Assessment of Austrian contribution toward EU 2020 Target Sharing

Determining reduction targets for 2020 based on potentials for energy efficiency and renewables

November 20007

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This is document is part of the Synthesis Report ***Assessing Austria in the EU 2020 Target Sharing*** coordinated by Nebojsa Nakicenovic, Vienna University of Technology and IIASA, and Stefan P. Schleicher, University of Graz and Austrian Institute of Economic Research, Vienna.

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1 Executive Summary

The Austrian contribution to the negotiation process

Austria is committed to contributing towards the process that allocates the EU 2020 Community targets for climate and energy to the Member States. We propose that any allocation scheme should reflect and take into account the following:

- The current status and specific circumstances of Member States as well as their emissions reduction commitments;
- Possible future developments, such as, increase in economic activities and potentials for energy efficiency improvements and GHG reductions;
- That the efforts required by each Member State to achieve Community targets be revealed in a transparent and reproducible procedure.

Three-step procedure for determining contraction and convergence

Based on the above, a three-step procedure for determining and sharing reduction targets in the Member States is suggested:

- Development of contraction and convergence criteria that reveal differences among Member States in economic growth and technological potentials, together with harmonized economic and technological indicators. This first step results in obtaining **relative reduction targets**, a distribution of the Community targets to the Member States.
- An evaluation by each Member State of the effective reduction effort required by comparing the emissions of each relative reduction target with expected future reference emissions (without additional reduction efforts). This second step thus reveals the **effective reduction effort** needed.

An evaluation of sensitivity of thus determined reduction efforts by each Member State by taking into account **different target-sharing indicators** such as emissions intensities of per capita income or energy and Kyoto commitments.

A range of suggested targets for Austria

Using this three-step procedure, a range of GHG reduction targets for Austria are obtained that can be summarized as follows:

- Based on a WIFO-WegC reference scenario for 2020, Austria will need to achieve reductions **of more than 40%.**

This **effective reduction effort** is the result of:

- A **relative reduction target** in the range of 0% to 5% below 1990 emissions if contraction and convergence criteria are used for allocating the EU Target of 20% below 1990 levels.
- **Expected emissions increase** by 2020 in the baseline up to more than 40% over 1990 levels even in a rather cautious reference scenario;
- **A share of renewables** consistent with a scenario that meets in 2020 a 3% emissions target below 1990 and covers 28% of total energy supply by providing 445 PJ per year.
- **A sensitivity analysis** reveals the crucial impact of convergence both in economic and technology parameters within the EU-27 as well as the sensitivity as to the choice of single indicators.

Emissions reductions for Austria based on **Kyoto commitments** of all EU-27 countries indicates the need for a whopping minus 34% emissions decline by 2020 with respect to 1990 levels or minus 72% with respect to the 2020 emissions in the scenario. These constitute exceedingly large reductions.

Avoiding stranded investments and increasing GHG emissions

It is not possible to achieve any of these reduction targets with current trends. Immediate policy changes and actions are required to bring about a paradigm shift for deployment of carbon saving measures and policies.

Every investment decision needs to be reevaluated from this perspective. Otherwise, there is a risk of stranded investments or lock-in into carbon-intensive structures.

2 Background

2.1 The EU 2020 Targets

The 20% targets for greenhouse gases, renewables and energy efficiency

The 2007 Spring European Council agreed on three far-reaching targets for EU climate and energy policy:

- By 2020 greenhouse gas emissions need to be reduced by 20% compared with 1990 levels. The EU is committed to raising these reductions to 30% if countries like the United States, China and India commit themselves to comparable emission reductions.
- By 2020 the share of renewables needs to be raised to 20% and requires the Member States to have 10% biofuels in their transport fuel mix.
- By 2020 energy efficiency needs to be boosted by 20%, thus enabling saving 20% of total primary energy consumption.

Target Sharing and restructuring energy systems

Two challenging decisions are required to meet these ambitious targets: First, their allocation among the Member States, and second, the restructuring of the energy systems of the Member States.

We suggest procedures that support negotiations about 2020 Target Sharing and indicates which energy flows and energy mix – in particular renewables – are compatible with a given emissions target.

2.2 Procedures for deciding on Target Sharing

Conventional single criteria indicators

In allocating Community targets to Member States, indicators that differentiate according to emissions per person, per GDP or per energy used are usually suggested. These single criteria indicators are sometimes weighted to obtain multi-criteria indicators.

Structural indicators

In addition to using single and weighted multiple indicators here we also use a set of structural indicators based on the demand and supply structure of the energy system and related emissions. These indicators offer a number of advantages:

- The indicators refer to the key parameters that determine demand (such as economic activity and energy intensity) and supply of energy (such as conversion efficiency and energy mix) and the related emissions.
- These indicators are most suitable for specifying contraction and convergence targets.
- The conventional single criteria indicators follow from a specified set of structural indicators.

Contraction and convergence criteria

A major advantage of using a set of structural indicators is the ability to simulate contraction and convergence strategies. These criteria deserve special attention because of the obvious need to harmonize economic activity and technological standards among old and new Member States.

3 Austria's energy and carbon profile compared with EU-27

3.1 Austria's distance to the Kyoto target

Austria's greenhouse gas emissions are 36% above the Kyoto target

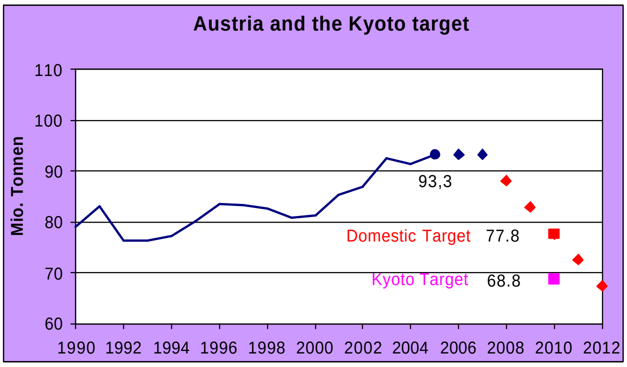
The last reported GHG emissions for Austria were 93.3 mt (million tons) of CO_2 equivalent for 2005. Thus, the 2005 emissions are 18% above 1990 emissions of 79.1 mt and 36% above Austria's Kyoto target of 68,8 mt (which requires a 13% reduction of 1990 emissions).

Table 1: Kyoto targets for EU-27

	Kyoto Target				
	Mill Tons	Mill Tons	Base = 100	Distance to Target (%)	
	Base year	2008 - 2012 p.a.		from Base	from Kyoto
Malta					
Spain	289.4	332.8	115.0	38	32
Cyprus					
Portugal	60.9	77.3	127.0	16	11
Ireland	55.8	63.1	113.0	13	11
Greece	111.1	138.9	125.0	1	-1
Austria	79.1	68.8	87.0	31	36
Italy	519.5	485.7	93.5	19	19
Slovenia	20.2	18.6	92.0	18	10
Luxembourg	12.7	9.1	72.0	28	39
Netherlands	214.6	201.7	94.0	6	5
Belgium	146.9	135.9	92.5	6	6
France	563.9	563.9	100.0	-2	-1
Finland	71.1	71.1	100.0	-3	-3
Denmark	69.3	54.7	79.0	14	20
Sweden	72.2	75.1	104.0	-11	-11
UK	779.9	682.4	87.5	-2	-4
Poland	586.9	551.7	94.0	-12	-28
Hungary	123.0	115.6	94.0	-12	-31
Germany	1,232.5	973.7	79.0	3	3
Czech Rep.	196.3	180.6	92.0	-18	-19
Slovakia	73.4	67.5	92.0	-26	-29
Romania	282.5	259.9	92.0	-30	-41
Bulgaria	132.1	121.5	92.0	-32	-42
Estonia	43.0	39.6	92.0	-43	-47
Lithuania	48.1	44.2	92.0	-45	-49
Latvia	25.9	23.8	92.0	-51	-54
EU-27	5,818.5	5357.3	92.1	0	-3
EU-15	4,278.9	3934.3	91.9	6	7
EU-16:27	1,539.6	1423.0	92.4	-20	-31

Austria's domestic Kyoto target

The reasons behind Austria's large distance to the Kyoto target can be identified by looking at a few indicators.

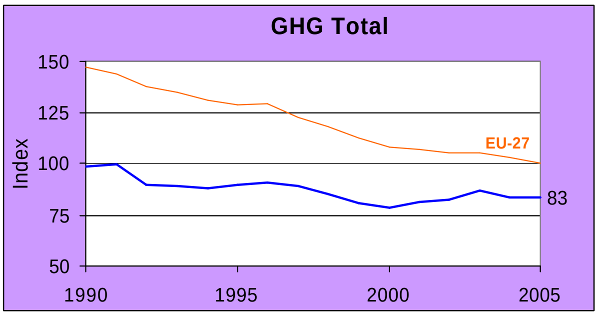


3.2 Austria's position relative to EU-27

Low overall GHG intensity

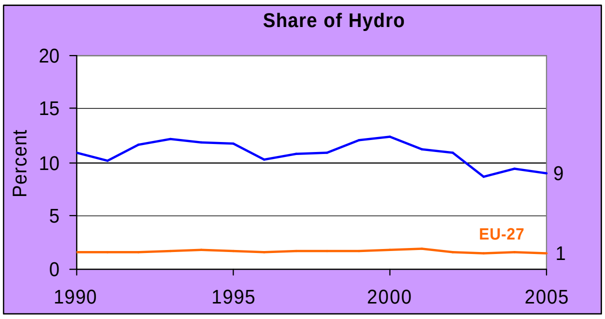
Austria's GHG intensity – the ratio of GHG to GDP at 2000 Euro purchasing power parity (ppp) is 17% below the corresponding indicator for the EU-27. However, the rate of improvement of Austrian GHG intensity was markedly below the EU-27 trends since 1990.

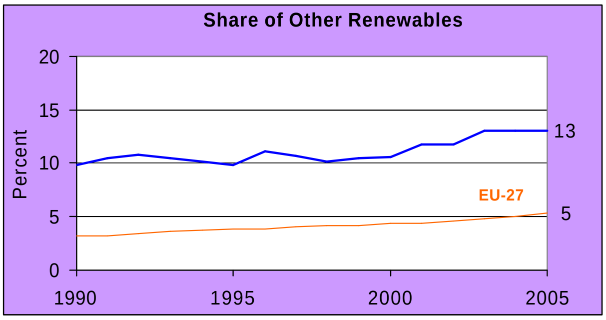
In order to facilitate comparisons, the series in this graph and similar ones are normalized such that the index value for the EU-27 is always 100 for the year 2005.



A very high share of renewables

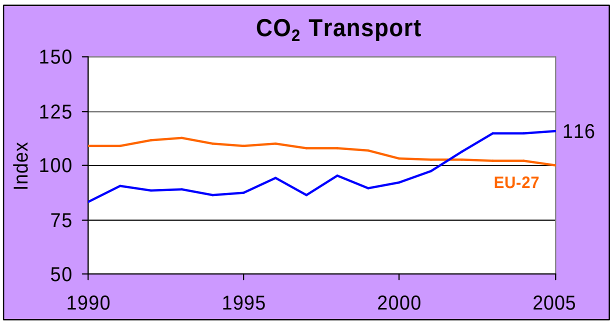
With a share of 22% of renewables (including hydro power) in total energy supply, Austria ranks with this indicator among the top Member States since for the EU-27 this share is only 6%.





