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	2572	-9%	compared to 2005					395	14%	compared to 2005

Table 2: Reference Target System 2020 (distance to target recalculated based on PRIMES2009 projections and a variant with an economic growth path lower than the 2009 projections and which could be the case of the forthcoming EU projections to be published this year)

Reference Target System 2020 (based on P			**Distance to target**				**Distance to target**			
			Target fixed on PRIMES2007				Target fixed on PRIMES2007			
1) Final Energy			+ PRIMES2009 development				+ Lower than PRIMES2009 economic developmer			
Absolute final energy target	Mtoe		151	11%			23	2%		
Sectoral targets:										
Industry	*Mtoe*									
Residential	*Mtoe*									
Tertiary	*Mtoe*									
Transport	*Mtoe*									
Final energy intensity target	toe/MEuro'05		18	21%			18	21%		
Final energy saving target	Mtoe		270	22%			270	24%		
	Mtoe		89	8%			89	8%		
2) Primary Energy										
Absolute primary energy target	Mtoe		231	13%			54	3%		
Primary energy intensity target	toe/MEuro'05		26	23%			26	23%		
Primary energy saving target	Mtoe		368	22%			368	24%		
3) Renewable energy			189				169			
			204				183			
RES production	Mtoe		15	2%	Share RES in Gross Fin		14	2%	Share RES in Gross Fin	
				5%				5%		
RES-H	*Mtoe*									
RES-E	*Mtoe*									
RES-T	*Mtoe*									
4) Resulting GHG emissions										
Absolute GHG emissions	Mt CO2eq		310	6%			-179	-3%		
Absolute GHG emissions	Mt CO2eq									
Absolute CO2 emissions (energy-related)	Mt CO2eq									
5) ETS/Efforts-sharing										
ETS emissions	Mt CO2eq		99	4%			-100	-4%		
Effort-sharing sectors emissions	Mt CO2eq		211	7%			-79	-3%		

The change in the economic development which is expressed in the PRIMES 2009 update induced that the distance to target decreased considerably. For example the distance to target in terms of absolute primary energy of 1474 Mtoe, which was the value chosen in the frame of the EU Energy Efficiency Directive 2012/27/EU (EED)[5] decreased from originally 368 Mtoe (-20% compared to the baseline) to 231 Mtoe (-13% compared to the baseline) and could further decrease to 54 Mtoe (-3%) under the assumptions of lower growth up to 2020. **This change in the distance to target was the combined effect of economic crises, energy efficiency measures realized in the meantime and higher than expected shares of renewable in Gross Final Energy Demand as compared to the expected reference development.** However, a major impact was made by the changes in economic drivers.

Similar changes in the distance to target occur for final energy and GHG emissions (all targets/values which are formulated in absolute manner) while targets formulated in energy intensity terms or as energy savings are little or less subject to such changes. The change in distance to target was, however, not the main problem with the fact that there is a constantly changing baseline while the reference target system is static. **The major problem arose from the fact that the triple target system was not coherent anymore**. This is seen from Table 3 which recalculates the target system which would have been consistent with the PRIMES 2009 projections[6]. Based on this new projection, a 20% renewable share and a 20% energy efficiency improvement expressed as a consumption target in final energy terms were coherent with a 27% reduction in greenhouse gas emissions in 2020 (and a 22% reduction in primary energy). This means that the EU could have moved to the international conditional GHG target of 30%, which was also shown by impact analysis at the EU level[7].

Further, the coupled ETS/Effort sharing target was not consistent any more with the headline targets, as a consequence that the overall GHG target of 20% was too low compared to the baseline developments. If the -21% target were maintained for the ETS, the effort sharing targets would have to be enhanced from -10% to -21%, or, in case that one would have tried to repair the ETS (which from the current perspective has one annual emission inventory too much in the system), one should have increased the ETS target to -34% while maintaining roughly the Effort Sharing target.

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5 Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC [OJ L315 p.1] http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

6 For simplification we take here the view that though between 2007 and 2009 that is the time between the two projections, some measures have been implemented but that the major change was induced by the changes in the drivers and activity levels

7 EC (2012): Commission Staff Working Paper - Analysis of options beyond 20% GHG emission reductions: Member State results. Brussels, 1.2.2012, SWD(2012) 5 final. http://ec.europa.eu/clima/policies/package/docs/swd_2012_5_en.pdf

Table 3: Reference Target System 2020 (based on PRIMES2009 projections)

Reference Target System 2020 (based on PRIMES2009)									Distance to target		
									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	983	-20%	compared to reference					246	20%	
Sectoral targets:		Potential-based			Flat						
Industry	*Mtoe*				*266*	*-20%*	*compared to reference*				
Residential	*Mtoe*				*253*	*-20%*	*compared to reference*				
Tertiary	*Mtoe*				*148*	*-20%*	*compared to reference*				
Transport	*Mtoe*				*316*	*-20%*	*compared to reference*				
Final energy intensity target	toe/MEuro'05	69	-20%	compared to reference					17	20%	
Final energy saving target	Mtoe	246	-20%	compared to reference					246	20%	
	Mtoe	190	-16%	compared to 2005					190	16%	
2) Primary Energy											
Absolute primary energy target	Mtoe	1.322	-22%	compared to reference					383	22%	
Primary energy intensity target	toe/MEuro'05	93	-22%	compared to reference					27	22%	
Primary energy saving target	Mtoe	383	-22%	compared to reference					383	22%	
							RES production absolute in 2020 reference development				
3) Renewable energy								Mtoe	189		
							RES production absolute in 2020 target system				
								Mtoe	204		
RES production	Mtoe	204	20%	RES share in gross final energy demand					15	2%	RES share in Gross Final Energy Demand (PRIM
										5%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*99*	*22%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*							
RES-E	*Mtoe*	*79*	*30%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*							
RES-T	*Mtoe*	*26*	*10%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*							
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	4.047	-27%	compared to 1990					651	12%	compared to 1990
Absolute GHG emissions	Mt CO2eq	4.047	-21%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	3.041	-23%	compared to 1990							
5) ETS/Efforts-sharing											
Variante 1: No change in ETS target as compared to PRIMES2007 baseline											
ETS emissions	Mt CO2eq	1805	-21%	compared to 2005					110	5%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	2242	-21%	compared to 2005					541	19%	compared to 2005
Variante 2: Remove one annual ETS inventory to "repair" ETS											
ETS emissions	Mt CO2eq	1519	-34%	compared to 2005					395	17%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	2528	-11%	compared to 2005					255	9%	compared to 2005

A few major conclusions from this discussion are:

- Target systems, **especially when based on absolute targets**[8], **will inevitably become inconsistent over time** as reality (nearly) always evolves differently over time as projections. This raises questions such as dynamic versus static formulations of target systems, periodic or dynamic adaptations of target systems, stability versus dynamic features in a target system, stability versus flexibility etc.
- Second, **targets formulated in an absolute manner are much more subject to problems when such changes occur than target systems formulated in terms of energy intensities**[8] **or absolute energy savings**. However the latter two types of targets do not guarantee that energy consumption is indeed lowered. Targets formulated in energy savings have led to larger difficulties in the frame of the Energy Efficiency and Energy Services Directive from 2006 due to the difficulties to separate autonomous from policy induced changes (as it was the original intention of that directive to promote savings BEYOND autonomous progress and the saving target was formulated correspondingly).

Renewables targets are typically formulated in terms of a percentage of gross final energy demand which links them intimately with energy efficiency targets. The absolute amount of renewables is not relevant per se. On the contrary, **GHG targets are typically formulated in absolute terms or as percentage reduction from historic values** as the greenhouse gas effect is influenced by the absolute levels of emissions. **This shows that for energy efficiency there is the broadest range of choices in terms of target formulation under discussion**.

4. A 2030 Reference Target System

In this section we will develop a quantitative view on a possible 2030 target system, keeping in mind, however, a major conclusion from the previous section that a static target system may always run into problems after a point in time and may need adjustments which are already discussed and introduced in a transparent manner when the target system is discussed. The following calculations are based on the PRIMES 2009 baseline[9]. Eventually this has to be updated with the PRIMES 2013 update, once available.

Table 4 shows a coherent reference target system based on the Primes 2009 projections. The target system is fixed on the final energy consumption side at the overall value of potentials as

[8] For the discussion of problems arising in the case of intensity targets, see section 5.

[9] Another possibility could be to formulate the 2030 reference target system once again on the basis of the PRIMES 2007 projections to keep transparency with the formulation of the 2020 target system. In that case the targets must be higher in percentage points as the projections of PRIMES 2009 are lower than the PRIMES 2007 projections.

provided by the Fraunhofer 2012 potential study[10] and which has been intensively discussed in the frame of stakeholder workshops (see the Phase 1 Report for the Coalition for Energy Saving[11]). It could, however, also be used to set a target on the primary energy side. **The energy efficiency improvement at the demand side[12] is set at -41% compared to the Primes 2030 baseline which corresponds to a full realization of sectoral potentials as calculated for 2030** (it should be noted that the potentials calculated are dynamic over time as they depend on the investment cycles and do, generally, not include early replacement of equipment. The **reduction target is distributed according the potentials in the different sectors** (hence the residential sector gets a larger target and the industry sector a smaller target. For the other two sectors the difference is not as large compared to the flat rate targets across the sectors which is provided again for comparison purposes).

