Working Paper 4/2007

BMF
FEDERAL MINISTRY
OF FINANCE

Thomas Micholitsch

Facing the Challenge *of a Low Carbon Economy in Austria*

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Introductory motto

"There is enough alcohol in one year's yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for one hundred years."

Henry Ford, 1925

Executive Summary & Key Messages

Rise in consumption of fossil energy products, once a measure for the gross domestic product of industrialized nations, has developed into a scourge threatening to stifle Europe's economic growth in the opening decades of the new century. As natural reserves dwindle, marginal costs of extraction skyrocket, resulting in soaring intermediate input costs for energy that eat into profits of commercial consumers. Concurrently, rising emissions of greenhouse gases from fossil energy combustion cause widespread environmental and biodiversity devastation not limited to the negative effects of global warming. With Kyoto Protocol greenhouse gas reduction goals laid down in the acquis communautaire, EU Member States are legally compelled to aspire to low carbon economies in the long term and to makeshift solutions until the end of the Kyoto compliance period 2012. The sooner substantial levels of public and private funds will be dedicated to meeting the Austrian 2012 Kyoto goal, the higher the opportunity revenue will be. Prevaricating with financial decisions will entail a cost rise by a factor of up to nine. This study advocates a fast-track cost-efficiency approach to Kyoto budgeting, identifies hitherto neglected policy areas where greenhouse gas abatement potential lies dormant and funding is available, calls for policy change where low-yield areas have benefited unduly from ample budget allocations and encourages to challenge cherished economic dogmata of renewable energy policy.

Key messages:

- The purported close dependencies bonding together taxes, subsidies and decreases in negative environmental effects have to be reassessed as they may be weaker than generally believed.
- The federal environment subsidy regime needs to be restructured along the lines of a revolving fund allowing for cost recovery by the State.
- In general, subsidies are less cost-efficient than carbon purchases for contributing to meeting the Austrian Kyoto goal. Existing slices of the federal budget need to be reallocated accordingly.
- Detailed compliance measures in the policy areas of agriculture, residential heating and transport are elaborated that could contribute eight megatons of carbon dioxide equivalent per year to the total annual tab of 20.85 megatons. Funding is available through special-purpose allocations of Austrian federal provinces.

- An elastic demand relationship between prices and consumption of petroleum products is contested. Whether demand is price elastic or inelastic cannot be conclusively ascertained. Politically engineered price increases in petroleum products may provide unsuitable leverage for curbing carbon dioxide emissions from road transport.

The proposed package deal of measures would yield considerable opportunity revenue for the Austrian federal budget if implemented promptly.

INTRODUCTION: Attempting to avoid a budgetary commitment

Studies on human-induced climate change and the need for a sustainable energy shift are customarily produced by those whose mission is to rally sympathy for the environmentalist's point of view. Authors would confront readers with a plethora of data explaining how gigawatts and terrawatts of fossil energies are being transformed into megatons and gigatons of menacing greenhouse gases each year, turning the world's atmosphere into a gigantic pressure cooker (Fig.1). Mother earth would be depicted as an ailing patient deprived of her respiratory organ by the unscrupulous burning of her primary forest cover, thus further stepping up carbon dioxide output. Other "greens" would argue that polar ice caps melting as a result of global warming will cause a one-meter rise in sea levels by the year 2100, reinventing thirty-nine countries of the present-day Alliance of Small Island States as Federated Republic of Atlantis (Fig.2). Even the occurrence of a floundering whale swept ashore lifeless by tides bereft of heat-sensitive plankton would serve for proving their point that energy consumption needs to be decoupled from economic growth[1].

This author, however, is an analyst of the federal budget. By trade impervious to agitative propaganda of all provenance, budget analysts take a detached view of things and do not easily succumb to the urge of allocating an intrinsic value to rain forests and oceans, nor a commercial value to whales and other endangered commodities that cannot be traded on most stock exchanges inside the European Union.