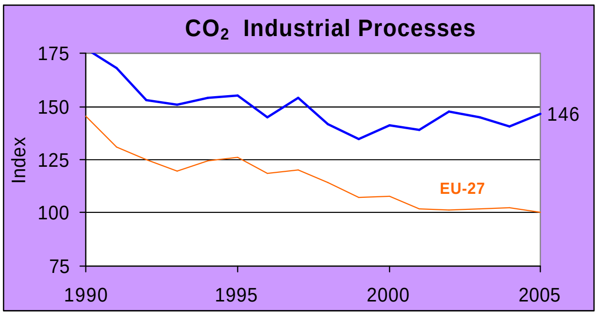
Extraordinary high increase of emissions from transport

Emissions from transport – again normalized by GDP – exhibit an extraordinary increase since the late 1990s and are now 16% higher than in the EU-27.



A very high share of industries with emissions from processes

Austria's emissions from industrial processes such as steel and cement production are 46% above the corresponding EU-27 indicator and have leveled off during the last decade while EU-27 have continued to decline.



4 Potentials for energy efficiency and GHG reductions

This section explores the potentials for improving energy efficiency and for reducing GHG emissions by looking at the following indicators:

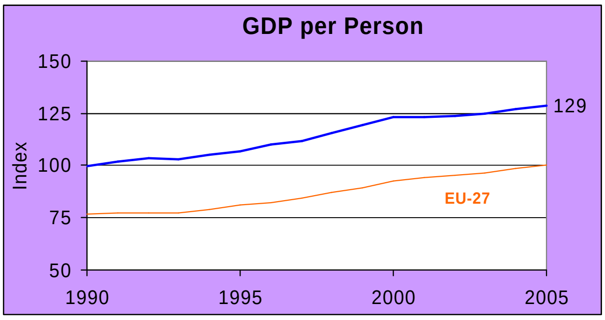
- Economic activity – real GDP per person
- Energy intensity – final energy consumption per GDP
- Transformation efficiency – the difference between total energy supply and final energy consumption
- Share of non-fossil energy in total energy supply
- Carbon intensity of fossil fuels – GHG per fossil energy supply

4.1 Economic activity, energy services and energy intensity

Very high intensity and dynamics of economic activity

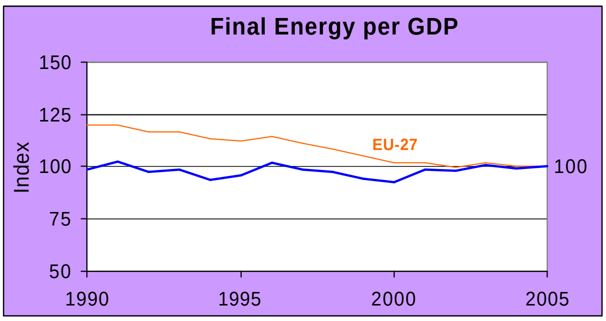
With 29% above GDP per person of the EU-27, Austria belongs to the top Member States in terms of both the intensity and dynamics of economic activity.

While decoupling energy flows from the energy services of mobility, housing and production is a highly desirable aim, over the next few years economic activity will remain the main driver for energy demand.



Average and stagnating energy intensity

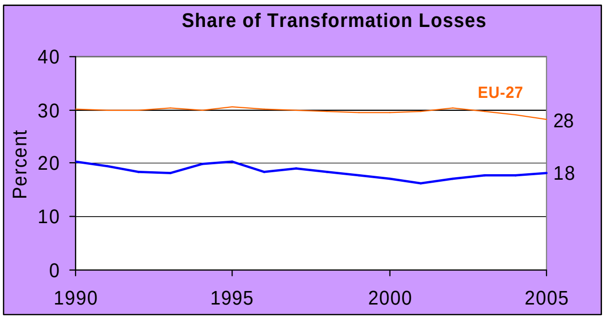
Austria's energy intensity – the amount of final energy consumption per unit of real GDP – is about the same as for the EU-27 but stagnating. While the EU-27 energy intensity improved by almost 25% between 1990 and 2000, there was no noticeable improvement in Austria. This reveals a substantial potential for increasing the efficiency in final energy.



4.2 Energy transformation and energy supply

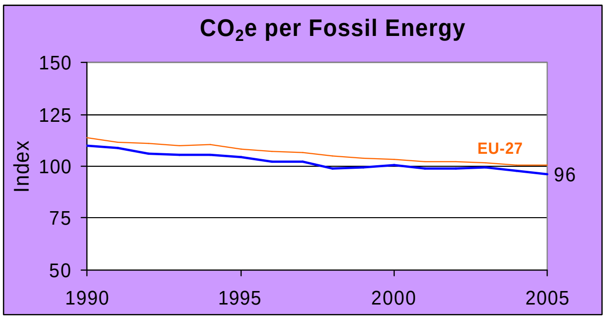
Lowering transformation and distribution losses

Although Austria's 18% losses of total energy supply from transformation and distribution of energy are much lower than the corresponding 28% for EU-27, there is still a large potential for lowering these losses by increasing the use of cogeneration technologies in thermal conversion processes.



A further shift from coal to gas

Austria's carbon intensity of fossils – approximated for this aggregate analysis by GHG per unit of fossil energy supply – is 4% below the corresponding EU-27 indicator. Lowering the Austrian carbon intensity of fossils would require in particular a shift from remaining coal to gas.



5 The potential for renewables

5.1 Theoretical and technical potentials

International comparisons

Renewable energy accounted for over 15% of world primary energy supply in 2004, including traditional biomass with between 7% and 8%, large hydro-electricity with 5.3% (16% of electricity), and other "new" renewables with 2.5% (IPCC, 2007).

In 2005, the share of renewable energy in the EU-27 was 6.7%, including 4.6% bioenergy (all forms of biomass), 0.3% wind and 1.5% hydropower (IEA, 2006).

In comparison, renewable energy contributions were significantly larger in Austria in 2005 with a share of 22% in total primary energy, including 8.8% bioenergy (wood, biofuels and wastes), 0.4% wind and 9% hydropower.

Renewable potentials are large

Future renewable energy potentials are large compared to the current contributions. This is true at the global level, in the EU-27 and in Austria. For example, it is estimated that the global technical potential by 2020 for renewable energy sources could exceed current total primary energy by three to four times (Energy Primer, 1995, WEA, 2000). The still-to-be-developed potential is large in absolute terms, corresponding to a third of all primary energy needs in 2005. The current share of renewables is about 22%, meaning that in principle it could be increased to 50% (assuming no further growth in energy demand, an unlikely possibility).

Difference between theoretical and technical potentials

Renewable energy sources represent annual flows that are available, in principle, on an indefinite and sustainable basis. In contrast, fossil energy reserves and resources, although expanding over time, are fundamentally finite quantities. In this context, the annual natural flows of solar, wind, hydro, and geothermal energy are potentially available in nature in the form of biomass, wind, rivers, solar insulation, geothermal sources and so on. Often, these flows are referred to as **theoretical potentials**. The theoretical potential is usually characterized in the literature as the amount of renewable energy sources that can be conceivably maximally harnessed independent of whether the technologies that would be required exist or not. In contrast, the **technical potential** includes all of the practical constraints that limit the theoretical potential but does not include economic considerations.

The technical potential of renewables is significantly smaller than the theoretical one

In other words, the distinction between theoretical and technical potentials reflects the degree of possible use determined by thermodynamic or technological limitations without consideration of practical feasibility or costs (WEA, Chapter 5, 2000). The technical potential is the portion of the theoretical potential that can be harnessed by accounting for all sorts of recovery, practical and technical considerations (Energy Primer, 1995). Sometimes, the technical potential is limited to deployment of technologies or practices that have already been demonstrated. Usually, the definition of technical potential does not include any specific reference to costs, but only to "practical constraints" although in some cases implicit economic considerations are taken into account (IPCC, 2007). The economic potential is the portion of the technical potential that could be used cost-effectively and is generally significantly smaller. The theoretical potential is the largest, technical is smaller while the economic potential is the smallest of all three magnitudes.

5.2 Assessing practical potentials by 2020 for Austria

Practical potentials are based on eight studies

In this assessment, more practical potentials are presented that can be realized by 2020 with current and near- to medium-term technologies, limitations and cost structures. The estimated 2020 potentials are based on eight recent literature sources (some still available only as initial drafts). The economic potentials can be assumed to be generally smaller than the practical potential by 2020 presented in this assessment. Table 2 gives an overview of additional renewable potentials by 2020. The ranges across eight different studies are presented, from the smallest to the largest value for biomass, solar photovoltaic and thermal, wind, hydro, geothermal and other environmental renewable energy sources. These ranges reflect the degree of uncertainty across different estimates. The lower values are more likely to be realizable with near-term technologies and economic conditions, while the higher ones are likely to require more suitable economic conditions, further improvements of technologies and institutional arrangements.

The estimates of 2020 potentials are quite similar

Table 3 summarizes the potentials reported in the eight sources used in this study, while Box 1 summarizes some of the salient characteristics of the eight studies. The congruence of renewable potentials by 2020 is quite high given the numerous uncertainties surrounding such estimates. The largest difference is a factor of 4.5 between the lowest and highest estimates for photovoltaics and the smallest is barely 10% in the case of bioenergy.

Technical potentials beyond 2020 are significantly larger

In comparison, the theoretical and technical potentials are large but cannot be implemented by 2020. The VEÖ Study (Source 1) presents the theoretical and technical potentials of all sources of electricity in Austria. The theoretical potential of hydropower is estimated at 908 PJ and a technical potential at 216 PJ (equivalent to 2005 Austrian electricity generation), compared to the much more humble additional practical potential by 2020 of up to some 25 PJ given in Table 3. Wind technical potential is estimated at 32.4 PJ and practical by 2020 of 16 to 26 PJ (Table 2). Solar theoretical potential is large with 332 EJ (332 thousand PJ) with technical photovoltaic potential of 93 EJ and solar thermal technical potential of between 111 and 222 EJ. The practical potential by 2020 is significantly smaller with 2 to 9 PJ photovoltaics and 10 to 25 PJ solar thermal. Finally, the theoretical potential of ambient energy (extracted through heat pumps) is 11.8 EJ, the technical potential about 122 to 142 PJ (roughly 50% of the 2005 heat and process heat in Austria), while the practical potential by 2020 ranges from 23 to 27 PJ.