The **renewable energy share is set to 35% with this overall RES target being distributed on the RES subsectors for** renewable electricity (RES-E), renewable heating/cooling (RES-H) and renewable in transport (RES-T). The renewable electricity share is fixed at 47% which is consistent with the development of the power mix as developed in Fraunhofer (2012).

From these figures there are then also the CO_2/GHG emission reductions calculated as well as the primary energy reduction and primary/final energy intensities. **GHG emissions are reduced by 49%[13], CO_2 emissions by 54% both compared to 1990**. **Primary energy is to be reduced by about 46% compared to the baseline,** with two competing factors: because of the penetration of renewable and other supply side efficiency improvement the improvement of primary energy should be stronger than for final energy but there is also an increasing penetration of electricity which is still partly generated with fossil fuels. This counteracts the improving factor as long as the penetration of renewable with high formal conversion efficiencies is not very high. It should be noted that we calculate the impacts in the target system of EE and RES on CO_2-emissions only. Concerning non-CO_2 GHG and process-related CO_2 emissions we do not assume reductions beyond the reference development provided in PRIMES 2009 (which is based on calculations with the GAINS model). Hence these percentage reductions in GHG should not be mixed up with GHG targets. Therefore, the figures mentioned in the column "Distance to target" for GHG

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10 Fraunhofer ISI (2012): Contribution of Energy Efficiency Measures to Climate Protection within the EuropeanUnion until 2050. Report on behalf of the German Ministry for the Environment, Karlsruhe, November 2012.
http://www.bmu.de/bmu/presse-reden/pressemitteilungen/pm/artikel/studie-energiebedarf-der-eu-laesst-sich-um-zwei-drittel-senken/
or: http://www.isi.fraunhofer.de/isi-en/e/projekte/bmu_eu-energy-roadmap_315192_ei.php

11 Fraunhofer ISI (2013a): Summary of comments and replies concerning the stakeholder interventions during the sectoral workshops 11/12 April 2013 in Brussels. Report to the Coalition for Energy Savings (Draft Version 3) in the frame of the project "Energy Savings 2030: on the 2050 Pathway".

12 Note that this is reduced by the conversion savings

13 GHG emissions reduce less than primary energy because it is assumed here that the emission reduction for non-CO_2-GHG is the same as for the baseline which makes it lower than the reduction in primary energy and hence the energy-related CO_2-emissions.

emissions should be interpreted as the distance which separates the baseline GHG emissions from the GHG emissions arising in the reference target system (or a sensitivity variant).

Now the following notes are to be made:

- **We would call the values calculated "the reference target system" as it is consistent** under the given GDP development, the assumed structural changes in the economy and the given penetration of renewable and penetration of energy efficiency options. This does not imply that it would remain consistent under changing frame conditions.
- **The absolute level of the reference target system is here based on the maximum overall final energy potentials (in conjunction with an ambitious penetration of renewables in the electricity sector)**. Another reference target system could be based on a GHG headline target which allows for further flexibility by allowing higher or lower shares of renewables in the power mix or allows for trade-offs between renewable, energy efficiency and other GHG reduction measures but which has also considerable drawbacks (see Section 6).

An important point to be mentioned here is the macroeconomic impacts of energy savings. In fact, improvements in energy efficiency can produce significant positive macroeconomic impacts such as increases in GDP, trade balance, economy restructuring, employment, and national competitiveness. Such impacts have been established in a variety of studies form the European Commission, the International Energy Agency (IEA)[14] or the World Bank.

Such effects will also impact on the relationship of energy savings to energy intensity in a dynamic relationship. Energy savings in the economy as a whole will increase GDP and in turn lower energy intensity for the economy as a whole. The same happens at sectoral and sub-sectoral level but in some sectors impacts on energy intensities can be larger than in other sectors.

Such additional benefits of energy efficiency cannot be easily captured with the simple model used for the calculations in this report but are referred here for completeness.

[14] See for example International Energy Agency (2012): Spreading the Net – the Multiple Benefits of Energy Efficiency Improvements, OECD/IEA, Paris 2012.
www.iea.org/publications/insights/ee_improvements.pdf
This reference for example states that "the few studies examining the macroeconomic effects of improved energy efficiency (where energy demand is reduced by 8 to 15%) suggest significant potential impacts including increases in GDP ranging from 0.8% to 1.26%".

Table 4: Reference Target System 2030 (based on PRIMES2009 projections)

Reference Target System 2030 (based on PRIMES2009), full realisation of economic EE potentials									Distance to target		
									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	712	-41%	compared to reference					504	41%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*254*	*-26%*	*compared to reference*	*202*	*-41%*	*compared to reference*		*90*	*26%*	
Residential	*Mtoe*	*121*	*-61%*	*compared to reference*	*181*	*-41%*	*compared to reference*		*187*	*61%*	
Tertiary	*Mtoe*	*114*	*-38%*	*compared to reference*	*108*	*-41%*	*compared to reference*		*71*	*38%*	
Transport	*Mtoe*	*223*	*-41%*	*compared to reference*	*222*	*-41%*	*compared to reference*		*156*	*41%*	
Final energy intensity target	toe/MEuro'05	42	-41%	compared to reference					30	41%	
Final energy saving target	Mtoe	504	-41%	compared to reference					504	41%	
	Mtoe	461	-39%	compared to 2005					461	39%	
2) Primary Energy											
Absolute primary energy target	Mtoe	905	-46%	compared to reference					783	46%	
Primary energy intensity target	toe/MEuro'05	54	-46%	compared to reference					47	46%	
Primary energy saving target	Mtoe	783	-46%	compared to reference					783	46%	
							RES production absolute in 2030 reference development				
3) Renewable energy								Mtoe 233			
							RES production absolute in 2030 target system				
								Mtoe 260			
RES production	Mtoe	260	35%	RES share in gross final energy demand					27	4%	RES share in Gross Final Energy De
										17%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*81*	*36%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					-10	-4%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*152*	*47%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					38	12%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*27*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					-1	-1%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	2.829	-49%	compared to 1990					1341	24%	compared to 1990
Absolute GHG emissions	Mt CO2eq	2.829	-45%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	1.811	-54%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					246	11%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	1573	-45%	compared to 2005					1095	38%	compared to 2005

5. Sensitivity analysis of the "Distance to target" in the 2030 reference target system

Sensitivity analysis of the "Distance to target" in the 2030 reference target system with respect to economic growth

Table 5 shows the sensitivity of the "Distance to target" in the reference target system with respect to economic growth for the different parts of target systems and for the alternative formulations in terms of consumption, intensity and saving targets. We assume a low growth case where GDP is evolving with 1.46% annual growth from 2020 to 2030, as compared to 1.83% in the PRIMES 2009 projections[15]. These growth values for this low growth scenario was chosen with a similar argument than in section 3. The argument of the long-term impacts of the crisis may be weaker for the longer time horizon up to 2030 because it can be hoped that there will be again periods of economic recovery, but for comparison purposes it must be said that for example the average annual growth the European Union between 1990 and 2012 (22 years) was about 1.64% annually, the average growth from 2000 to 2012 (12 years) was only 1.21% annually, so both figures rather in the low-growth range as compared to the range span up by PRIMES 2009 at the higher growth side and the low growth scenario defined above with 1,46% annual growth rate. So from the current perspective the low growth range could be the most realistic one up to 2030.

Similar to the 2020 reference targets system this has considerable impacts on distance to target in the case of absolute formulations of the target. Distance to greenhouse gas emissions as arising from the reference system and for primary energy are subject to similar changes

Sensitivity analysis of the "Distance to target" in the 2030 reference target system with respect to saving potentials

Table 6 shows the sensitivity of the "Distance to target" in the reference target system with respect to a lower realization of the potentials (85% realization of final energy efficiency potentials). In that case the final energy target would be only 35% while the renewable target is maintained at 35% (but implies higher absolute amounts of RES, as the overall consumption to be covered is higher). Correspondingly also the primary energy targets and resulting GHG emissions, as well as the ETS/Effort sharing emissions are lower.

[15] We do not assume a corresponding high growth case beyond the PRIMES 2009 projections with for example 2.2% annually from 2020 to 2030, as this would return to the PRIMES 2007 projections which, from the present perspective is very unlikely.

Sensitivity analysis of the "Distance to target" in the 2030 reference target system with respect to higher penetration of RES

Table 7 shows the sensitivity of the "Distance to target" in the reference target system with respect to a higher penetration of RES (overall a 48% penetration of RES in Gross Final Energy Demand corresponding to the "advanced RES scenario" of EREC[16]; 69% RES in Gross Electricity Generation). Correspondingly also the primary energy targets (-46% compared to the reference[17]) and resulting GHG emissions (-55% compared to 1990), as well as the ETS/Effort sharing emissions are higher in that case due to a larger penetration of renewables.