Where lies the wisdom of financing environment? A simple analysis usually helps determine whether a slice of budget should be committed to a new type of expenditure. The expected revenues or cost-savings divided by the planned budgetary contribution should yield an acceptable cost-benefit ratio. Seen from within the confines of a budget directorate in a treasury, allocations to environment often seem to yield a return of zero as a result of zero expected savings in other federal expenses. If so, budgeting will remain largely noncommittal and will in turn only trigger a small portion of the potentially enormous private investment needed to offset adverse environmental effects. Exceptions to this statement apply when the return is political rather than financial. However, political profit can only be reaped if an adverse effect has an obvious attributable cause, harm is done domestically and

[1] Most OECD countries have achieved decoupling during the 1990s. Outside the OECD, however, carbon dioxide output still matches GDP growth.

if cause and effect coincide during the same legislative period. Sulphur dioxide emissions fit this pattern well. Emissions of this air pollutant from industrial plants transpose into harmful immissions to nearby communities with little delay. An increase in immissions causing negative health effects in a certain geographical area can be traced back to previous increases in sulphur dioxide emissions emanating from specific industrial plants in roughly that same area.

In contrast, carbon dioxide emissions resulting from excessive consumption of fossil fuels bring about human-induced climate change globally rather than locally. Emissions from a specific carbon dioxide source cannot be held responsible for any specific harmful health or weather event occurring in the same or any other geographical area of the world. To make matters worse, a delay of several decades lies between the event of emitting a ton of carbon dioxide into the air and its contribution to the harmful greenhouse effect, which can in turn lead to extreme weather phenomena. A policy area where cause and effect relate to each other neither in place nor in time must seem questionable to budget people and will not easily allure them to the crusade against climate change. They will rather feel the uneasiness of a bank clerk who is supposed to approve of a multi-billion loan granted to an anonymous borrower offering no collateral and admitting that his investment project will yield only an intrinsic return at the end of a decade-long maturity.

The hypothesis of a zero cost-benefit ratio does not entirely hold true from a macroeconomic vantage point. The costs of catastrophic weather events attributed to climate change have risen dramatically in recent decades (Munich Re, 2006) and so has the insured portion of the corresponding economic losses (Figs.3-4). Actuarial returns may be resilient against increased risk up to a certain extent, as insurance companies tend to restrict coverage and raise premiums (Tol, 1998). Still, companies can be destabilized by sudden large losses in geographical areas where actuarial tables and estimated risks do not sufficiently reflect actual weather risk. This is indicated by the ratio of weather-related losses to premiums which has been rising steadily since the 1980s (Mills, 2005; Fig.5). Should this trend continue, technical reserves of insurance companies may become increasingly inadequate for covering losses.

However, apart from weather-induced declines of value added inflicted on the insurance industry, other cost types of damage related to climate change are much less tangible and data scarce[2]. The UN Rio Conventions and DG Environment of the European Commission have declared that the external costs of biodiversity losses are to be internalized into macroeconomic accounting systems. They fail to tell how this is accomplished, though. As a result, the price tag of a rainforest tree is still attached to its trunk rather than to the irretrievable loss of the species it represents. Which, from the treasury point of view, makes it yet another case of zero justifiable investment due to zero achievable cost savings.

We may carefully conclude that a macroeconomic approach to environment budgeting is not entirely useful in a policy area such as climate change, where harmful effects cannot be directly attributed to specific causes, nor observed environmental benefit to specific historic investments. The prospect of Austria unwittingly financing the solutions to some other countries' climate change problem is not appealing. If we do surrender to this conclusion, how easily could we reach the verdict that such an intangible cause does not warrant any sizeable budgetary commitment?

The Austrian Climate Strategy of 2002 is detailing greenhouse gas reduction potentials for eight emitter groups as a core measure package for meeting the Austrian Kyoto goal (cf. chapters 1-2). However, before the Strategy could pass the Council of Ministers, seemingly irreconcilable views on the national priorities in greenhouse gas abatement put forth by various parts of the federal administration and other interest groups had delayed reaching a national consensus for a year. An agreement was finally struck but with the slimmest margin of approval. Full implementation of the measure package has since suffered from an absence of a broad-based ownership feeling towards the Strategy. Uncertainties over whether and how abatement measures are to be prioritized and financed have certainly contributed to the reluctance of some public players to embrace the Strategy as their own.