Table 2: Overview: Range of possible realizable potentials of renewable energies in Austria in 2020

Energy Source	Current status in PJ	Range of total realizable potential in 2020 Minimum in PJ	 Maximum in PJ	Assumptions	Data Source
Photovoltaic	0.05[1]	3	Up to 9	Minimum value: Potential based on electricity that could compete with electricity at a residential prices level if PV develops with medium learning rates Maximum value: Based on PV road map	Minimum value: Source 6, energy systems of the future, project number 819797, Maximum value: PV Road Map
Wind energy	6[1]	16	26	Additional 550 – 700 wind converters and an increase of average full load hours by 10-25%	Minimum value: Source 6, energy systems of the future, project number 819797, Maximum value: Source 3 and 5
Geothermal energy	0.5[3]	0.5	0.5	No literature explores significant additional potentials in Austria	
Solar thermal energy	2-4[2]	10.5	23	Values imply that about 30% of buildings have solar thermal water heating and Minimum Value: in addition about 10% of buildings have solar space heating which supplies about 20-25% of the required energy Maximum Value: in addition to the 30% of buildings with solar thermal water heating about 20% of buildings have solar space heating which supplies about 50% of the required energy. This scenario would require ambitious low temperature heat storage technologies	Minimum value: Source 8 Maximum value: Source 6
Heat pump / ambient energy	~6	23	27	Consensus of most studies. Values mean that about 10-15% of buildings have installed a heat pump	
Hydro power additional energy	139[1]	25	25		
Large scale hydro		19	19	Would be realizable by ambitious retrofitting of existing power plants without additional hydro power plants	Source 3
Small scale hydro		6	6	Realizable by ambitious retrofitting of existing power plants, additional potential of new small scale power plants is higher	Source 3
Bioenergy	157[3]	220	262		Minimum value: Source 1, 2 Maximum value: Source 4
Total	311	437	513		

Data source

1 www.e-control.at, hydro power corrected by long term mean production coefficient

2 Fanninger et al., Erneuerbare Energie in Österreich, Marktentwicklung 2006.
WKÖ, Wärme und Kälte aus Erneuerbaren in 2030, 2007

3 Statistik Austria, Energy Balance, 2004

Table 3: Reference studies of potentials of renewable energy in Austria in 2020

All values in PJ	**VEÖ** Perspektiven regenerativer Energien in Österreich	**VEÖ** Biomasse-aufkommen in Österreich	**BMLFUW** Erneuerbare Energie - Potentiale in Österreich	**WIFO** Evaluierung des Biomasse-potentials in Österreich	**Energy Agency** Ökostrom-gesetz – Evaluierung und Empfehlungen	**EEG** GreenX Datenbank	**e-control**[1] Evaluierung der Ökostrom-entwicklung und Ökostrom-potenziale	**WKÖ** Wärme und Kälte aus Erneuerbaren in 2030
Study reference number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Bioenergy (primary energy)	Final energy: 195 (primary energy: ~215-225)[7]	Final energy: 186 (primary energy: ~210)	293 (272 final energy)	262	[2]	295 incl. imports[5]	[2]	-[4]
Hydro power (additional potentials to current 134 PJ)	14-25	-	14 – 25[6]	-	-	24	13	-
Large scale hydro		-	11– 19	-	-	10	-	-
Small scale hydro		-	4 – 6	-	4 – 6	14	-	-
Heat pump, ambient energy		-	25 – 27	-	-	26.5	-	23 – 27
Photovoltaic	0.4	-	7.2 – 10.8[3]	-	[3]	3	0,2	-
Solar thermal energy	14	-	26 – 28	-	-	23.1	12.8	5.5 – 10.5
Wind energy	26.3	-	26 – 26.5	-	26.3	16.2	9.7 – 11.7	-
Geothermal energy	20	-	-	-	-		-	-

1 Potentials based on current technologies and costs.

2 These studies only evaluate technologies for electricity production.

3 Values based on PV road map (develops a scenario that results in 20% electricity from PV in 2050).

4 Study includes only heat supply, potential mainly based on diffusion processes.

5 165.4 PJ biomass from forestry incl. imports; 74.5 PJ biomass from agriculture; 55.6 PJ biogenic municipal and industrial waste from industry and black liquor (Pulp and paper industry).

6 The estimate of 41PJ is quoted from the study by the Biomasseverband, otherwise the upper value is 25PJ for other quoted estimates.

7 An additional final energy potential for biomass of 52 PJ has been estimated, of which 19 PJ are biofuels, additional 12.6 PJ and 11.8 PJ comes from agriculture and forestry respectively, and 8.5 PJ from biogenic industrial waste and byproducts, and black liquor.

Box 1	Summary of Sources
Source 1: VEÖ Stand und Perspektiven regenerativer Energien in Österreich – Technische, ökonomische und ökologische Einordnung und Analyse zukünftiger Nutzungsmöglichkeiten	The VEÖ Study has not been completed so far. Based on the draft, the potentials have been estimated as described in the assessment of all renewable potentials by 2020 given in Source 3. The draft of the VEÖ Study presents the theoretical and technical potentials of all sources of electricity in Austria. The theoretical potential of hydropower is estimated at 908 PJ and a technical potential of some 216 PJ (equivalent to 2005 Austrian electricity generation), compared to the much more humble additional technical potential by 2020 of some 25 PJ. Wind technical potential is estimated at 32.4 PJ and practical potential by 2020 of 26.3 PJ. Solar theoretical potential is very large with 332 EJ with technical photovoltaic potential of 93 EJ and solar thermal technical potential of between 111 and 222 EJ (62 is the realizable potential). The theoretical potential of ambient energy (extracted through heat pumps) is 11.8 EJ while the technical potential is estimated at 122 to 142 PJ (roughly 50% of 2005 heat and process heat in Austria)
Source 2: VEÖ Biomasseaufkommen in Österreich	One of the study objectives is to evaluate the feasibility of reaching the target of 45% renewable energy set by the Austrian government. Priority is given to increasing the share of biofuels in final energy. It is assumed that about 250 thousand hectares of farmland and 100 thousand hectares of grassland and other marginal lands are deployed for biofuel production. These assumptions translate into a primary energy potential of abut 210 PJ including 24 PJ of black liquor from the pulp and paper industry. These estimates are in line with other studies such as the potential of 220 PJ reported by the Institute of Social Ecology, Faculty for Interdisciplinary Studies, University of Klagenfurt. The total primary energy potential of 210 PJ results in a final energy potential of 40 PJ district heat and electricity, 20 PJ of biofuels and about 85 PJ of house hold final energy.
Source 3: BMLFUW Erneuerbare Energie - Potentiale in Österreich	The report is based on a comprehensive assessment of renewable energy potentials by 2020 in Austria. The assessment was conducted by four working groups focusing on hydropower, biomass from forestry, biomass from agriculture and other renewable energy carriers. The study estimates the additional hydropower potential for Austria at some 14 to 41 PJ without including the two possible new power plants along the Danube. They are excluded because of possible adverse ecological effects. Biomass potential from forestry is estimated at 137 PJ without municipal and industrial waste and additional imports. Biomass from agriculture is estimated at 76.5 PJ final (or about 100 PJ primary) energy, including 40 PJ of primary converted into 19 PJ motor fuels together with about 17.5 PJ of straw (corresponding to one quarter of all agricultural straw). Altogether, the study assumes that 400 thousand hectares of farmland would be devoted to energy production and released from food production due to yield increases. Other renewable potentials include up to 27 PJ ambient energy (to be harnessed by heat pumps), 10.8 PJ of solar photovoltaic and 28 PJ solar thermal, and up to 28.5 PJ wind energy.
Source 4: WIFO Volkswirtschaftliche Evaluierung des Biomassepotentials in Österreich	The study analyses the macroeconomic implications of the 45% renewable target in Austria based on WIFO's simulation tool PROMETEUS and compares this with the baseline scenario from 2005. Apart from biomass, other renewables are taken from secondary literature and account to about 151 PJ. The preliminary potential of total biogenic renewables is in the range of up to 262 PJ.
Source 5: Energy agency Ökostromgesetz – Evaluierung und Empfehlungen	The study evaluates possible consequences of the Austrian renewable electricity law by 2010. It also considers longer-term renewable potentials. Wind energy potentials are based on estimates by the Austrian Wind Energy Association and the photovoltaic ones on the PV Roadmap with a goal of reaching a 20% share in electricity by 2050.
Studie 6: EEG GreenX Datenbank	The renewable potentials by 2020 are based on the assessment of many studies and estimates in the literature for the EU 27 countries including Austria. GreenX is a model developed to simulate renewable energy potentials and deployment in Europe in the context of alternative policies and measures. GreenX scenarios of future deployment of renewables in Europe realize to a varying degree the estimated potentials (additional information: www.green-x.at). It should be noted that estimated potentials for Austria do include imports, e.g. bioenergy from forestry. This means that the domestic potentials would be smaller.
Studie 7: e-control Bericht über die Ökostrom-Entwicklung und fossile Kraft-Wärme-Kopplung in Österreich. Evaluierung der Ökostromentwicklung und Ökostrompotenziale	The study estimates renewable energy potentials for electricity generation. The estimates are generally based on current costs and technologies. This means that they correspond more to economic rather than to technical potentials. Therefore, the study can be seen as an appropriate source for short-term potentials until 2010-2015. It very likely underestimates the medium to long-term potentials through 2020.
Studie 8: WKÖ Wärme und Kälte aus Erneuerbaren 2030	The study estimates the potential of renewable energy carriers for heating and space cooling applications in Austria until 2030. The building sector is analyzed with a comprehensive disaggregated buildings model that simulates technological diffusion processes. The estimates of the potentials are thus based to a large degree on technological diffusion potentials.

6 Projections for EU 2020 Target Sharing

6.1 Three energy and emissions scenarios for Austria

The design of three scenarios

We present in this section three energy and emissions scenarios for Austria.

Two are embedded in Target Sharing scenarios for the EU-27 with a 20% and 30% reduction target for 2020 GHG emissions compared with 1990, respectively. These scenarios are based on the WIFO-WegC model-based structural indicators using contraction and convergence criteria.

The third scenario is a reference scenario for Austria based on extrapolating current trends of structural indicators but limiting the expansion of emissions from transport, thus giving this scenario a rather cautious bias.

The message of the scenarios

A first look at the Tables 4 to 6 which summarize the scenarios reveals the following insights:

- **Scenario 1** exhibits a minus 3% reduction target for Austria's GHG emissions in 2020 that is compatible with a Community target of a minus 20% reduction, both compared to the 1990 levels.
  This is the result of assumptions to be discussed later about Community targets and convergence intensities for population, economic activity, energy efficiency and energy mix.
  Further key indicators of this scenario are a volume of renewables of 445 PJ that corresponds to a share of 28% of total energy supply.
- **Scenario 2** increases the Austrian reduction target to minus 20% compared to 1990. In the EU-27 framework this would be compatible with a Community reduction target of minus 30% for 2020 compared with 1990.
  Although this scenario further increases application and transformation efficiencies, the volume of renewables needed to achieve this extraordinary stringent target reaches 559 PJ or 37% of total energy supply. This is beyond domestic potentials identified in the previous section.
- **Scenario R** serves as a reference for evaluating the effective reduction effort need given a relative reduction target agreed upon in the 2020 Target Sharing negotiations.
  Although this reference scenario is extremely cautious as to the further expansion of emissions in transport, electricity and industrial processes, current trends indicate an overall 38% expansion of GHG by 2020 compared to 1990.
  Assuming the same amount of renewables available as used in Scenario 1, despite the doubling of the volume of renewables compared to 1990 the share in 2020 increases only to 23%.
  This reference scenario may be checked against other scenarios as soon as they become available.

These three scenarios reveal the extraordinary effort that Austria will need to contribute to the 2020 EU Target Sharing. Compared to 1990, the effective reduction effort will be composed of the 38% or similar reduction towards a reference scenario plus the additional relative reduction target negotiated in the Target Sharing agreement.