Sensitivity analysis of the "Distance to target" in the 2030 reference target system with respect to higher structural change as compared to the PRIMES 2009 case

Table 8 shows the impact of a higher structural change as compared to PRIMES 2009 on the distance to target. Between PRIMES 2007 and PRIMES 2009 structural change did not change considerably. Also in the low-growth case considered above there was no deviation from the structural change from the baseline development. This is the reason why energy intensities seem little affected by the sensitivity calculations carried out so far. We have therefore assumed a baseline scenario with higher structural change as compared to the PRIMES 2009 projections. In this scenario the part of energy intensive industries in energy consumption is reduced while the share of services is increased. Overall GDP growth is the same (the part lost by industry is taken up by services) but energy consumption is reduced. This has an important impact on the distance to target for energy intensities (but also on the absolute levels of energy consumption) which becomes evident by comparing Table 5 and Table 8. For the industry sector this becomes even more visible as this sector would with the structural changes more than reach the possible targets obtainable if the energy efficiency potentials are to be realized (see the negative sign for this sector in Table 8). For the tertiary sector the distance to target would increase as this sector takes up some additional energy consumption. The impacts on renewable is limited as it is assumed, for simplicity reasons, that electricity consumption is unchanged and that renewable for heat mainly concern sectors other than industry.

Table 9 gathers a discussion which shows the links between target formulation and sensitivities. Figure 1 shows for final energy the sensitivites for the three main target formulations for final energy (absolute consumption targeted, intensity target, savings target). While the energy intensity target is (approximatively) independent from economic growth (in fact there is a slight dependency due to capacity effects which was not included here for

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[16] EREC (2011): 45% by 2030 –Towards a truely sustainable energy system in the EU, European renewable Energy Council EREC, May 2011.

[17] The primary energy savings exceed the final energy savings due tot he high penetration of renewables with a high formal conversion efficiency which compensates the previously mentioned effect of an increasing share of electricity in the transformation sector which is partly generated with fossil fuels

simplicity reasons), the energy consumption target shows a strong dependency on economic growth assumptions (low economic growth decreases the distance to target considerably). The saving target shows also a dependency with economic growth but opposite to the consumption target: the higher the economic growth the smaller the distance to target in relative terms. Failure to reach EE-targets would then have to be addressed by RES levels in order to reach the same GHG emissions.

The impact of structural changes beyond baseline assumptions is visible by comparing the dashed lines with the solid lines. While the energy saving target is not influenced by structural changes (beyond the original baseline assumptions), both energy intensity and energy consumption targets are influenced by this factor.

Table 5: Sensitivity of the "Distance to target" for the 2030 Reference Target system with respect to economic growth assumptions

Reference Target System 2030 (based on F			Distance to target					Distance to target (low economic growth)				
			Target fixed on PRIMES2009					Target fixed on PRIMES2009				
1) Final Energy			+ PRIMES2009 development					+ PRIMES2009 development (low economic growth)				
Absolute final energy target	Mtoe		504	41%				341	28%			
Sectoral targets:			Potential-based					Potential-based				
Industry	*Mtoe*		*90*	*26%*				*44*	*15%*			
Residential	*Mtoe*		*187*	*61%*				*146*	*55%*			
Tertiary	*Mtoe*		*71*	*38%*				*46*	*29%*			
Transport	*Mtoe*		*156*	*41%*				*105*	*32%*			
Final energy intensity target	toe/MEuro'05		30	41%				30	41%			
Final energy saving target	Mtoe		504	41%				504	48%			
	Mtoe		461	39%				461	39%			
2) Primary Energy												
Absolute primary energy target	Mtoe		783	46%				557	38%			
Primary energy intensity target	toe/MEuro'05		47	46%				47	46%			
Primary energy saving target	Mtoe		783	46%				783	54%			
3) Renewable energy		Mtoe	233					202				
		Mtoe	260					225				
RES production	Mtoe		27	4%	RES share in Gross Final Energy De			23	4%			
				17%	Percentage diff. Ref.-Target				17%			
RES-H	*Mtoe*		-10	-4%	RES-H share in heating/cooling dema			-8	-4%			
RES-E	*Mtoe*		38	12%	RES share in Gross Electricity Dema			33	12%			
RES-T	*Mtoe*		-1	-1%	%RES-T, transport as in Article 3(4)a			-1	-1%			
4) Resulting GHG emissions												
Absolute GHG emissions	Mt CO2eq		1341	24%	compared to 1990			781	14%			
Absolute GHG emissions	Mt CO2eq											
CO2 emissions (energy-related)	Mt CO2eq											
5) ETS/Efforts-sharing												
ETS emissions	Mt CO2eq		246	11%	compared to 2005			44	2%			
Effort-sharing sectors emissions	Mt CO2eq		1095	38%	compared to 2005			737	26%			

Table 6: Sensitivity of the 2030 Reference Target system with respect to energy efficiency potentials (85% realization of potentials)

Reference Target System 2030 (based on PRIMES2009), partial realisation of economic EE potentials (85%									Distance to target		
									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	790	-35%	compared to reference					426	35%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*268*	*-22%*	*compared to reference*	*224*	*-35%*	*compared to reference*		*76*	*22%*	
Residential	*Mtoe*	*150*	*-51%*	*compared to reference*	*200*	*-35%*	*compared to reference*		*158*	*51%*	
Tertiary	*Mtoe*	*125*	*-32%*	*compared to reference*	*120*	*-35%*	*compared to reference*		*60*	*32%*	
Transport	*Mtoe*	*247*	*-35%*	*compared to reference*	*246*	*-35%*	*compared to reference*		*132*	*35%*	
Final energy intensity target	toe/MEuro'05	47	-35%	compared to reference					25	35%	
Final energy saving target	Mtoe	426	-35%	compared to reference					426	35%	
	Mtoe	383	-33%	compared to 2005					383	33%	
2) Primary Energy											
Absolute primary energy target	Mtoe	988	-42%	compared to reference					701	42%	
Primary energy intensity target	toe/MEuro'05	59	-42%	compared to reference					42	42%	
Primary energy saving target	Mtoe	701	-42%	compared to reference					701	42%	
							RES production absolute in 2030 reference development				
3) Renewable energy							Mtoe	233			
							RES production absolute in 2030 target system				
							Mtoe	289			
RES production	Mtoe	289	35%	RES share in gross final energy demand					56	7%	RES share in Gross Final Energy De
										17%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*107*	*38%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					16	6%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*152*	*47%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					38	12%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*30*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					1	1%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	2.937	-47%	compared to 1990					1232	22%	compared to 1990
Absolute GHG emissions	Mt CO2eq	2.937	-43%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	1.919	-51%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					246	11%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	1681	-41%	compared to 2005					986	35%	compared to 2005

Table 7: Sensitivity of the 2030 Reference Target system with respect to RES (high RES case)

Reference Target System 2030 (based on PRIMES2009), high RES									Distance to target		
									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	712	-41%	compared to reference					504	41%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*254*	*-26%*	*compared to reference*	*202*	*-41%*	*compared to reference*		*90*	*26%*	
Residential	*Mtoe*	*121*	*-61%*	*compared to reference*	*181*	*-41%*	*compared to reference*		*187*	*61%*	
Tertiary	*Mtoe*	*114*	*-38%*	*compared to reference*	*108*	*-41%*	*compared to reference*		*71*	*38%*	
Transport	*Mtoe*	*223*	*-41%*	*compared to reference*	*222*	*-41%*	*compared to reference*		*156*	*41%*	
Final energy intensity target	toe/MEuro'05	42	-41%	compared to reference					30	41%	
Final energy saving target	Mtoe	504	-41%	compared to reference					504	41%	
	Mtoe	461	-39%	compared to 2005					461	39%	
2) Primary Energy											
Absolute primary energy target	Mtoe	857	-49%	compared to reference					831	49%	
Primary energy intensity target	toe/MEuro'05	51	-49%	compared to reference					49	49%	
Primary energy saving target	Mtoe	831	-49%	compared to reference					831	49%	
							RES production absolute in 2030 reference development				
3) Renewable energy							Mtoe	233			
							RES production absolute in 2030 target system				
							Mtoe	357			
RES production	Mtoe	357	48%	RES share in gross final energy demand					124	17%	RES share in Gross Final Energy De
										30%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*106*	*47%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					16	7%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*223*	*69%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					109	34%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*27*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					-1	-1%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	2.467	-55%	compared to 1990					1703	31%	compared to 1990
Absolute GHG emissions	Mt CO2eq	2.467	-52%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	1.449	-63%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					246	11%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	1210	-57%	compared to 2005					1457	51%	compared to 2005

Table 8: Sensitivity of the 2030 Reference Target system with respect to Structural Change (stronger structural change than in PRIMES 2009)