[2] Sir Nicholas Stern's Review on the Economics of Climate Change, published in October 2006, offers preliminary macroeconomic cost estimates. According to Sir Stern, disaster costs incurred as a result of climate change phenomena amount to 5-20% of the annual global GDP, whereas costs of preventive action against climate change would only amount to 1% of the annual global GDP (Stern, 2006).

CHAPTER 1: European Union inaugurates Kyotoland – at a price

On 16 February 2005, musings on whether or not treasuries of EU member states should commit to funding measures in favour of an energy shift and against climate change became obsolete when the Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) entered into force after the Russian Federation had ratified it in late 2004. As a precondition, 55 parties to the UNFCCC including parties responsible for at least 55% of the total 1990 carbon dioxide output of the industrialized UNFCCC parties had to ratify the Protocol[3]. In arithmetic terms, this meant that the Protocol could not enter into force unless either one of the world's two most significant emitters of carbon dioxide, the USA or the Russian Federation (or both) would ratify. For years, the likelihood of this ever to happen seemed slim. In December 2004, however, President Putin signalled the Duma that a ratification would be in order. His motivation presumably sprung from expected profits from future sales of excess carbon tonnage to needy Western European governments. The overall goal of the Kyoto Protocol, a reduction of at least 5% below 1990 global greenhouse gas levels during the Kyoto commitment period 2008 to 2012, seemed in reach for the first time.

Even before, the Protocol had been fleshed out with a list of reduction goals for industrialized parties. The European Union was allocated a summary 8% emission reduction target, affectionately known to Kyoto-ites as the "EU bubble". For Protocol parties outside the Union, reduction goals remained indicative, as no international law provisions exist for persecuting non-fulfilment. The EU Environment Ministers, in contrast, had already prepared a burden-sharing agreement for the 15 Member States as early as 2002, in anticipation of the Kyoto Protocol to enter into force (Council Decision 2002/358/EC of 25 April 2002). With the Protocol finally off the ground and the burden-sharing in place, fulfilment of the reduction goals became legally binding for Member States. Failure to reach compliance until the Kyoto commitment period will subject a Member State to a costly breach of EC Treaty lawsuit potentially resulting in a fine levied by the European Commission[4] together with a ruling that the missing balance of carbon dioxide tonnage be purchased on the carbon

[3] Only 38 of the 55 parties necessary for entering into force were industrialized parties subjected to greenhouse gas reduction goals. The remaining parties were non-industrialized with no goals.

[4] Fines levied by the European Commission against Member States as a result of a verdict of breach of EC Treaty in the area of the environment acquis communautaire may amount to several hundred thousand Euros per day (cf. Crete, landfill case) up to one million Euro per day (Bavaria, case related to NATURA 2000). Fines are payable until the breach is remedied.

market[5]. Furthermore, the defaulting Member State may have to pay an additional, Kyoto-specific fine per excess ton of carbon dioxide[6].

Like it or not: the obstinacy of European Union legislators turned crusaders against the unholy alliance of worldwide greenhouse gas emitters has finally provided state budget people with a figure they can cling to: a high ratio of cost-savings to cost which warrants expenditure. Whereas cause (emitting greenhouse gases) and negative budgetary effect (fines in place by 2012) still do not coincide during the same legislative period (the effect occurring in subsequent periods), the expected cost-savings divided by budgetary input will now most likely yield a positive return (Fig.6).

The expenditure that industrialized Kyoto Protocol parties[7] will have to incur for fulfilling their pledged reduction goals will result in GDP losses to their respective economies (IPCC, 2001; Fig.7)[8]. In order to cushion these losses, the Protocol is foreseeing three market-based "flexible Kyoto mechanisms"[9] following the principle of exploiting regional cost differences of reducing greenhouse gases. While each Protocol party still has to achieve the bulk of her reduction effort domestically, the two project-and-trade based and one purely trade-based flexible mechanisms acknowledge the nature of climate change as a global phenomenon. The mechanisms therefore focus on the global Kyoto reduction goal rather than on single regional goals, allowing trade transfers of carbon dioxide tonnage from parties with carbon to sell to parties in dire straits (Fig.7). Ideally, establishment of the required carbon markets will not compromise but support the fulfilment of the global goal. At any rate, the

[5] Potential non-compliance can only be substantiated at the end of the Kyoto commitment period 2012 or during the grace period starting 2013. By that time, carbon markets will likely be demand-heavy with prices per ton of carbon dioxide certificate substantially higher than in the pre-2012 period.