Table 4: Scenario 1 - Minus 20% 2020 Target Sharing
with minus 3% emissions target for Austria compared to 1990

		1990	2005	2020		1990	2005	2020
GHG emissions	mtoe	**79.1**	**93.3**	**77.0**	Index	100	118	97
Final energy	PJ	**839**	**1,179**	**1,292**	Index	100	141	154
Energy supply	PJ	**1,050**	**1,439**	**1,576**	Index	100	137	150
Nuclear	PJ	0	0	0	Index			
Renewables	PJ	216	316	445	Index	100	146	206
Hydro	*PJ*	*113*	*129*	*159*	Index	100	114	140
Other renewables	*PJ*	*102*	*187*	*286*	Index	100	182	280
Fossils	PJ	834	1,123	1,131	Index	100	135	136
Share of renewables	%	21	22	28				

Table 5: Scenario 2 - Minus 30% 2020 Target Sharing
with minus 20% emissions target for Austria compared to 1990

		1990	2005	2020		1990	2005	2020
GHG emissions	mtoe	**79.1**	**93.3**	**63.4**	Index	100	118	80
Final energy	PJ	**839**	**1,179**	**1,249**	Index	100	141	149
Energy supply	PJ	**1,050**	**1,439**	**1,506**	Index	100	137	143
Nuclear	PJ	0	0	0	Index			
Renewables	PJ	216	316	559	Index	100	146	259
Hydro	*PJ*	*113*	*129*	*180*	Index	100	114	159
Other renewables	*PJ*	*102*	*187*	*379*	Index	100	182	370
Fossils	PJ	834	1,123	947	Index	100	135	114
Share of renewables	%	21	22	37				

Table 6: Scenario R – Reference Scenario for 2020
with plus 38% projected emissions for Austria compared to 1990

		1990	2005	2020		1990	2005	2020
GHG emissions	mtoe	**79.1**	**93.3**	**109.4**	Index	100	118	138
Final energy	PJ	**839**	**1,179**	**1,606**	Index	100	141	191
Energy supply	PJ	**1,050**	**1,439**	**1,959**	Index	100	137	187
Nuclear	PJ	0	0	0	Index			
Renewables	PJ	216	316	445	Index	100	146	206
Hydro	*PJ*	*113*	*129*	*159*	Index	100	114	140
Other renewables	*PJ*	*102*	*187*	*286*	Index	100	182	280
Fossils	PJ	834	1,123	1,514	Index	100	135	182
Share of renewables	%	21	22	23				

6.2 Relative reduction targets based on contraction and convergence criteria

Applying contraction and convergence criteria to a set of linked structural indicators

As the core method for determining relative reduction targets that match a Community target sharing goal we employ a structural energy-emissions model – the WIFO-WegC GAIN model.

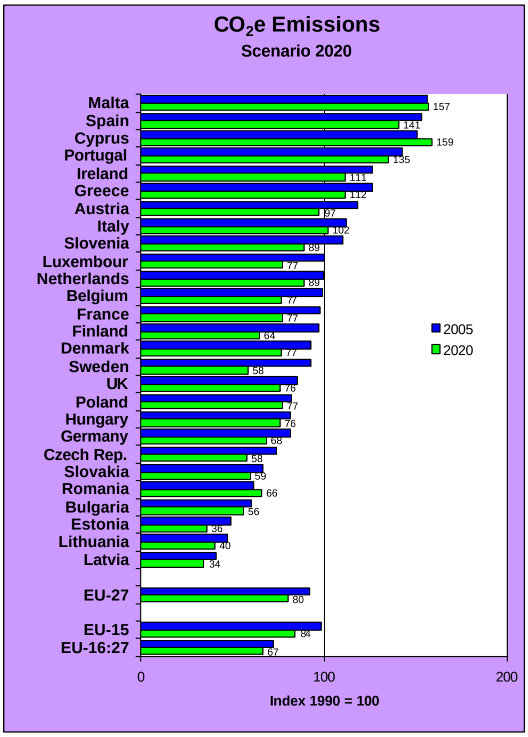
The key parameters of this model describe

- Population
- Economic activity
- Energy intensity
- Transformation efficiency
- Nuclear, hydro, other renewables
- Carbon intensity of fossils

We use these parameters as a set of linked indicators for applying con-tracting and convergence criteria. As a result we obtain Scenarios 1 and 2.

The following figures describe the results for an allocation of a 20% GHG reduction target. The corresponding reduction for Austria would be 3% below 1990 as a relative reduction target.

Figure 1: Scenario 1 – Target Sharing Scenario for 20% GHG reduction



	CO_2e Emissions				
	Index 1990 = 100		Mill Tons CO_2e		
	2005	2020	1990	2005	2020
Malta	156	157	2.2	3.5	3.5
Spain	153	141	287.4	440.6	404.5
Cyprus	151	159	6.0	9.1	9.6
Portugal	143	135	59.9	85.5	81.1
Ireland	126	111	55.4	69.9	61.7
Greece	126	112	108.8	137.3	121.4
Austria	118	97	79.1	93.3	77.0
Italy	112	102	516.9	579.5	527.5
Slovenia	110	89	18.5	20.4	16.5
Luxembourg	100	77	12.7	12.7	9.8
Netherlands	100	89	213.0	212.1	189.1
Belgium	99	77	145.8	143.8	111.9
France	98	77	567.8	555.7	437.1
Finland	97	64	71.1	69.2	45.8
Denmark	93	77	70.4	65.5	54.0
Sweden	93	58	72.2	67.0	42.1
UK	85	76	771.4	657.4	584.4
Poland	82	77	485.4	399.0	374.6
Hungary	82	76	98.1	80.2	74.3
Germany	82	68	1,227.9	1,001.5	839.4
Czech Rep.	74	58	196.3	145.7	113.5
Slovakia	66	59	72.1	47.9	42.9
Romania	62	66	248.7	153.7	164.1
Bulgaria	60	56	116.6	70.0	65.3
Estonia	49	36	42.6	20.9	15.3
Lithuania	47	40	48.1	22.6	19.3
Latvia	41	34	26.4	10.9	9.1
EU-27	92	80	5,620.8	5,175.0	4,494.7
EU-15	98	84	4,259.7	4,191.2	3,586.8
EU-16:27	72	67	1,361.1	983.8	907.9

6.3 A single indicator approach to Target Sharing

GHG emissions per energy supply as Target Sharing indicator

Since target sharing arguments are often conducted by using single or weighted single indicators, we provide results for the three most often suggested indicators:

- GHG per energy supply
- GHG per GDP
- GHG per person

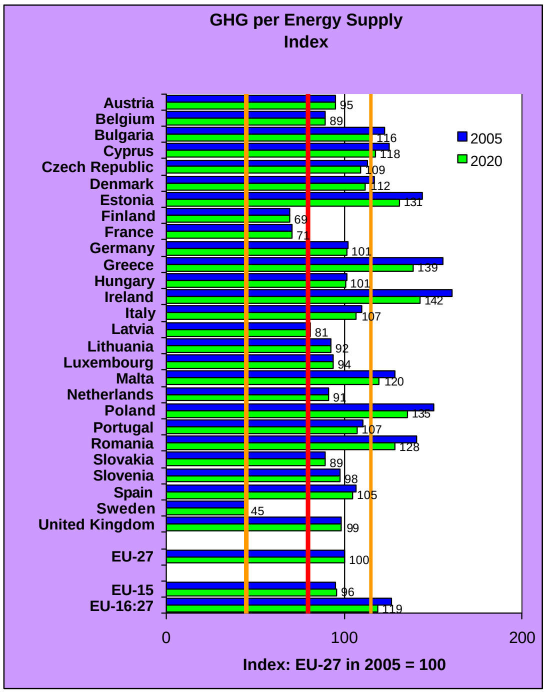
6.3.1 Indicator GHG per energy supply

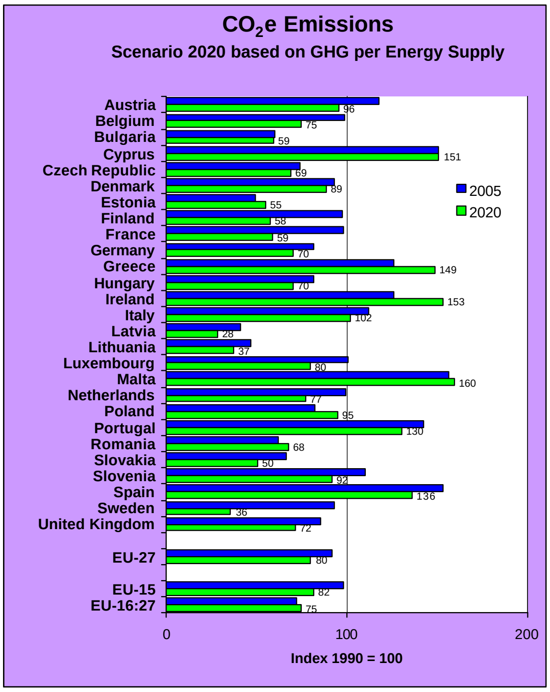
GHG per energy supply

Figure 2 depicts the indicator GHG per unit energy supply in 2005 with convergence of 30% and contraction of minus 20% for EU-27 GHGs.

This indicator suggests for Austria a relative reduction target of 4% below 1990 emissions.

Figure 2: Indicator GHG per Energy Supply





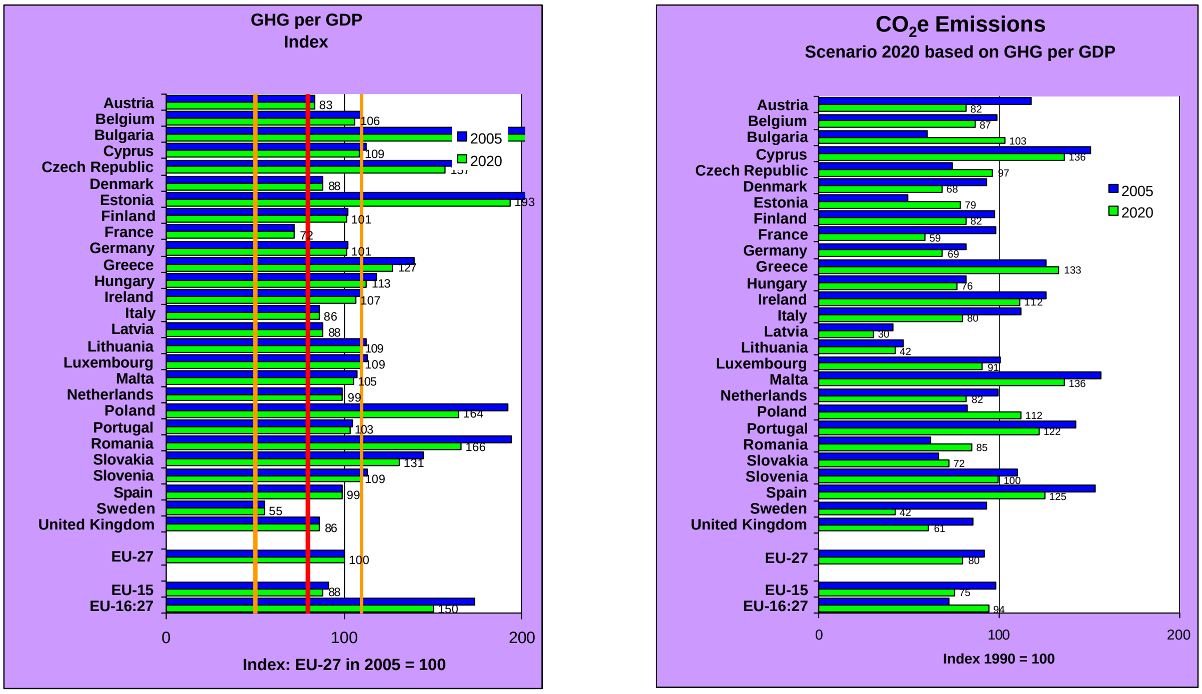
6.3.2 Indicator GHG per GDP

GHG per GDP

Another popular indicator is GHG per GDP. Figure 3 shows this indicator for 2005 with convergence of 30% and contraction of minus 20% for EU-27 GHGs.