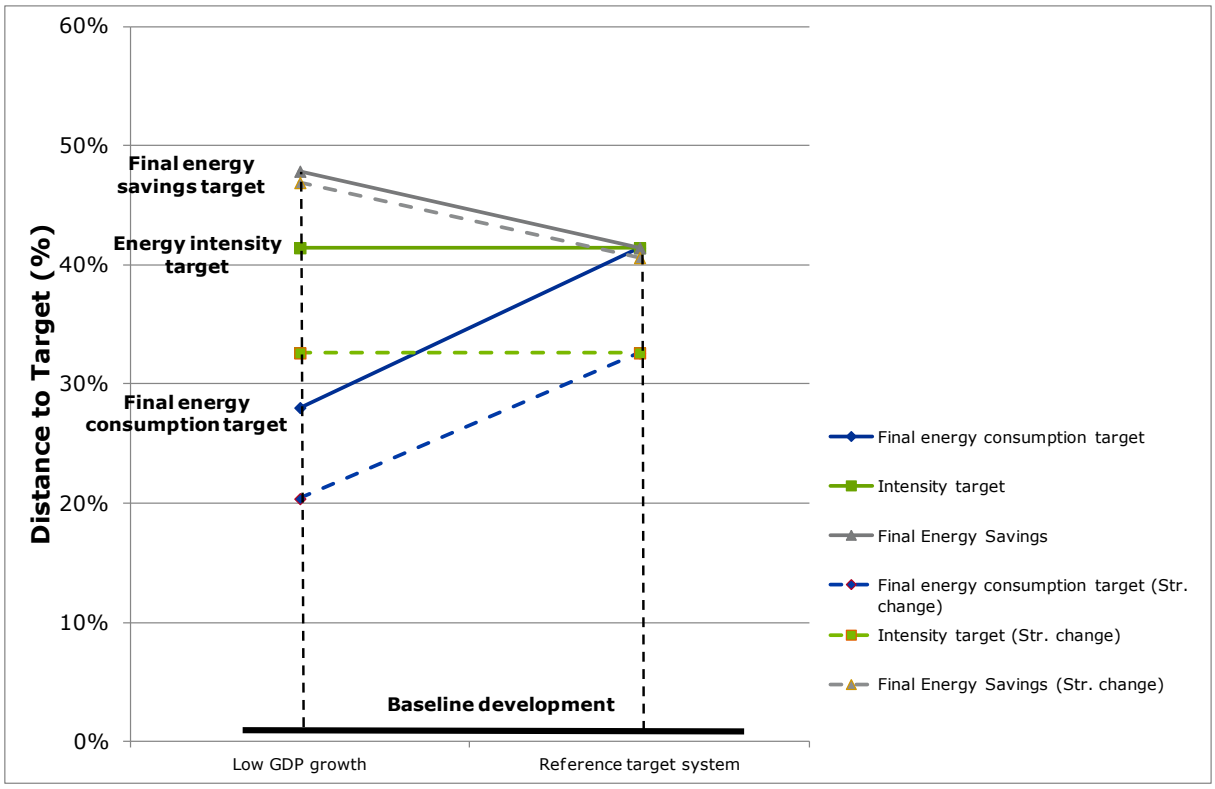
Reference Target System 2030 (based on PRIMES2009), actual development: structural change scenario									Distance to target		
									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 - structural change scenario		
Absolute final energy target	Mtoe	712	-41%	compared to reference					397	33%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*254*	*-26%*	*compared to reference*	*202*	*-41%*	*compared to reference*		*-22*	*-6%*	
Residential	*Mtoe*	*121*	*-61%*	*compared to reference*	*181*	*-41%*	*compared to reference*		*187*	*61%*	
Tertiary	*Mtoe*	*114*	*-38%*	*compared to reference*	*108*	*-41%*	*compared to reference*		*75*	*41%*	
Transport	*Mtoe*	*223*	*-41%*	*compared to reference*	*222*	*-41%*	*compared to reference*		*156*	*41%*	
Final energy intensity target	toe/MEuro'05	42	-41%	compared to reference					24	33%	
Final energy saving target	Mtoe	504	-41%	compared to reference					504	41%	
	Mtoe	461	-39%	compared to 2005					461	39%	
2) Primary Energy											
Absolute primary energy target	Mtoe	905	-46%	compared to reference					624	37%	
Primary energy intensity target	toe/MEuro'05	54	-46%	compared to reference					37	37%	
Primary energy saving target	Mtoe	783	-46%	compared to reference					783	46%	
							RES production absolute in 2030 reference development				
3) Renewable energy							Mtoe	213			
							RES production absolute in 2030 target system				
							Mtoe	221			
RES production	Mtoe	260	35%	RES share in gross final energy demand					8	1%	RES share in Gross Final Energy De
										17%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*81*	*36%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					-28	-13%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*152*	*47%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					38	12%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*27*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					-1	-1%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	2.698	-51%	compared to 1990					1194	22%	compared to 1990
Absolute GHG emissions	Mt CO2eq	2.698	-47%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	1.680	-57%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					94	4%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	1441	-49%	compared to 2005					1100	39%	compared to 2005

Compare with Table 5

Table 9: Link between target formulation and sensitivities

Efficiency target formulation	**Sensitivity of the "Distance to Target"**
Targets formulated in absolute terms (consumption target) Equals: Targets formulated with respect to a fixed reference development or base year	Distance to target strongly sensitive to economic growth rate Resulting GHG emissions not sensitive to changes to economic growth rate (they are determined by the target level to be reached which does not change with economic growth) "Distance to target" particularly sensitive to renewables development if target formulated in primary energy terms (because of the "100% renewable like wind and solar"). "Distance to target" sensitive to the realization of energy efficiency potentials in both final/primary energy terms Targets easy to monitor and formulate
Targets formulated as absolute energy savings based on projections (or historic development)	Distance to target little to medium-sensitive to economic growth rate Resulting GHG emission little to medium sensitive to changes in economic growth rate (as about the same savings are to be achieved resulting GHG emissions will be higher or lower with different economic growth perspectives) Energy target particularly sensitive to renewable development if formulated in primary energy terms (because of the "100% renewable like wind and solar"). "Distance to target" sensitive to the realization of energy efficiency potentials in both final/primary energy terms Targets difficult to monitor but easy to formulate
Targets formulated in relative terms (intensity targets)	Important sensitivity to structural changes different from assumptions in the baseline. Distance to target not sensitive to growth rate as long as there is not a strong structural change compared to the assumed baseline. Resulting GHG emission strongly sensitive to economic growth rate Energy target particularly sensitive to renewable development if formulated in primary energy terms (because of the "100% renewable like wind and solar"). "Distance to target" sensitive to the realization of energy efficiency potentials in both final/primary energy terms. Targets easy to monitor and formulate.

Figure 1: Sensitivities for the three main target formulations for final energy (absolute consumption targeted, intensity target, savings target). Dashed lines are for baseline scenario with stronger structural change than expected.



6. A 2030 Reference Target System with GHG emissions as the headline target

In principle the target system can also be accessed from the primary energy or CO_2/GHG side. But then one other target either the renewable target or the final energy target (or both) need to be adapted in case of change. Further, one can also access the target system from the energy intensity side (either primary or secondary and then recalculate the absolute values).

Table 10 shows an example of how energy efficiency and renewable targets would have to be adapted to cope with a GHG target as a headline target. In this variant care was taken that the adaptations concerned both energy efficiency and renewable about equally.

Energy efficiency evolves with a reduction of 25% in terms of final energy and 27% in terms of primary energy not very strongly beyond 2020. The same happens with renewable were the RES share in Gross Final Energy Consumption would just reach 28% in 2030, and the renewable electricity share around 35%.

Table 11 shows the case of lower than in Primes 2009 expected economic growth. As emissions would be lower due to lower activity levels, the contribution of energy efficiency and renewable options must be lower in order to maintain the same GHG targets. This clearly shows that in case of lower economic growth a GHG headline target would reduce the developments of energy efficiency and renewable targets, independent in which format they have been formulated (absolute, in intensity terms or as saving targets. The opposite would be true in stronger than expected economic growth scenarios. In fact the reduction in primary energy would be with 20% barely beyond 2020 targets in percentage terms and the renewable with a share of 18% would have to be lower than the 2020 value. It should also be noted that the presently installed RES already produced in 2012 an estimated amount of 160 Mtoe, pretty close to the target production of 159 Mtoe specified in the table for 2030.

Table 12 shows the same low-growth case but with the RES share unchanged as compared to Table 10. In that case there is no reduction in final energy required as compared to the baseline and primary energy would have to decrease by 8% as compared to the baseline. Still the greenhouse gas reduction would slightly exceed the 40% reduction level.