[6] The magnitude of this future type of fine for Member States is still unclear. However, it is safe to speculate that the European Commission will not levy a Member State fine lower than the existing fine of 100 Euro per excess ton of carbon dioxide for the private sectior within the framework of the EU emission trading regime (Second Trading Period 2008-2012; Directive 2003/87/EC of 13 October 2003). For the time being, however, there is no EU legal basis for such fines on Member State level.

[7] Apart from the European Union and its 25 Member States, the following countries have ratified the Kyoto Protocol and have accepted reduction goals: Bulgaria, Canada, Iceland, Japan, Liechtenstein, Monaco, New Zealand, Norway, Romania, Russian Federation, Switzerland and Ukraine.

[8] IPCC findings may seem surprising at first glance, as most compliance expenditure is invested in industry branches located inside the OECD, not in developing countries (e.g. production of renewable energy generator modules and fuel switch research). These positive economic effects are, however, apparently outweighed by negative effects associated with elimination of energy-inefficient products from the market or the investment needed for improving the ratio of output unit per ton of oil equivalent (u/toe).

[9] "Joint Implementation", "Clean Development Mechanism" and "Emissions Trading" according to, respectively, Articles 6, 12 and 17 of the Kyoto Protocol.

"mechanisms" stand no chance at sidestepping the Kyoto obligations of individual countries, as they cannot influence the magnitude of their abatement goals.

By a similar token, marginal costs of compliance with Kyoto targets are higher in Europe and Japan, where policies promoting energy saving had already been more widespread in 1990, the Kyoto baseline year, than in the rest of the OECD (Fig.8). In other words, "environment rogue states" suffer lower marginal costs of compliance in 2006 because of their lesser degree of pre-Kyoto compliance in 1990. However, with full flexible Kyoto trading in place, marginal costs decline dramatically and variance between marginal costs in different parts of the OECD becomes minimal (Fig.8).

CHAPTER 2: Austria spearheading the EU climate and energy shift crusade

Austria has chosen to take on remarkably ambitious fulfilment goals under both the EU Kyoto burden sharing agreement of 2002 and under the EU Directive on the promotion of electricity produced from renewable energy sources of 2001[10]. Austria is rather unique in this respect. Most Member States acknowledged their limited Kyoto reduction potential and renewable energy development potential and received correspondingly modest goals. Some other Member States took advantage of the 1990 baseline, knowing they would profit from big one-off declines in carbon emissions that took place after 1990 and are thus accountable under the fulfilment goals[11]. In Austria, most easy-to-achieve industrial energy efficiency measures were conducted pre-1990. Carbon cuts accrued through these measures are thus now "lost" for Kyoto accountancy. With few cheap measures still available in post-1990, marginal costs of compliance with environment goals have been higher in Austria than in all other Member States except Denmark. Under such circumstances, even relatively unambitious compliance goals would seem hard to meet. Surprising hence to see that Austria agreed to one of the highest compliance burdens despite her early energy-efficiency leadership role in Europe. More surprising still that half the other Member States were "rewarded" for sloppy pre-1990 energy-efficiency standards and assigned lenient Kyoto and renewable energy goals. Goals they should find relatively easy to fulfil courtesy of the untapped high efficiency potentials still prevailing in those countries (Fig.9).