According to this indicator the Austria reduction target would be 18% below 1990 emissions.

Figure 3: Indicator GHG per GDP



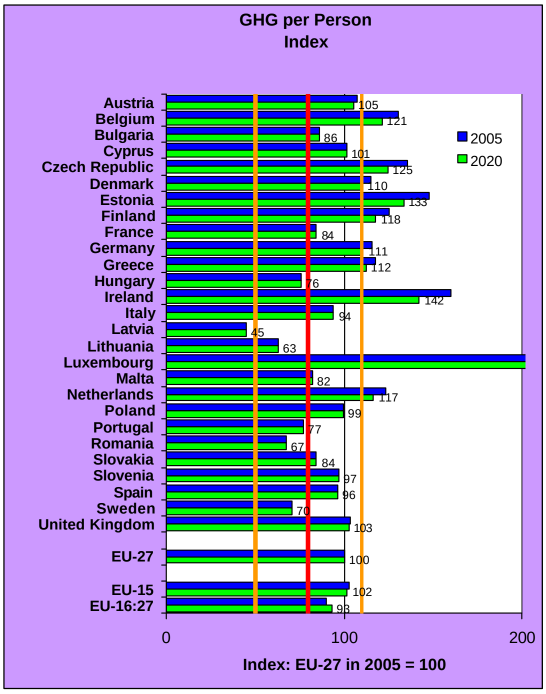
6.3.3 Indicator GHG per person

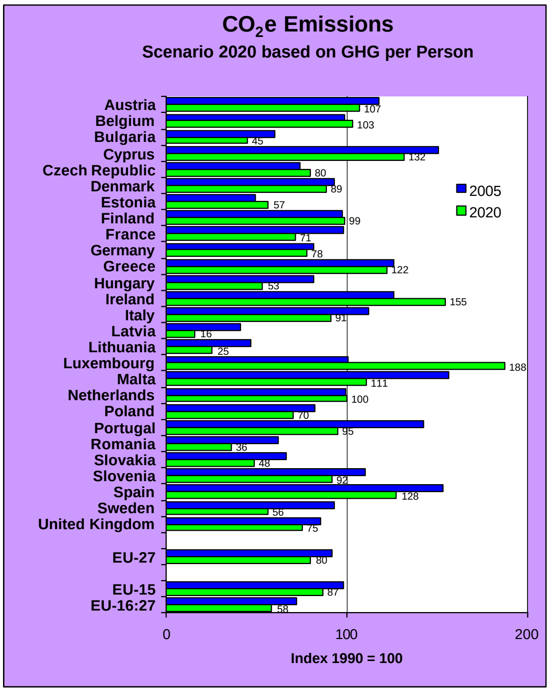
GHG per GDP

Finally we check as indicator GHG per person. In Figure 4 this indicator is shown for 2005 with convergence of 30% and contraction of minus 20% for EU-27 GHGs.

According to this indicator Austria would be allowed a 7% increase above 1990 emissions.

Figure 4: Indicator GHG per person





6.4 Sensitivity analysis of Target Sharing scenarios

The results presented about Target Sharing scenarios need to be assessed for robustness and plausibility. We investigate this issue both for integrated structural and single indicators.

6.4.1 Volatile results for single indicators

A wide range of suggested reduction targets

The three popular indicators suggest quite different ranges of 2020 relative reduction targets for Austria compared to 1990 levels:

- Minus 4% for indicator GHG per energy supply,
- Minus 18% for indicator GHG per GDP and
- Plus 7% for indicator GHG per person.

Caveats

Two caveats follow from these results.

The first is obvious: Single indicator produce Target Sharing schemes that are extremely sensitive with respect to the choice of indicators. This deficiency is inherent and cannot be completely overcome by starting weighting several indicators since weighting adds additional uncertainty to this approach.

The second is less obvious: Although these indicators may be used because of their plausibility and transparency for designing a Target Sharing proposal, the indicators do not necessarily hold after an allocation. For example the GHG per GDP indicator requires substantial GDP reductions if applied to 2020 GHG levels. This ex-post inconsistency is an obvious consequence of neglecting the causal structure of energy and emission flows. Full integrated assessment models are needed to provide such perspectives and account for different feedbacks of mitigation measures on economy and human activities in general.

Table 7: Sensitivity of scenarios

	Scenario 1		Scenario 2		Scenario 3	
	Target	Convergence	Target	Convergence	Target	Convergence
Population	100	30	100	20	100	30
Economic activity	130	30	130	20	130	30
Final energy intensity	85	30	85	20	85	5
Transformation losses	90	30	90	20	90	5
Share of nuclear	100	0	100	0	100	0
Share of hydro	150	30	160	20	150	5
Share of other renewables	170	30	220	20	170	5
Carbon intensity of fossils	81	30	80	20	81	5
Relarice reduction target for Austria in 2020 compared to 1990	-3%		-20%		-13%	

6.4.2 Robust results for integrated structural indicators

Linked indicators in a causal modeling structure

The integrated structural indicators used in the contraction and convergence approach overcome some the deficiencies of single indicator procedures. All indicators reflect economic and technology parameters and are linked in a causal modeling structure.

In addition the conventional single indicators follow as a by-product from the integrated approach.

Sensitivity of reduction requirements for Austria depending on the convergence assumptions

Nevertheless we want to investigate the sensitivity of this approach with respect to variations in the key indicators.

The results of Table 7 highlight, for example, the sensitivity of the reduction requirement for Austria with respect to the chosen convergence assumptions.

The robust result is that a few, but less than minus 5%, reduction with respect to 1990 levels is the typical target sharing result that is rather invariant with respect to convergence requirements around 30%. Scenario 1 is a representative result of this set of assumptions.

Only a radical reduction of convergence requirements increases the Austrian relative reduction target, in our Scenario minus 3 to minus 13%. This is due to the fact that the New Member states offer plenty of opportunities for increasing energy efficiency and lower carbon intensities compared to the old Member States.

Table 7 also highlights the path from moving from a minus 3% to a minus 20% reduction in Scenario 2. This scenario lowers the convergence assumptions of Scenario 1 but in addition requires additional efforts as to energy efficiency and use of renewables.

6.5 Considering the Kyoto commitments

A result that would imply exceedingly large emissions reductions

Another suggestion for allocating the Community target to the Member State is to start from the situation where all countries fulfill their Kyoto target and only the remaining reduction volume for a 20% reduction of EU-27 is allocated separately.

We analyzed this allocation scheme and obtained a result that might appear to be puzzling at the first glance. According to this allocation procedure Austria would be required to reduce its emissions by 34% below 1990. This result can be easily explained despite the extremely large emissions reductions that it implies. The new Member States are in 2005 already considerably below their Kyoto target. This means that most of the adjustment needs to be borne by the old Member States.

Under the same allocation procedure used in Scenario 1, Austria would obtain a burden that is exceedingly high implying emissions decline of about 72% compared to the baseline levels in 2020.

6.6 WIFO-WegC reference scenario and effective reduction efforts

Scenario R

The following table summarizes Scenario R, the reference scenario produced with the WIFO-WegC GAIN energy-emissions model.

The model extrapolates current trends by taking into account time-varying parameter structures. The driving force of the projections are economic activity in terms of GDP, population and technology parameters. Only the dynamics of transport were restricted by assuming a decoupling of economic activity and transport emissions by 2020.

Table 7: Scenario R – WIFO-WegC reference scenarios

In 1,000 toe	1990	2005	2010	2015	2020
Total GHG emissions (excl. LULUCF)	**79.1**	**93.3**	**100,221**	**105,416**	**109,448**
1. CO_2	**61,930**	**63,661**	**87,458**	**93,567**	**98,444**
2. CH_4	**9,181**	**8,522**	**6,584**	**6,037**	**5,535**
3. N_2O	**6,337**	**6,636**	**4,897**	**4,563**	**4,252**
4. Others	**1,605**	**1,475**	**1,282**	**1,249**	**1,217**
A. CO_2 from Energy	**54,351**	**56,279**	**78,175**	**83,650**	**87,849**
1.Energy Industries	**13,659**	**12,637**	**17,034**	**18,324**	**19,712**
2. Manufacturing Industries and Construction	**13,579**	**14,203**	**16,463**	**17,443**	**18,482**
3. Transport	**12,400**	**14,463**	**28,638**	**31,348**	**32,611**
4. Other Sectors	**14,713**	**14,975**	**16,040**	**16,534**	**17,044**
B. CO_2 from industrial processes	**7,579**	**7,382**	**9,282**	**9,917**	**10,595**

Index 1990 = 100	1990	2005	2010	2015	2020
Total GHG emissions (excl. LULUCF)	**100**	**118**	**127**	**133**	**138**
1. CO_2	100	103	141	151	159
2. CH_4	100	93	72	66	60
3. N_2O	100	105	77	72	67
4. Others	100	92	80	78	76
A. CO_2 from Energy	**100**	**104**	**144**	**154**	**162**
1.Energy Industries	100	93	125	134	144
2. Manufacturing Industries and Construction	100	105	121	128	136
3. Transport	100	117	231	253	263
4. Other Sectors	100	102	109	112	116
B. CO_2 from industrial processes	**100**	**97**	**122**	**131**	**140**

6.7 Determining Target Sharing efforts: A synthesis

Austria's low relative reduction requirements translate into effective reduction requirements of more than 40 %

There are different methods in the literature to assess alternative burden-sharing schemes for EU-27 post-2012 commitments.

Based on the multi-indicator contraction and convergence approach, Austria needs to reduce GHG emissions by a few up to about minus 5% with respect to the 1990 levels in a target sharing agreement. These relative reduction targets translate into an effective reduction effort of minus 40% and more with respect to 2020 according to the Reference Scenario.

Quite often a range of single target-sharing indicators such as GHG per energy, per GDP or per capita, as well as the combination of these indicators are proposed. Assuming 30% convergence by 2020 for these indicators we obtain reduction suggestions ranging from minus 18% to plus 7% compared with 1990.

Consideration of Koto commitments increases the reduction requirements to some minus 34%.

In all cases, enormous amount of energy efficiency improvements is required and the contribution of renewables is close to, or above, the identified potentials across the recent eight studies assessed above.

Limits for more stringent reduction requirements

More stringent reduction requirements for Austria would be limited by upper bounds of estimated renewable potentials.

One of the relatively robust policy implications of this assessment of the renewable potentials by 2020 indicates that they might pose a serious limit to implementation of more ambitious 2020 emissions reductions in Austria, namely those that are more stringent compared to emissions reduction of minus 5% or so below the 1990 levels. Further reductions would have to rely on other carbon-saving options such as more vigorous adjustment of consumer behavior toward more rational energy use, e.g. toward mobility and other carbon-intensive goods and services, and a significant deployment of carbon capture and storage.

The need for an immediate change in energy policies

In all cases, meeting of the 2020 reduction goals even under the contraction and convergence scheme is going to be a major challenge and would require full deployment of the estimated renewable energy potentials. This will require immediate change in energy policies and a paradigm shift toward achieving the post-carbon society. Otherwise, the risk is very high of stranded investment and a lock-in into carbon intensive development paths not consistent with the EU-27 Community reductions goals, whether they turn out to be more or less stringent than the three scenarios considered here.