Table 10: Reference target system for 2030 in case of a 40% GHG headline target and economic growth according to PRIMES 2009

Reference Target System 2030 (based on PRIMES2009), 40% GHG headline target									Distance to target		
									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	912	-25%	compared to reference					304	25%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*290*	*-16%*	*compared to reference*	*258*	*-25%*	*compared to reference*		*54*	*16%*	
Residential	*Mtoe*	*195*	*-37%*	*compared to reference*	*231*	*-25%*	*compared to reference*		*113*	*37%*	
Tertiary	*Mtoe*	*142*	*-23%*	*compared to reference*	*139*	*-25%*	*compared to reference*		*43*	*23%*	
Transport	*Mtoe*	*285*	*-25%*	*compared to reference*	*284*	*-25%*	*compared to reference*		*94*	*25%*	
Final energy intensity target	toe/MEuro'05	54	-25%	compared to reference					18	25%	
Final energy saving target	Mtoe	304	-25%	compared to reference					304	25%	
	Mtoe	261	-22%	compared to 2005					261	22%	
2) Primary Energy											
Absolute primary energy target	Mtoe	1.142	-32%	compared to reference					546	32%	
Primary energy intensity target	toe/MEuro'05	68	-32%	compared to reference					32	32%	
Primary energy saving target	Mtoe	546	-32%	compared to reference					546	32%	
							RES production absolute in 2030 reference development				
3) Renewable energy								Mtoe	233		
							RES production absolute in 2030 target system				
								Mtoe	271		
RES production	Mtoe	271	28%	RES share in gross final energy demand					37	4%	RES share in Gross Final Energy De
										10%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*123*	*34%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					32	9%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*113*	*35%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					-1	0%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*35*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					6	3%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	3.319	-40%	compared to 1990					851	15%	compared to 1990
Absolute GHG emissions	Mt CO2eq	3.319	-35%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	2.301	-42%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					246	11%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	2062	-28%	compared to 2005					605	21%	compared to 2005

Table 11: Reference target system for 2030 in case of a 40% GHG headline target and low economic growth (roughly equal change RES/HH)

Reference Target System 2030 (based on PRIMES2009), 40% GHG headline target, low economic growth									**Distance to target**		
("Equal reduction RES and EE")									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	870	-17%	compared to reference					183	17%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*265*	*-11%*	*compared to reference*	*246*	*-17%*	*compared to reference*		*33*	*11%*	
Residential	*Mtoe*	*199*	*-26%*	*compared to reference*	*220*	*-17%*	*compared to reference*		*68*	*26%*	
Tertiary	*Mtoe*	*134*	*-16%*	*compared to reference*	*132*	*-17%*	*compared to reference*		*26*	*16%*	
Transport	*Mtoe*	*272*	*-17%*	*compared to reference*	*271*	*-17%*	*compared to reference*		*57*	*17%*	
Final energy intensity target	toe/MEuro'05	60	-17%	compared to reference					13	17%	
Final energy saving target	Mtoe	183	-17%	compared to reference					183	17%	
	Mtoe	304	-26%	compared to 2005					304	26%	
2) Primary Energy											
Absolute primary energy target	Mtoe	1.082	-26%	compared to reference					380	26%	
Primary energy intensity target	toe/MEuro'05	74	-26%	compared to reference					26	26%	
Primary energy saving target	Mtoe	380	-26%	compared to reference					380	26%	
							RES production absolute in 2030 reference development				
3) Renewable energy							Mtoe	202			
							RES production absolute in 2030 target system				
							Mtoe	159			
RES production	Mtoe	159	18%	RES share in gross final energy demand					-43	-5%	RES share in Gross Final Energy De
										-1%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*42*	*11%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					-36	-10%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*84*	*30%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					-15	-5%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*33*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					8	4%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	3.317	-40%	compared to 1990					293	5%	compared to 1990
Absolute GHG emissions	Mt CO2eq	3.317	-35%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	2.436	-38%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					44	2%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	2060	-28%	compared to 2005					249	9%	compared to 2005

Table 12: Reference target system for 2030 in case of a 40% GHG headline target and low economic growth ("RES share unchanged")

Reference Target System 2030 (based on PRIMES2009), GHG headline target + low economic growth									**Distance to target**		
("RES shares constant")									Target fixed on PRIMES2009		
1) Final Energy									+ PRIMES2009 development		
Absolute final energy target	Mtoe	1.053	0%	compared to reference					0	0%	
Sectoral targets:		Potential-based			Flat				Potential-based		
Industry	*Mtoe*	*298*	*0%*	*compared to reference*	*298*	*0%*	*compared to reference*		*0*	*0%*	
Residential	*Mtoe*	*267*	*0%*	*compared to reference*	*267*	*0%*	*compared to reference*		*0*	*0%*	
Tertiary	*Mtoe*	*160*	*0%*	*compared to reference*	*160*	*0%*	*compared to reference*		*0*	*0%*	
Transport	*Mtoe*	*328*	*0%*	*compared to reference*	*328*	*0%*	*compared to reference*		*0*	*0%*	
Final energy intensity target	toe/MEuro'05	72	0%	compared to reference					0	0%	
Final energy saving target	Mtoe	0	0%	compared to reference					0	0%	
	Mtoe	121	-10%	compared to 2005					121	10%	
2) Primary Energy											
Absolute primary energy target	Mtoe	1.266	-13%	compared to reference					196	13%	
Primary energy intensity target	toe/MEuro'05	87	-13%	compared to reference					13	13%	
Primary energy saving target	Mtoe	196	-13%	compared to reference					196	13%	
							RES production absolute in 2030 reference development				
3) Renewable energy							Mtoe	202			
							RES production absolute in 2030 target system				
							Mtoe	312			
RES production	Mtoe	312	28%	RES share in gross final energy demand					110	10%	RES share in Gross Final Energy De
										10%	Percentage diff. Ref.-Target
RES-H	*Mtoe*	*174*	*35%*	*RES-H share in heating/cooling (as defined by Directive 2009/28/EC)*					96	19%	RES-H share in heating/cooling dema
RES-E	*Mtoe*	*98*	*35%*	*RES-E share in gross electr. demand (as defined by Directive 2009/28/EC)f*					-1	0%	RES share in Gross Electricity Dema
RES-T	*Mtoe*	*40*	*15%*	*RES-T share in transport (as defined by Directive 2009/28/EC)*					15	6%	%RES-T, transport as in Article 3(4)a
4) Resulting GHG emissions											
Absolute GHG emissions	Mt CO2eq	3.275	-41%	compared to 1990					335	6%	compared to 1990
Absolute GHG emissions	Mt CO2eq	3.275	-36%	compared to 2005							
CO2 emissions (energy-related)	Mt CO2eq	2.394	-39%	compared to 1990							
5) ETS/Efforts-sharing											
ETS emissions	Mt CO2eq	1257	-45%	compared to 2005					44	2%	compared to 2005
Effort-sharing sectors emissions	Mt CO2eq	2018	-29%	compared to 2005					291	10%	compared to 2005

7. Summary tables and figures

This section provides a summary view on the different results starting with the cost effective saving potentials which have been used in this study in section 7.1 and providing a summary of main mechanisms emerging from the different forms of formulation of energy efficiency targets and target interactions in section 7.2.

7.1 Summary of cost effective energy savings potentials

The cost-effective savings potential is defined as the savings that can be realized through energy efficiency improvement measures that deliver over their lifetime net financial benefits for the individual actor making the investment, in addition to many macro-economic and other societal co-benefits. The investment costs are discounted at normal rates and are calculated under the assumption that non-economic barriers to efficiency, e.g. lack of access to information and split-incentives, are removed.

The proposed energy savings target is based on the most detailed and available bottom-up assessment of the cost-effective energy savings potentials, which was developed by Fraunhofer ISI for the European Commission in 2009[18] and updated in 2012 for the German Environment Ministry[19]. It takes a conservative approach to assessing the potentials by considering:

- The cost effectiveness of each type of intervention, e.g. the replacement of equipment and materials with more efficient commercially available alternatives, new industrial processes or building refurbishment;
- Removal of key market and non-economic barriers, e.g. lack of information and access to financing;
- Investment cycles follow normal, historical patterns and drivers, and only commercially available technologies are applied.[20]

The result is (see Figure 2): The overall energy end use savings potential is 504 Mtoe, which corresponds to 41% reduction compared to the Primes 2009 baseline for final energy[21], composed of individual sector potentials: residential (61%), transport (41%), tertiary (38%) and industry (26%).

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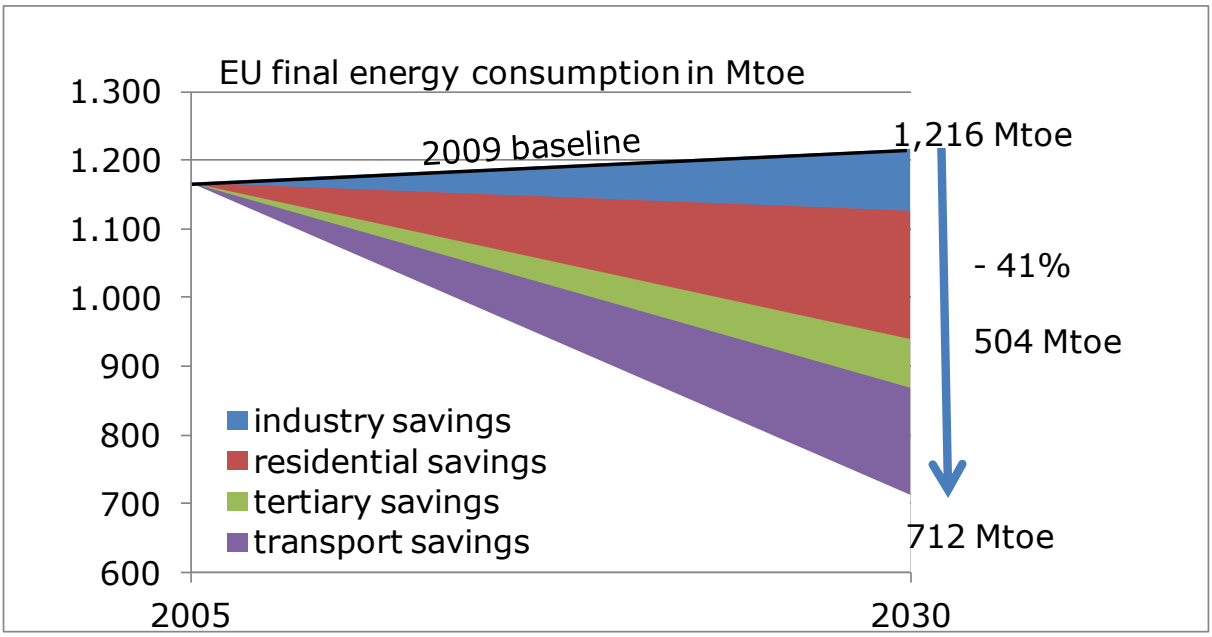
[18] Fraunhofer ISI et al. 2009; Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries - Final Report for the European Commission Directorate-General Energy and Transport.