With effective compliance strategies still on the drawing board, the gap between the Austrian Kyoto goal of 68.7 megatons of carbon dioxide equivalent to be reached until 2008-2012 and actual emissions has been widening since 1990. From the onset, there has been much political contention about whose emission forecasts to trust, how to register business-as-usual emission trends of the various gas-emitting sectors and by which formulae to project their future emission trends. However, Environment, Economy and Finance seem to be bound by a peculiar tacit agreement not to spread too blatantly the gospel of widening

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[10] Directive 2001/77/EC of 27 September 2001. What started out as "reference values" for EU-15 Member States has since developed into compulsory goals as Article 3 of that Directive is linking the "reference values" to Kyoto Protocol fulfilment obligations. Energy customers bear the brunt of the renewable energy goal via eco-surcharges on top of their electricity bills. Besides, the federal budget is burdened by increasing demands for kyoto-related state subsidies thought to trigger private investment for renewable energy power plant projects.

[11] Germany and the UK profited from substantial carbon dioxide reductions achieved "for free" via the post-1990 closure of major coal pits. In both cases, carbon cuts were the by-product of profound political and macroeconomic changes rather than a result of successful environment policies.

fulfilment gaps. The common interest in this unspoken tripartite pact is obvious. Environment would be loathe to concede the elusive nature of reduction goals. Economy would be wary of placing a higher compliance burden on their clientèle. Finance would shun the inevitable consequence of having to release additional public funds for triggering higher amounts of "green" private sector investment (Fig.10).

CHAPTER 3: Tax revenue to subsidies to a better world? – dismantling a dogma

A strong belief has prevailed in Austria and elsewhere that a government's toolbox for achieving fulfilment of national environmental goals should contain four instruments: taxes, subsidies, a hefty compendium of regulatory law and voluntary measures. Market-based trading systems have recently been added as a fifth instrument. The belief holds that a raise in taxes discourages the taxed activity (cf. Hoerner and Bosquet, 2001), in our case the output of fossil energy emissions. The State is in turn assumed to reinvest revenue acquired from "emission charge" tax types into environment-related subsidies (cf. Bontems and Bourgeon, 2005) or into subsidies on employers' social security contributions, thus boosting the labour market (cf. Galeotti and Carraro, 1996). By the book, such tax revenue is supposed to substitute other forms of taxation that are reputedly distorting the functioning of the economy (cf. Oates, 1995). The notion of freeing labour, capital or savings from distortive taxation while at the same time burdening polluters with new environment taxes is commonly referred to as creating "the double dividend" (cf. four last quotations; Fig.11). Environment tax reformers are heavily advertising the double dividend's revenue neutrality effect, emphasizing that any tax raises always precisely equal tax cuts.

Yet, real interdependencies among the variables involved (tax levels, subsidy levels and effects thereof) seem to defy the double dividend doctrine. As a result, it does not lend itself easily to the budgeting routine of a treasury. While Fig.11 depicts the ideal textbook notion of "double dividend", Fig.12 tries to revise that notion according to the author’s practical experience.

First, tax reforms normally result in a decrease or an increase of the total tax burden. Tax cuts (or raises) in one policy area seldom correspond directly to tax raises (or cuts) in another area. It is generally impossible to tell whether any raise in a specific tax was motivated by a previous cut in any other specific tax; it is likewise tough to ascertain whether tax revenue losses [-x] from a cut [a] really correspond to tax revenue gains [x] from a raise [a'].

Hikes in environment/energy-related taxes ("element #2" of double dividend) are often motivated by a purported need for "internalizing all external environment costs". This notion that consumer good prices need to be burdened by augmented taxes so that retail prices truly reflect the degree of damage inflicted on the environment during the process of producing the goods continues to sound far-fetched. Especially the implied mechanics of how such tax revenue is reinvested into the environment tends to be poorly explained by its advocates and hence remains poorly understood[12].

Another assumption holds that heavier taxation of environment-hostile consumer goods, especially of fossil fuel products, invariably results in a price elasticity factor of bigger than one ($\varepsilon > 1$), meaning that demand for these products must fall significantly as the tax burden rises. The assumption that demand is sensitive to price changes actually holds true in many areas. For instance, there is clear evidence of a strong tie between rising levels of tobacco taxation and declining demand for tobacco products (e.g. Chaloupka, Cummings et al., 2002). In contrast, with regard to fossil fuel consumption, price elasticity of demand is more erratic and can normally not be anticipated well enough to base policy models on: Fig.12 and Tab.5 in chapter 9.