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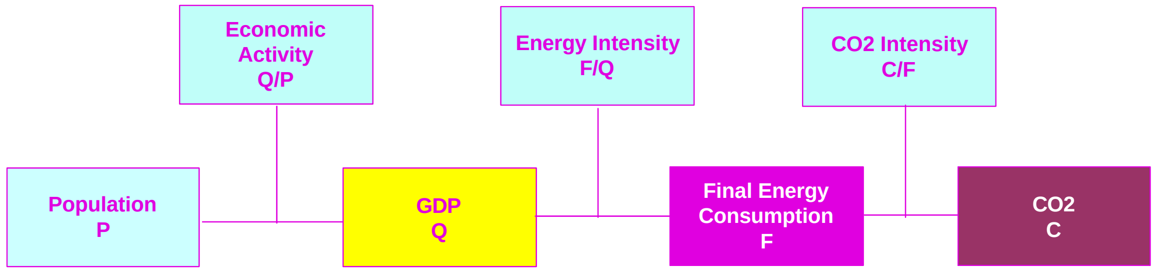
8 Appendix: Structural indicators

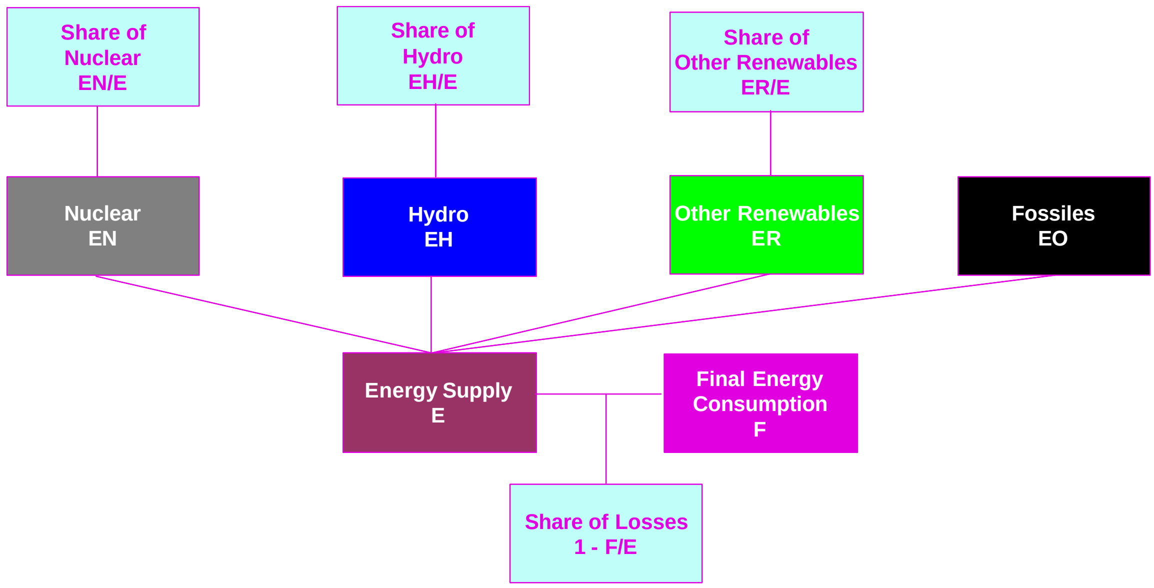
This appendix provides details of the structural model and the corresponding indicators used for the contraction and convergence analysis that results in Scenario 1.

The structural model

Demand modul

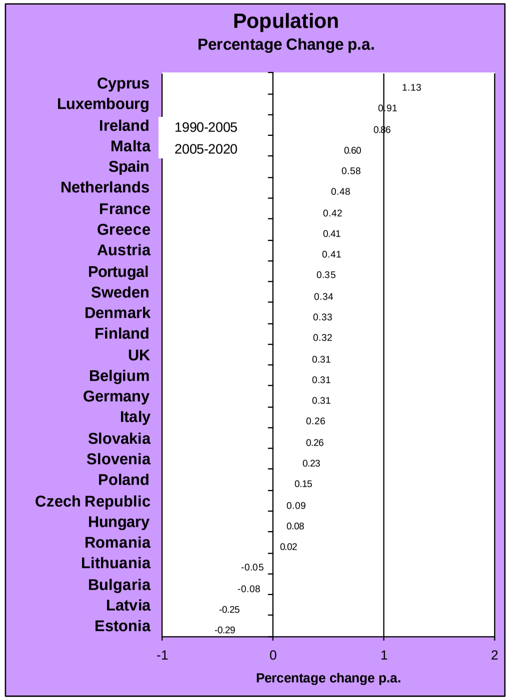


Supply modul



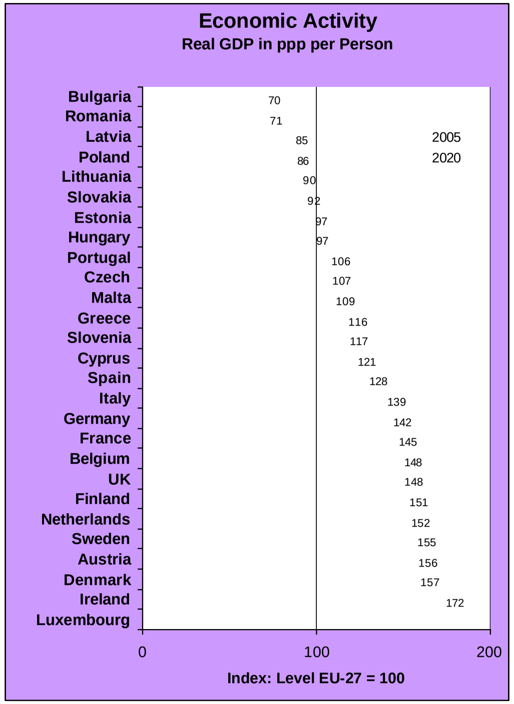
Structural indicator 1: Population

	Population: Percentage Change p.a. 2005/1990	Population: Percentage Change p.a. 2020/2005	Population: Index 1990 = 100, 2005	Population: Index 1990 = 100, 2020	Population: Mill Persons, 1990	Population: Mill Persons, 2005	Population: Mill Persons, 2020
Malta	0.74	0.60	112	122	0.4	0.4	0.4
Spain	0.71	0.58	111	121	39.0	43.4	47.3
Cyprus	1.50	1.13	125	148	0.7	0.9	1.0
Portugal	0.39	0.35	106	111	10.0	10.6	11.1
Ireland	1.12	0.86	118	135	3.5	4.2	4.7
Greece	0.48	0.41	107	114	10.3	11.1	11.8
Austria	0.47	0.41	107	114	7.7	8.2	8.8
Italy	0.26	0.26	103	107	56.7	58.6	60.9
Slovenia	0.21	0.23	100	104	2.0	2.0	2.1
Luxembourg	1.19	0.91	119	137	0.4	0.5	0.5
Netherlands	0.58	0.48	109	117	15.0	16.3	17.5
Belgium	0.34	0.31	105	110	10.0	10.5	11.0
France	0.49	0.42	108	114	58.2	62.6	66.6
Finland	0.35	0.32	105	110	5.0	5.2	5.5
Denmark	0.35	0.33	105	111	5.1	5.4	5.7
Sweden	0.37	0.34	105	111	8.6	9.0	9.5
UK	0.34	0.31	105	110	57.2	60.2	63.1
Poland	0.11	0.15	100	102	38.1	38.2	39.0
Hungary	0.01	0.08	97	99	10.4	10.1	10.2
Germany	0.33	0.31	104	109	79.4	82.5	86.4
Czech Rep.	0.01	0.09	99	100	10.4	10.2	10.4
Slovakia	0.26	0.26	102	106	5.3	5.4	5.6
Romania	-0.08	0.02	93	93	23.2	21.6	21.7
Bulgaria	-0.22	-0.08	89	87	8.7	7.7	7.6
Estonia	-0.53	-0.29	86	82	1.6	1.3	1.3
Lithuania	-0.18	-0.05	92	92	3.7	3.4	3.4
Latvia	-0.47	-0.25	86	83	2.7	2.3	2.2
EU-27	0.26	0.31	104	109	473.1	491.7	515.3
EU-15	0.39	0.37	106	112	366.0	388.1	410.3
EU-16:27	-0.22	0.09	97	98	107.1	103.5	105.0



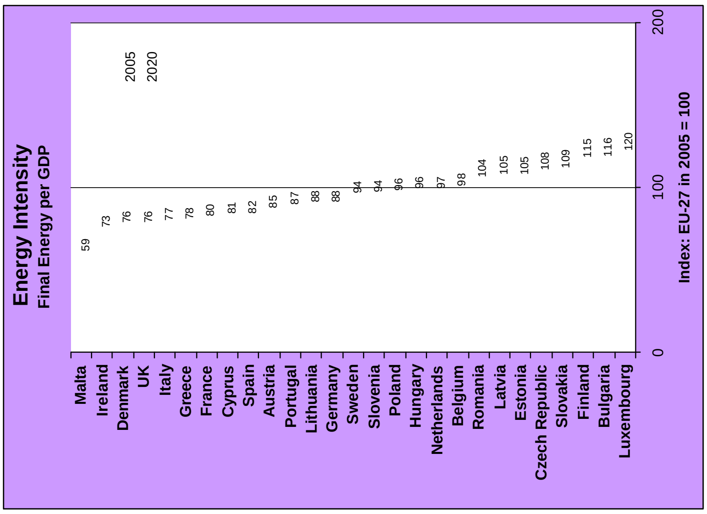
Structural indicator 2: Economic activity

	GDP per Person			GDP				
	Index: EU-27 2005 = 100			Index 1990 = 100		Bill 2000 € ppp		
	2005	2020		2005	2020	1990	2005	2020
	76	109	Malta	182	283	4.264	7.778	12.079
	98	128	Spain	154	220	696.872	1,073.371	1,531.471
	90	121	Cyprus	183	290	10.660	19.462	30.881
	74	106	Portugal	135	204	146.147	196.752	298.642
	146	172	Ireland	258	346	59.491	153.591	205.609
	84	116	Greece	155	227	152.532	237.045	345.852
	129	156	Austria	139	179	193.474	268.603	346.293
	109	139	Italy	122	160	1,333.041	1,620.213	2,132.994
	85	117	Slovenia	141	199	30.790	43.266	61.184
	236	254	Luxembourg	199	245	13.647	27.105	33.395
	124	152	Netherlands	139	183	368.387	513.637	675.548
	120	148	Belgium	132	172	239.556	317.365	410.945
	117	145	France	133	177	1,385.108	1,847.452	2,446.665
	123	151	Finland	135	174	120.530	163.188	210.144
	130	157	Denmark	138	176	128.788	178.247	226.395
	128	155	Sweden	136	173	215.141	291.960	373.019
	120	148	UK	143	185	1,277.900	1,830.991	2,368.519
	52	86	Poland	166	283	300.866	499.291	849.980
	64	97	Hungary	131	202	124.372	163.163	251.132
	113	142	Germany	128	168	1,847.706	2,358.944	3,100.633
	75	107	Czech Rep.	122	177	158.063	193.260	280.376
	59	92	Slovakia	138	226	57.846	79.780	130.647
	35	71	Romania	113	231	167.835	190.487	387.936
	34	70	Bulgaria	101	205	65.725	66.254	134.864
	63	97	Estonia	143	208	15.119	21.581	31.521
	56	90	Lithuania	105	168	45.855	48.180	76.994
	51	85	Latvia	108	174	27.468	29.648	47.830
	100	130	**EU-27**	135	185	9,187.186	12,440.614	17,001.548
	113	142	**EU-15**	135	180	8,178.323	11,078.464	14,706.124
	52	86	**EU-16:27**	135	228	1,008.864	1,362.151	2,295.424