[19] Fraunhofer ISI 2012; Contribution of Energy Efficiency Measures to Climate Protection within the European Union until 2050, German Federal Ministry for the Environment. http://www.isi.fraunhofer.de/isi-en/e/projekte/bmu_eu-energy-roadmap_315192_ei.php

[20] Another more common approach is macro-economic modelling, as done for most EU projections, which applies usually a set of equations to simulate equilibrium between demand and supply. As there is no functioning market for energy efficiency, the simulations cannot adequately handle efficiency effects, and an arbitrarily high discount rate is used to approximate non-economic barriers. This leads to an overestimation of costs of energy efficiency measures, and thus significantly possible lower improvements in end-use energy efficiency.

[21] On the primary energy side there is an interaction between demand side and supply side potentials which has been taken into account in the calculations in this report.

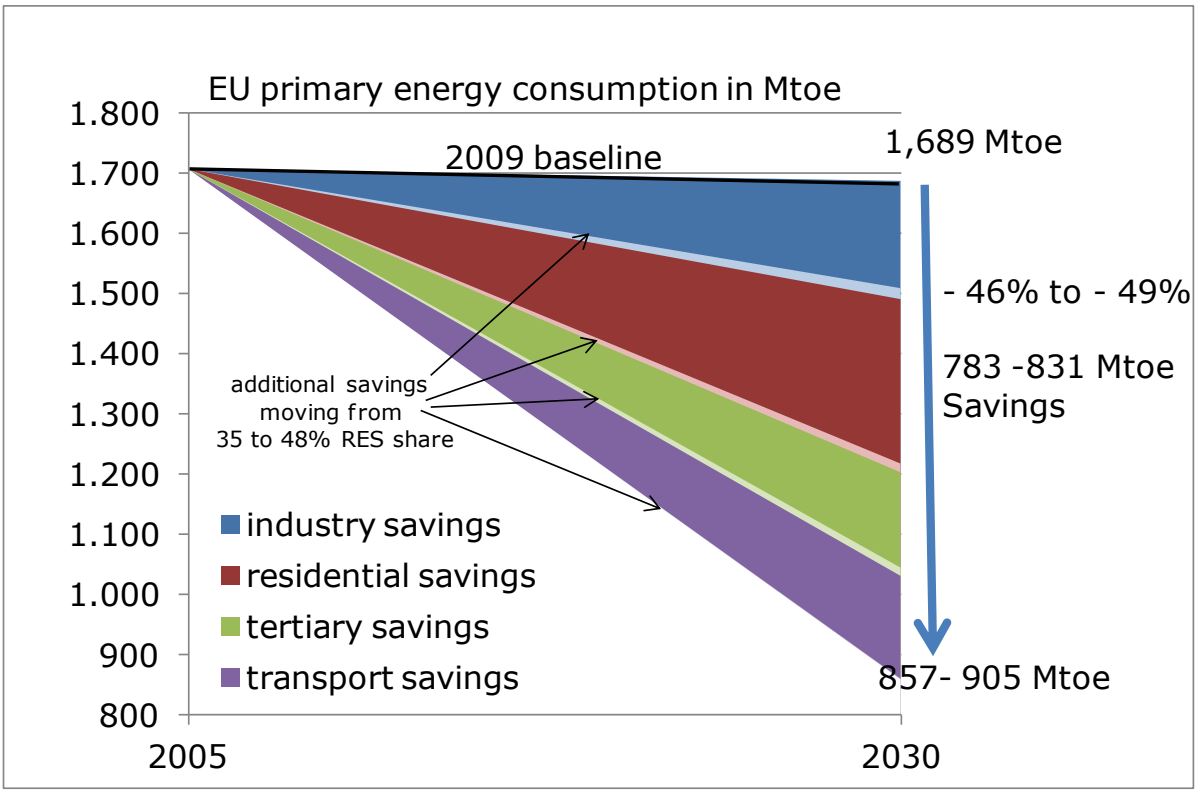
Figure 2: Results of bottom-up modelling of cost-effective saving potentials, showing the relative contribution of different sectors to the overall target



41% end use savings translates into 46-49% primary energy savings[22] compared to 2009 baseline and a similar reduction compared to 2005 levels (see Figure 3). It would help the EU to stay below 905 to 857 Mtoe primary energy consumption. This is assuming efficiency improvements in the supply, transformation and distribution and reaching 35 - 48% renewable energy share by 2030 while increasing the share of electricity in final demand from 25 to 38%.

[22] Primary energy is defined here as in the Energy Efficiency Directive EED, i.e. excluding non-energy use, to be distinguished from Gross Domestic Consumption which includes the non-energy uses.

Figure 3: Primary energy saving potentials, depending on different assumptions of renewable energy shares



7.2 Summary of main mechanisms emerging from the different forms of formulation of energy efficiency targets and target interactions

The following main mechanisms emerge from the different forms of formulation of energy efficiency targets (see detailed numbers in Table 13 and the associated Figures):

- If an energy efficiency target is formulated in absolute terms (**consumption target**) the uncertainty remains with energy efficiency policies and programmes, i.e. low GDP = low energy efficiency investments and vice versa.
- If an energy efficiency targets is formulated in relative terms (**intensity target**) the investments will also be lower for energy efficiency as the activity levels depend on economic growth. There is also a strong impact of possible additional structural changes.
- If an energy efficiency targets is formulated in saving terms (**saving target**) the investments are fixed and do not depend on economic growth. Uncertainties will have to be handled by GHG policies, i.e. lower GDP = lower carbon price and vice-versa. Energy saving targets appear as most stable compared to potential changes in activity levels and structural changes as assumed for a reference target system though they do not assure that absolute energy consumption will decrease and monitoring is more challenging as evidenced by the development of discussions around the Energy Service Directive, the predecessor of the Energy Efficiency Directive. However, given the fact that primary energy consumption is stabilizing in the EU27, it appears that promoting substantial amounts of energy savings also leads to an absolute reduction in primary energy consumption. Further, much has been learned about monitoring energy savings in the past years which should help establishing a reliable monitoring system.

Important in that context is to clearify from the beginning which type of savings are to be included in the monitoring system and to make the distinction between autonomous and previous savings on the one hand as compared to additional savings on the other hand.

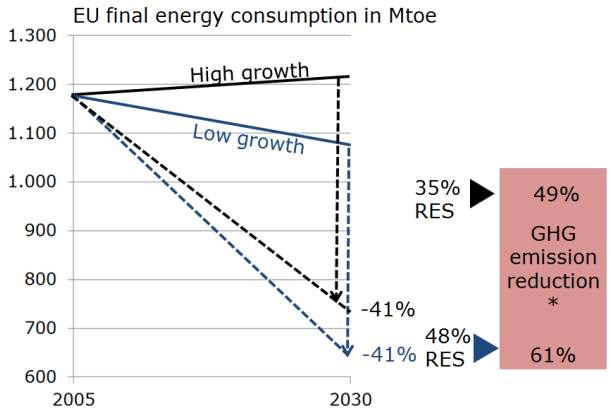
- A **different development of renewable energy sources compared** to the reference target system impacts only on energy efficiency investments if the target is formulated in primary energy terms, and then equally on either way of formulating the energy efficiency target (**interaction energy efficiency and RES targets**).
- An incomplete realization of (demand side) energy efficiency potentials impacts equally final and primary energy formulations of energy efficiency targets.