Even if additional tax revenue accrues, it is not typically earmarked for expenditure under any specific budget line such as for stepping up environment subsidies. Treasuries shun away from earmarking as it reduces the flexibility of shifting funds between budget lines during a budget cycle. Experience also shows that earmarking sometimes results in the accumulation of surplus funds in budget lines whose funding forecasts overestimated needs. Besides, earmarking is accompanied by a legal basis entitling a public entity beneficiary to the dedicated funds. Trying to revoke such a legal basis involves a lot of political bickering, even if the fact that surplus budgeting has occurred is uncontested. So, treasuries usually take great care to avoid any legally guaranteed earmarking in the first place (Fig.12).

Last, environment subsidies are typically quantified along annual pledging frames rather than along annual budget allocations. Unlike a budget allocation, a pledging frame is a political agreement determining a certain maximum amount that can be pledged in subsidies by a

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[12] Article 3 of the EC Treaty contains an exhaustive list of all policies of the Community. Article 6 specifies that "environmental protection requirements must be integrated into [...] Community policies [...] referred to in Article 3, in particular with a view to promoting sustainable development". Eventually, the Commission has coined the catch phrase of "internalizing external costs" in an attempt at enlivening the Article 6 requirement. Diverse Council working groups ranging from fisheries to education were commissioned to produce conclusions of how "internalizing" may be achieved in their respective policy areas. Comparison of the ensuing conclusion papers reveals that only Council WGs in the environment area fully endorse "internalizing" while others (among them industry, transport and internal market) remain lukewarm and rather tend to defend their own policies against pervasion by the "internalizing" doctrine. Since the Commission has failed to arbiter the consistency of the various Council WG conclusions in favour of "internalizing", the doctrine has never been more than a catch phrase.

public entity over a given year. However, what shows in the budget forecast of that year (that is, what is physically available as "budget") is not the frame but a lower amount. As subsidies for environment projects tend to be disbursed in installments over several years after pledging depending on project progress, the total budgeted amount for budget line "government subsidy regime" in year [n] will usually have to cover all installments of historic subsidies pledged during years [n-5, n-4, ...] that are likely to become mature during year [n]. Likewise, a year [n] budgeted amount typically has to cover only a fraction of subsidies pledged under the pledging frame of that same year. The expected annual environment-related private investment triggered by subsidies consequently has to be calculated from the actually budgeted amount for a given year and not from the amount suggested by the pledging frame[13]. In Figs.11-12, a ratio of pledged to budgeted subsidies of 2:1 is assumed over a given year.

The lower half of Fig.11 is presenting regulatory law as a tool well suited to decreasing negative environmental effects. Regulatory law provisions emanating from the EU acquis communautaire are usually indeed extremely effective at compelling private sector emitters of greenhouse gases to either cut their emission output and/or to acquire any gas ton balances exceeding their emission allocations via trading regimes. Production phase-outs of fluorinated gases and landfill gas containment are other policy areas with excellent environment dividends, paid for by a high degree of regulatory legal interference with private sector activity. However, actual decrease in negative environmental effects occurs only if regulatory provisions directly target an industrial plant's emissions or its production quotas. Hence, effective as it may be, too much emphasis on regulatory law as a tool for approaching environment goals can damage the economy by lowering its immunity against international competitors subjected to lesser degrees of regulation by the law compendiums of their respective countries.