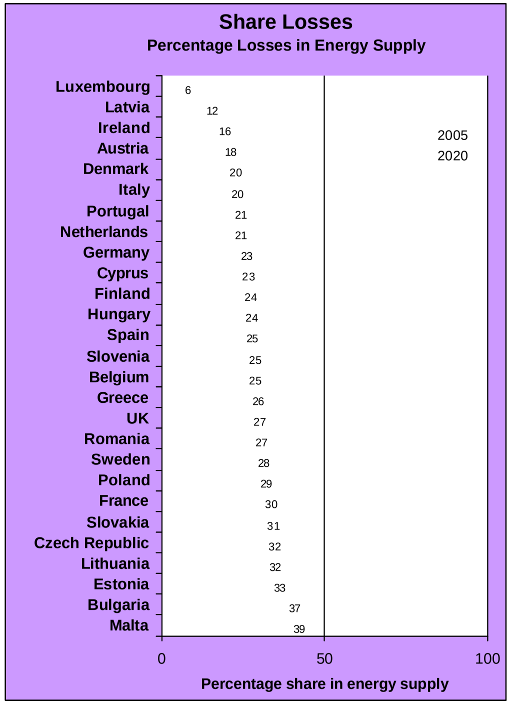


Structural indicator 3: Final energy intensity

Final Energy per GDP			Final Energy							
Index: EU-27 2005 = 100			Index 1990 = 100		Bill toe			Peta Joule		
2005	2020		2005	2020	1990	2005	2020	1990	2005	2020
59	59	Malta	139	215	0.345	0.477	0.741	14.427	19.991	31.044
94	82	Spain	170	210	62.498	106.189	131.053	2,616.684	4,445.941	5,486.942
94	81	Cyprus	169	232	1.136	1.914	2.632	47.559	80.150	110.204
104	87	Portugal	153	195	14.004	21.375	27.281	586.315	894.930	1,142.200
80	73	Ireland	160	196	7.992	12.807	15.693	334.606	536.198	657.020
88	78	Greece	141	182	15.466	21.807	28.169	647.526	913.035	1,179.378
100	85	Austria	141	154	20.034	28.165	30.854	838.801	1,179.202	1,291.813
87	77	Italy	126	147	117.649	148.074	172.960	4,925.724	6,199.569	7,241.478
116	94	Slovenia	140	162	3.738	5.245	6.048	156.489	219.613	253.202
159	120	Luxembourg	152	142	2.959	4.503	4.193	123.883	188.551	175.568
120	97	Netherlands	126	133	51.281	64.367	68.414	2,147.028	2,694.897	2,864.368
122	98	Belgium	122	127	33.259	40.621	42.273	1,392.504	1,700.732	1,769.872
91	80	France	119	138	147.757	176.395	204.347	6,186.301	7,385.314	8,555.580
151	115	Finland	114	112	22.718	25.846	25.416	951.149	1,082.099	1,064.112
84	76	Denmark	114	129	13.879	15.771	17.965	581.076	660.297	752.175
115	94	Sweden	108	112	32.739	35.227	36.742	1,370.711	1,474.877	1,538.334
85	76	UK	112	129	145.375	162.196	188.101	6,086.578	6,790.827	7,875.400
118	96	Poland	99	137	62.208	61.564	85.062	2,604.520	2,577.567	3,561.368
119	96	Hungary	97	121	21.016	20.363	25.356	879.886	852.549	1,061.593
106	88	Germany	106	116	247.276	261.010	286.947	10,352.941	10,927.948	12,013.879
139	108	Czech Rep.	83	94	33.791	28.064	31.714	1,414.759	1,174.979	1,327.791
141	109	Slovakia	75	95	15.802	11.794	14.981	661.608	493.785	627.229
132	104	Romania	61	97	43.373	26.251	42.171	1,815.954	1,099.069	1,765.613
152	116	Bulgaria	59	92	17.810	10.567	16.400	745.655	442.422	686.654
134	105	Estonia	51	58	6.002	3.033	3.478	251.299	126.983	145.604
105	88	Lithuania	50	67	10.605	5.313	7.109	444.030	222.462	297.627
133	105	Latvia	64	81	6.491	4.138	5.250	271.777	173.270	219.810
100	85	**EU-27**	113	131	1157.203	1303.078	1521.349	48,449.791	54,557.256	63,695.860
97	83	**EU-15**	120	137	934.886	1124.353	1280.408	39,141.828	47,074.416	53,608.121
125	100	**EU-16:27**	80	108	222.317	178.725	240.942	9,307.963	7,482.839	10,087.739



Structural indicator 4: Share of transformation losses



Share of Losses			Energy Supply Total							
Index: EU-27 2005 = 100			Index 1990 = 100		Bill toe			Peta Joule		
2005	2020		2005	2020	1990	2005	2020	1990	2005	2020
50	39	Malta	123	157	0.774	0.949	1.214	32.419	39.741	50.831
27	25	Spain	159	191	91.073	145.196	173.679	3,813.049	6,079.068	7,271.584
25	23	Cyprus	158	212	1.619	2.552	3.435	67.784	106.862	143.805
21	21	Portugal	153	195	17.746	27.166	34.554	743.000	1,137.405	1,446.710
16	16	Ireland	148	181	10.365	15.289	18.734	433.981	640.129	784.369
30	26	Greece	140	172	22.181	30.977	38.204	928.686	1,296.964	1,599.530
18	18	Austria	137	150	25.071	34.363	37.644	1,049.659	1,438.695	1,576.086
20	20	Italy	125	146	147.967	185.185	216.308	6,195.062	7,753.343	9,056.382
28	25	Slovenia	131	145	5.597	7.315	8.111	234.347	306.249	339.597
6	6	Luxembourg	134	125	3.571	4.776	4.447	149.530	199.977	186.208
21	21	Netherlands	123	130	66.751	81.849	86.682	2,794.725	3,426.856	3,629.199
28	25	Belgium	115	115	49.161	56.653	56.701	2,058.279	2,371.961	2,373.945
36	30	France	121	129	227.816	275.970	293.388	9,538.192	11,554.295	12,283.556
26	24	Finland	120	115	29.171	34.961	33.461	1,221.337	1,463.735	1,400.952
20	20	Denmark	110	125	17.895	19.610	22.339	749.248	821.028	935.270
32	28	Sweden	110	107	47.566	52.174	51.089	1,991.511	2,184.435	2,139.006
31	27	UK	110	121	212.176	233.931	257.450	8,883.366	9,794.232	10,778.896
34	29	Poland	93	120	99.880	92.969	119.635	4,181.768	3,892.421	5,008.898
27	24	Hungary	97	117	28.558	27.762	33.543	1,195.670	1,162.340	1,404.389
24	23	Germany	97	105	356.221	344.746	372.272	14,914.262	14,433.845	15,586.289
38	32	Czech Rep.	92	95	48.993	45.205	46.302	2,051.232	1,892.650	1,938.573
37	31	Slovakia	88	102	21.315	18.831	21.763	892.420	788.429	911.161
32	27	Romania	61	93	62.403	38.343	58.156	2,612.709	1,605.344	2,434.862
47	37	Bulgaria	70	91	28.820	20.060	26.212	1,206.624	839.890	1,097.450
40	33	Estonia	53	54	9.582	5.096	5.200	401.178	213.370	217.725
38	32	Lithuania	53	64	16.186	8.587	10.398	677.694	359.508	435.341
12	12	Latvia	61	77	7.787	4.716	5.983	326.032	197.465	250.505
28	25	**EU-27**	110	123	1656.247	1815.234	2036.905	69,343.761	76,000.236	85,281.118
27	25	**EU-15**	116	128	1324.732	1542.848	1696.952	55,463.886	64,595.967	71,047.982
34	29	**EU-16:27**	82	103	331.515	272.386	339.953	13,879.875	11,404.268	14,233.136

Structural indicator 5: Share of nuclear

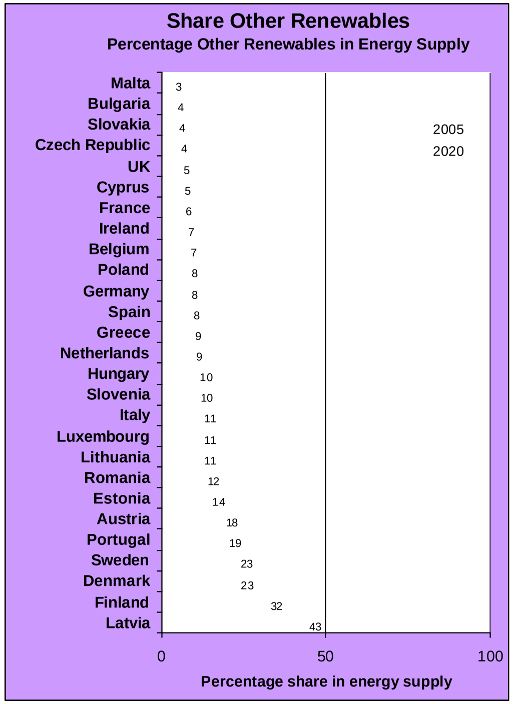
Share of Nuclear			Energy Supply Nuclear								
Index: EU-27 2005 = 100			Index 1990 = 100		Bill toe			Peta Joule			
2005	2020		2005	2020	1990	2005	2020	1990	2005	2020	
0	0	Malta	123	157	0.774	0.949	1.214	32.419	39.741	50.831	
10	10	Spain	159	191	91.073	145.196	173.679	3,813.049	6,079.068	7,271.584	
0	0	Cyprus	158	212	1.619	2.552	3.435	67.784	106.862	143.805	
0	0	Portugal	153	195	17.746	27.166	34.554	743.000	1,137.405	1,446.710	
0	0	Ireland	148	181	10.365	15.289	18.734	433.981	640.129	784.369	
0	0	Greece	140	172	22.181	30.977	38.204	928.686	1,296.964	1,599.530	
0	0	Austria	137	150	25.071	34.363	37.644	1,049.659	1,438.695	1,576.086	
0	0	Italy	125	146	147.967	185.185	216.308	6,195.062	7,753.343	9,056.382	
21	21	Slovenia	131	145	5.597	7.315	8.111	234.347	306.249	339.597	
0	0	Luxembourg	134	125	3.571	4.776	4.447	149.530	199.977	186.208	
1	1	Netherlands	123	130	66.751	81.849	86.682	2,794.725	3,426.856	3,629.199	
22	22	Belgium	115	115	49.161	56.653	56.701	2,058.279	2,371.961	2,373.945	
43	43	France	121	129	227.816	275.970	293.388	9,538.192	11,554.295	12,283.556	
17	17	Finland	120	115	29.171	34.961	33.461	1,221.337	1,463.735	1,400.952	
0	0	Denmark	110	125	17.895	19.610	22.339	749.248	821.028	935.270	
36	36	Sweden	110	107	47.566	52.174	51.089	1,991.511	2,184.435	2,139.006	
9	9	UK	110	121	212.176	233.931	257.450	8,883.366	9,794.232	10,778.896	
0	0	Poland	93	120	99.880	92.969	119.635	4,181.768	3,892.421	5,008.898	
13	13	Hungary	97	117	28.558	27.762	33.543	1,195.670	1,162.340	1,404.389	
12	12	Germany	97	105	356.221	344.746	372.272	14,914.262	14,433.845	15,586.289	
14	14	Czech Rep.	92	95	48.993	45.205	46.302	2,051.232	1,892.650	1,938.573	
25	25	Slovakia	88	102	21.315	18.831	21.763	892.420	788.429	911.161	
4	4	Romania	61	93	62.403	38.343	58.156	2,612.709	1,605.344	2,434.862	
24	24	Bulgaria	70	91	28.820	20.060	26.212	1,206.624	839.890	1,097.450	
0	0	Estonia	53	54	9.582	5.096	5.200	401.178	213.370	217.725	
32	32	Lithuania	53	64	16.186	8.587	10.398	677.694	359.508	435.341	
0	0	Latvia	61	77	7.787	4.716	5.983	326.032	197.465	250.505	
14	96	**EU-27**	110	123	1656.247	1815.234	2036.905	69,343.761	76,000.236	85,281.118	
15	103	**EU-15**	116	128	1324.732	1542.848	1696.952	55,463.886	64,595.967	71,047.982	
9	62	**EU-16:27**	82	103	331.515	272.386	339.953	13,879.875	11,404.268	14,233.136	