The interactions between energy savings and greenhouse gas emission reductions are illustrated by the following scenarios[23]:

<u>A. Full realisation of a 41% energy savings potentials with</u>

- High growth and 35% renewable energy share
- Low growth and 48% renewable energy share

⇨ **Results in at least 49 to 61% greenhouse gas emissions reductions compared to 1990**

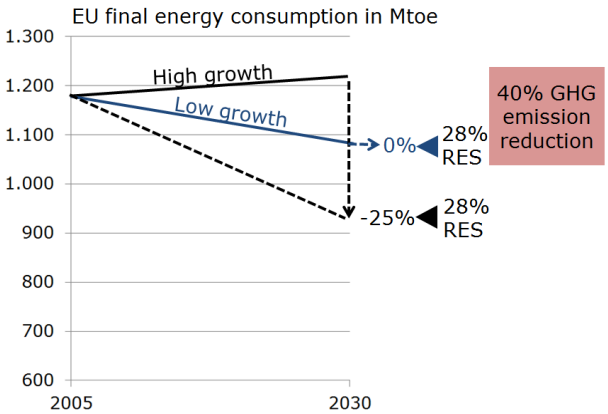


*Impacts of climate policies for non-energy greenhouse gas emissions are additional

<u>B. Reducing greenhouse gas emissions by 40% compared to 1990 levels with</u>

- High growth and 28% renewable energy share
- Low growth and 28% renewable energy share

⇨ **Requires no additional energy savings and could lead to increasing wastage of energy**



25% savings are already delivered by existing policies; no savings would actually mean decreasing energy efficiency and increasing energy wastage

The analysis finally also shows that independent from the choice of target formulation it is important **to integrate dynamic elements into the target formulation of 2030 targets or at least foresee intermediate steps of target adaptation in regular intervals**. There is

[23] In these scenarios high growth is 1.83% per annum (which corresponds to the PRIMES 2009 projections) and low growth is 1.46% per annum. Latest available EU projections published by ECFIN estimate a growth of 1.5-1.6% per annum until 2030, see European Commission 2013; Economic and budgetary projections for the 27 EU Member States (2010-2060), The 2012 Ageing Report.

certainly a compromise to be made between stability in targets to be provided to the actors and strong deviations from original targets but otherwise, depending on the target formulation, the impacts of economic growth and structural changes can be very important.

Table 13: Overview of sensitivity calculations for 2030

Comparison of 2030 sensitivities

Final Energy

	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Final Energy (% compared to baseline)	-41%	41%	28%	-35%	-41%	-33%	-25%	-17%	0%
	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Final Energy Intensity (% compared to base	-41%	41%	41%	-35%	-41%	-33%	-25%	-17%	0%
	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Final Energy Savings (% compared to basel	-41%	41%	48%	-35%	-41%	-41%	-25%	-17%	0%

Primary Energy

	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target (low growth)	GHG Headline target (low growth)	GHG Headline target (low growth)
Primary Energy (% compared to baseline)	-46%	46%	38%	-42%	-49%	-37%	-32%	-26%	-13%
	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Primary Energy Intensity (% compared to b	-46%	46%	46%	-42%	-49%	-37%	-32%	-26%	-13%
	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Primary Energy Savings (% compared to ba	-46%	46%	54%	-42%	-49%	-46%	-32%	-26%	-13%

Renewables Energy

	Reference target system	Distance to target	Distance to target (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
RES (% in gross final energy demand)	35%	4%	4%	35%	48%	35%	28%	18%	28%
Mtoe	Reference target system		Reference target system (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Absolute RES production (Baseline)	233		202	233	233	213	233	202	202
Absolute RES production (Target System)	260		225	289	357	221	271	159	312
Distance to target	27		23	56	124	8	37	-43	110

GHG emissions/ETS/Effort sharing

	Reference target system	Distance to reference target system emissions	Distance to reference target system emissions (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
GHG emissions (% compared to 1990)	-49%	24%	14%	-47%	-55%	-51%	-40%	-40%	-41%
	Reference target system	Distance to reference target system emissions	Distance to reference target system emissions (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Energy-related CO2 emissions (% compare	-54%			-51%	-63%	-57%	-42%	-38%	-39%
	Reference target system	Distance to reference target system emissions	Distance to reference target system emissions (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
ETS emissions	-45%	11%	2%	-45%	-45%	-45%	-45%	-45%	-45%
	Reference target system	Distance to reference target system emissions	Distance to reference target system emissions (low growth)	Partial realisation EE Potentials (85%)	High Res	Structural change	GHG Headline target 40%	GHG Headline target 40% (low growth)	GHG 40% (low growth, RES share const)
Effort-sharing sectors emissions	-45%	38%	26%	-41%	-57%	-49%	-28%	-28%	-29%

Figure 4: Required reduction in final and primary energy

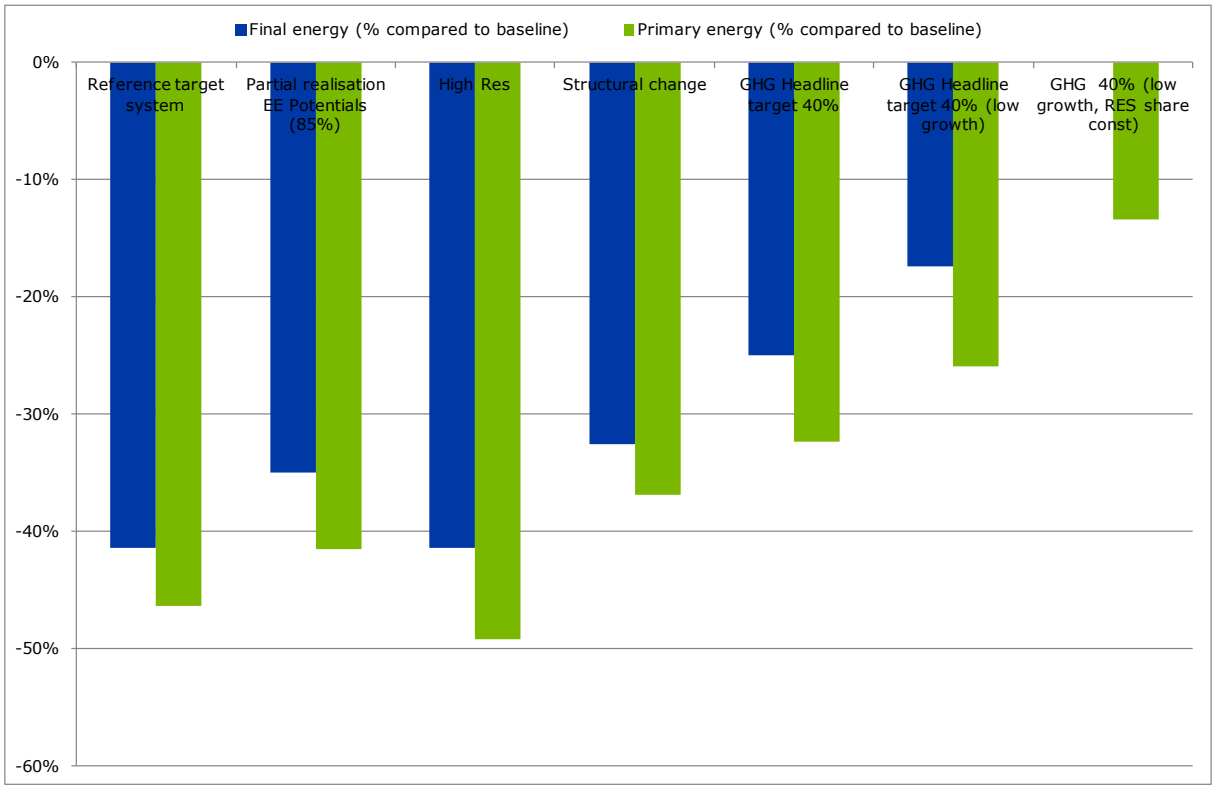
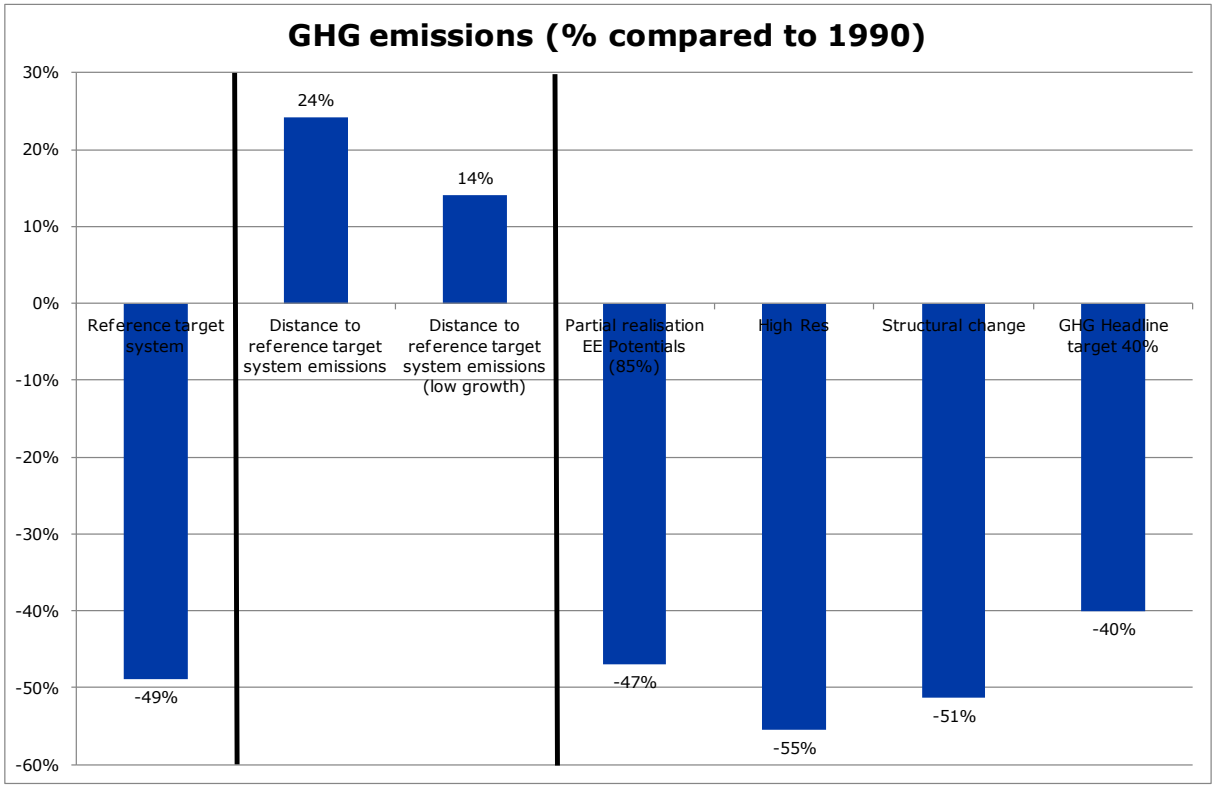


Figure 5: GHG emissions compared to 1990



ANNEX: Summary of the bottom-up assessment of the cost-effective energy savings potentials

The details of the bottom-up assessment of the cost-effective energy savings potential can be found in the Fraunhofer (2012) study[24]. This study looks at final and primary energy savings up to 2050. The following table simply summarizes the main final energy potentials calculated on the basis of the PRIMES 2009 baseline.

Energy savings potentials for 2030 (and underlying sector potentials)

	Change compared to PRIMES 2009 projection for 2030
Industry	*-26%*
Residential	*-61%*
Tertiary	*-38%*
Transport	*-41%*
Overall	***-41%***

The saving potentials identified should be understood as "realistic technical potentials" rather than theoretical potentials since their method of calculation follows a **scenario approach** that considers dynamic aspects in the uptake of technologies as well as the time horizon during which a technology may reasonably be available. Realistic technical energy-saving potentials depend on the future development of drivers such as the economic or social development (e.g. the stock of existing buildings or appliances may increase or decrease over time etc.). This takes into account that there are reinvestment cycles which depend on factors other than energy efficiency. Hence **the usual investment cycles are not substantially modified** with few exceptions. This is why the diffusion of energy efficiency potentials takes time and the technological potential identified does not penetrate the market immediately but takes at least the lifetime of the reference technology unless reinvestment cycles can be accelerated. **Non-economic barriers have not been translated into high discount rates** as for example in the PRIMES2009 projections but it was assumed that specific instruments could overcome such barriers[25].

With regard to the cost-effectiveness of efficiency technologies, **only economic technologies are selected** (i.e. the financial savings for the avoided fuel procurement exceed the additional

[24] Fraunhofer ISI 2012; Contribution of Energy Efficiency Measures to Climate Protection within the European Union until 2050, German Federal Ministry for the Environment.

[25] For example information barriers concerning energy efficient appliances have been overcome in the past by specific instruments such as appliances labels instead of raising energy prices to a level where consumers would start to look for the information themselves. This simple example shows that the economic lever would we a very inefficient instrument compared to the labeling approach.

investments required to implement the efficiency technology under the given assumptions concerning energy prices and discount rates) or at least near-economic ones, in order to include only technologies that are likely to reach market maturity. The following two graphs illustrate the bottom-up assessment methodology for the industry sector (pulp and paper industry) and a resulting cost curve for building related saving options up to 2050

Figure 6: Example of the details of energy savings in the industry sector and in particular the pulp and paper industry

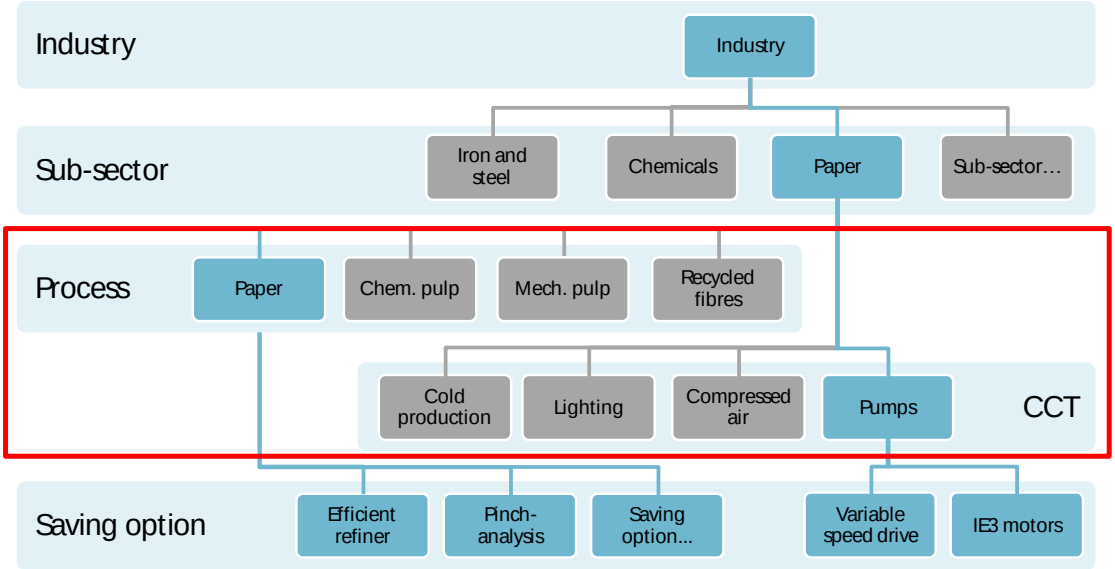
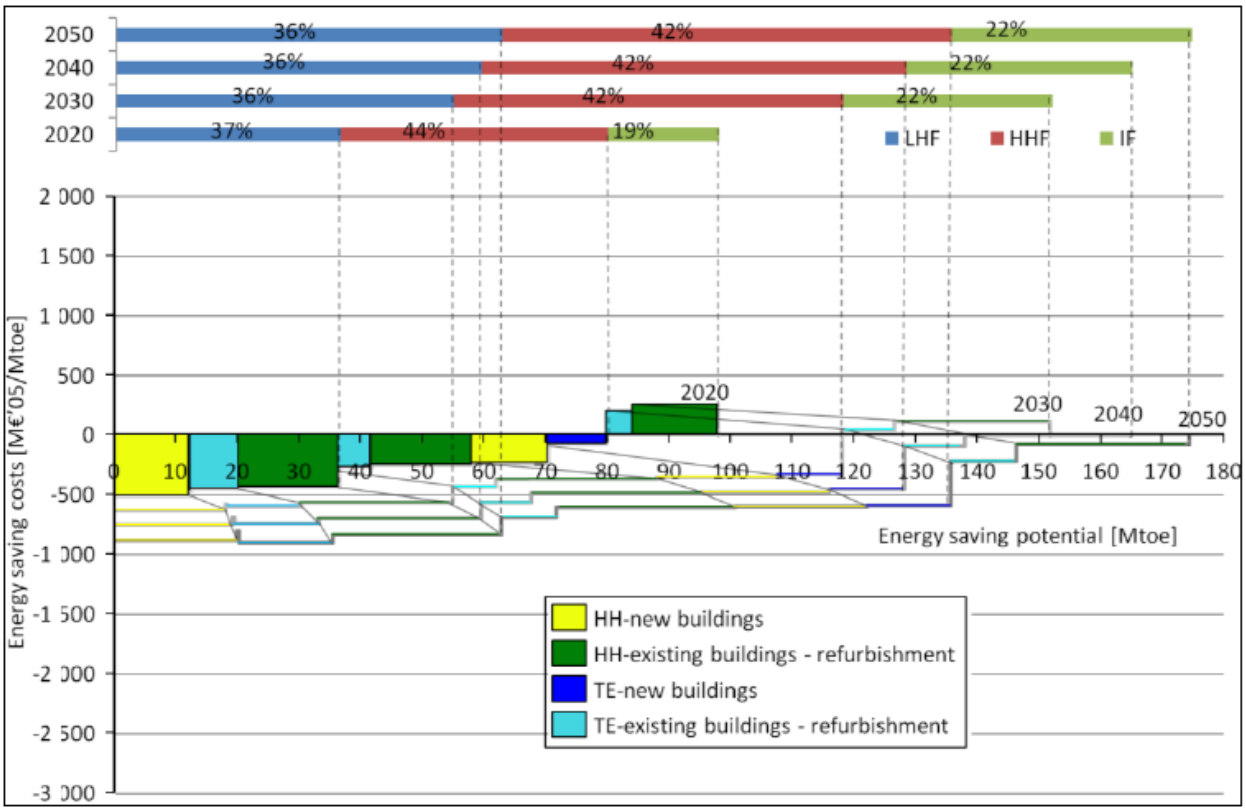



Figure 7: - Cost curve for building-related saving options up to 2050