Structural indicator 6: Share of hydro

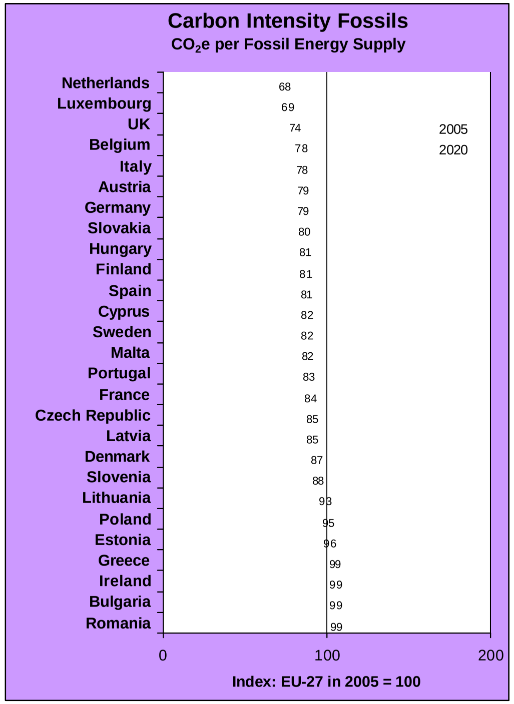
Share of Hydro			Energy Supply Hydro							
Index: EU-27 2005 = 100			Index 1990 = 100		Bill toe			Peta Joule		
2005	2020		2005	2020	1990	2005	2020	1990	2005	2020
0	0	Malta			0.000	0.000	0.000	0.000	0.000	0.000
1	2	Spain	77	148	2.186	1.682	3.238	91.507	70.403	135.548
0	0	Cyprus			0.000	0.000	0.000	0.000	0.000	0.000
1	2	Portugal	52	97	0.788	0.407	0.767	32.971	17.035	32.126
0	1	Ireland	91	319	0.060	0.054	0.191	2.510	2.272	8.006
1	2	Greece	284	530	0.152	0.431	0.806	6.370	18.064	33.758
9	10	Austria	114	140	2.710	3.085	3.793	113.453	129.170	158.794
2	2	Italy	106	182	2.720	2.890	4.947	113.874	121.011	207.104
4	5	Slovenia	117	157	0.254	0.298	0.399	10.622	12.462	16.710
0	1	Luxembourg	141	617	0.006	0.009	0.037	0.252	0.356	1.555
0	1	Netherlands	104	7800	0.007	0.008	0.570	0.306	0.317	23.871
0	1	Belgium	108	1720	0.023	0.025	0.393	0.958	1.037	16.474
2	2	France	96	148	4.627	4.446	6.864	193.729	186.150	287.396
3	4	Finland	127	151	0.934	1.185	1.408	39.099	49.631	58.956
0	1	Denmark	82	6110	0.002	0.002	0.147	0.101	0.083	6.160
12	13	Sweden	100	109	6.235	6.261	6.768	261.058	262.138	283.382
0	1	UK	95	483	0.448	0.427	2.161	18.749	17.863	90.493
0	1	Poland	155	846	0.122	0.189	1.031	5.102	7.925	43.168
0	1	Hungary	113	1564	0.015	0.017	0.239	0.641	0.727	10.024
0	1	Germany	112	288	1.499	1.684	4.322	62.745	70.504	180.945
0	1	Czech Rep.	205	521	0.100	0.205	0.520	4.180	8.570	21.779
2	3	Slovakia	247	387	0.162	0.399	0.625	6.769	16.700	26.169
5	5	Romania	177	320	0.981	1.738	3.144	41.087	72.758	131.651
2	3	Bulgaria	231	422	0.162	0.373	0.682	6.762	15.616	28.537
0	1	Estonia			0.000	0.002	0.036	0.000	0.079	1.496
0	1	Lithuania	109	328	0.036	0.039	0.117	1.491	1.624	4.886
6	7	Latvia	74	109	0.387	0.286	0.420	16.189	11.972	17.571
1	149	**EU-27**	106	177	24.614	26.141	43.627	1,030.523	1,094.467	1,826.558
1	149	**EU-15**	101	163	22.396	22.596	36.414	937.681	946.034	1,524.568
1	147	**EU-16:27**	160	325	2.218	3.545	7.213	92.843	148.433	301.990

Structural indicator 7: Share of other renewables

Share Other Renewables			Energy Supply Other Renewables							
Index: EU-27 2005 = 100			Index 1990 = 100		Bill toe			Peta Joule		
2005	2020		2005	2020	1990	2005	2020	1990	2005	2020
0	3	Malta			0.000	0.000	0.033	0.000	0.000	1.394
5	8	Spain	171	362	4.032	6.914	14.604	168.822	289.488	611.438
2	5	Cyprus	929	3022	0.006	0.057	0.185	0.257	2.386	7.764
14	19	Portugal	151	266	2.494	3.763	6.643	104.411	157.537	278.115
3	7	Ireland	476	1170	0.108	0.513	1.261	4.514	21.468	52.809
5	9	Greece	153	328	1.014	1.551	3.323	42.434	64.919	139.132
13	18	Austria	182	280	2.447	4.455	6.840	102.457	186.529	286.379
7	11	Italy	194	356	6.897	13.414	24.576	288.758	561.605	1,028.931
6	10	Slovenia	254	457	0.182	0.461	0.831	7.617	19.311	34.794
7	11	Luxembourg	95	139	0.363	0.346	0.505	15.194	14.490	21.161
5	9	Netherlands	252	454	1.750	4.415	7.941	73.283	184.862	332.479
4	7	Belgium	512	966	0.437	2.238	4.220	18.287	93.685	176.666
3	6	France	90	216	7.822	7.007	16.908	327.473	293.354	707.909
24	32	Finland	155	193	5.478	8.476	10.571	229.369	354.869	442.592
17	23	Denmark	182	281	1.806	3.287	5.069	75.616	137.629	212.210
17	23	Sweden	163	216	5.358	8.720	11.562	224.323	365.103	484.084
2	5	UK	300	816	1.666	4.993	13.598	69.754	209.043	569.301
4	8	Poland	177	425	2.140	3.794	9.090	89.581	158.858	380.596
6	10	Hungary	122	240	1.422	1.735	3.415	59.554	72.657	142.972
4	8	Germany	299	593	4.898	14.646	29.027	205.056	613.190	1,215.295
1	4	Czech Rep.			0.000	0.661	2.075	0.000	27.676	86.884
1	4	Slovakia	29	136	0.621	0.179	0.843	25.994	7.511	35.312
8	12	Romania	219	508	1.417	3.102	7.193	59.307	129.875	301.170
1	4	Bulgaria	26	185	0.498	0.131	0.923	20.866	5.495	38.634
9	14	Estonia			0.000	0.484	0.730	0.000	20.268	30.580
7	11	Lithuania			0.000	0.631	1.194	0.000	26.415	50.000
34	43	Latvia	161	259	1.002	1.613	2.599	41.938	67.533	108.818
5	170	**EU-27**	185	352	52.722	97.587	185.760	2,207.373	4,085.759	7,777.419
5	168	**EU-15**	182	336	46.569	84.737	156.647	1,949.751	3,547.773	6,558.500
5	182	**EU-16:27**	209	473	6.153	12.850	29.113	257.622	537.986	1,218.918



Structural indicator 8: Carbon intensity of fossils



CO2e per Fossils, Index: EU-27 2005 = 100, 2005	2020		Energy Supply Fossils, Index 1990 = 100, 2005	2020	Bill toe 1990	Bill toe 2005	Bill toe 2020	Peta Joule 1990	Peta Joule 2005	Peta Joule 2020
128	82	Malta	123	152	0.774	0.949	1.181	32.419	39.741	49.437
106	81	Spain	172	195	70.713	121.605	137.901	2,960.599	5,091.365	5,773.631
125	82	Cyprus	155	201	1.613	2.495	3.249	67.527	104.476	136.041
110	83	Portugal	159	188	14.465	22.997	27.144	605.617	962.833	1,136.469
160	99	Ireland	144	169	10.198	14.722	17.282	426.957	616.389	723.554
155	99	Greece	138	162	21.016	28.995	34.075	879.883	1,213.980	1,426.640
95	79	Austria	135	136	19.914	26.822	27.011	833.749	1,122.996	1,130.913
110	78	Italy	122	135	138.350	168.881	186.786	5,792.430	7,070.727	7,820.347
98	88	Slovenia	127	131	3.957	5.022	5.181	165.677	210.275	216.901
94	69	Luxembourg	138	122	3.203	4.422	3.905	134.084	185.131	163.491
91	68	Netherlands	119	120	64.081	76.384	77.068	2,682.926	3,198.066	3,226.662
89	78	Belgium	112	106	37.568	41.987	39.674	1,572.892	1,757.928	1,661.059
71	84	France	110	108	133.516	146.846	144.517	5,590.035	6,148.134	6,050.643
69	81	Finland	108	88	17.751	19.235	15.677	743.201	805.323	656.383
117	87	Denmark	101	106	16.087	16.321	17.123	673.531	683.316	716.900
45	82	Sweden	101	78	18.204	18.331	14.289	762.159	767.484	598.254
99	74	UK	107	113	192.927	207.242	218.282	8,077.473	8,676.788	9,139.033
151	95	Poland	91	112	97.618	88.985	109.514	4,087.085	3,725.637	4,585.134
101	81	Hungary	95	108	23.542	22.388	25.514	985.656	937.344	1,068.209
102	79	Germany	92	95	309.988	285.924	293.038	12,978.596	11,971.048	12,268.897
113	85	Czech Rep.	83	81	45.613	37.869	37.079	1,909.736	1,585.500	1,552.432
89	80	Slovakia	78	86	17.396	13.580	14.894	728.331	568.565	623.571
141	99	Romania	53	76	60.006	32.056	45.622	2,512.315	1,342.100	1,910.112
122	99	Bulgaria	60	75	24.338	14.681	18.237	1,018.985	614.653	763.556
144	96	Estonia	48	46	9.582	4.610	4.434	401.178	193.023	185.649
92	93	Lithuania	44	50	11.647	5.177	5.769	487.620	216.752	241.540
81	85	Latvia	44	46	6.399	2.817	2.964	267.905	117.960	124.116
100	81	**EU-27**	104	111	1371.598	1431.345	1527.409	57,426.058	59,927.532	63,949.575
95	79	**EU-15**	112	117	1067.979	1200.714	1253.771	44,714.133	50,271.507	52,492.878
127	92	**EU-16:27**	76	90	303.619	230.630	273.638	12,711.925	9,656.025	11,456.697