The purpose of this chapter has been to show in theory that causal loop diagrams linking tax raises with the fulfilment of purported environment policy goals via raised subsidy levels do not necessarily describe the interdependencies among these variables accurately. Based on

[13] If underfunding below pledging frame levels continues for several years, the total of matured subsidy installments to be disbursed during a given year will start exceeding the pledging frame amount for that year. Serious legal problems can arise when a budget forecast fails to anticipate this on time and part of the installments cannot be disbursed: subsidy contracts issued to beneficiaries by the relevant state authorities constitute a claim enforceable by the beneficiary as a liability against the state budget.

this, we may conclude that governments relying too excessively on upper-half-Fig.11-type schemes for approaching their policy goals may eventually end up short of these goals. A Fig.12-type scheme may better reflect reality, in which monocausal dependencies among variables are not expected to occur, resulting in a more cushioned or erratic yield in decreasing negative environment effects. Governments choosing to embrace the notion that the maximum achievable environment yield out of the tax-subsidy cycle is much lower than commonly assumed may eventually run a smaller risk of ending up short of their agreed international environment policy goals. That is if they anticipate these yield shortfalls early enough to have offset policies in place for compensation.

CHAPTER 4: Kyoto-relevant subsidies in Austria: screwing nails with wrenches?

Austrian developers of energy-efficiency and shift-of-energy-source projects are eligible to a wide array of public subsidies (cf. Sattler, 2005). All levels of Austrian government grant subsidies, especially the federal state and governments of federal provinces. To these may be added EU structural fund co-subsidies (European Fund for Regional Development, EFRD, for "Objective 2" regions)[14]. Remarkably, a developer can tap all three types of subsidies for one and the same project. Even more remarkably, funds disbursed by the Federal Environment Subsidy Regime (FESR)[15] take the form of non-refundable grants; likewise, FESR does not work along a revolving fund principle[16]. Varying among eligible project types, developers typically benefit from a FESR investment allowance of around 25% of total environment-relevant investment cost of a project. The percentage can peak up to just below 50% and is mostly below 25% when an EFRD co-subsidy is added. Any investment allowances granted by subsidy regimes of federal provinces have to be added to these figures. In the end, one to two thirds of the investment cost of a project will be covered by non-refundable grants. If another third is taken care of via a preferential loan put forth by a commercial bank in anticipation of the subsidy collateral, only a modest contribution in developer's equity capital will still be missing to the total financing package. With conditions as favourable as these, the number of project developers turning to the FESR for a subsidy as part of their project financing is approaching a thousand per year. Among those may be some ardent "green" developers primarily driven by an urge to abate carbon dioxide emissions, idealists who would be attracted to FESR even if it insisted on cost recovery. However, it might not be undue to speculate that the large majority of FESR subsidy beneficiaries are not of the eco-crusading type. Their motivation for submitting project

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[14] In this policy area, the federal state is represented by the Federal Minister of Agriculture, Forestry, Environment and Water. The Minister has subcontracted administration of federal environment subsidies and of EU structural fund co-subsidies to Kommunalkredit Public Consulting (a subsidiary of Kommunalkredit Bank). Due to the same administrator for federal and EU subsidy funds, excessive cumulation of these two subsidy types in a given project can be avoided. However, subsidies granted by federal provinces in addition to federal/EU subsidies cannot be held in check by the federal subsidy administrator as federal provinces usually do not communicate their data to the federal state. In this way, "overkill environment subsidizing" exceeding 50% of investment cost of a project may occur rather frequently yet will largely go unnoticed.

[15] "Umweltfoerderungen des Bundes im In- und Ausland" pursuant to Austrian Environment Subsidy Law ("Umweltfoerderungsgesetz", BGBl. 1993/185).

[16] Elsewhere, funding instruments for environment and development assistance are revolving; over a given time, the fund beneficiary is expected to repay the original sum, plus interest and fees to the fund administrator. The paid back sum restocks the fund. In contrast, in Austria, even the administrative fees involved in processing applications for subsidies are covered by the State budget.

proposals to the federal subsidy administrator may rather spring from the fact that FESR is an unprecedentedly alluring project financing vehicle.

In this world of deliberate zero percent stranded cost recovery, the government does not receive an equivalent market compensation in return for its subsidies. Admittedly, subsidized projects generate greenhouse gas reductions which in turn reflect positively on the national Kyoto inventory of the State. Legally however, Kyoto gas tonnage abated via FESR projects does not constitute a commodity whose ownership is transferred from project developer to the State in exchange for subsidies. In contrast to tradeable carbon dioxide quotas, gas tonnage from FESR projects is not tradeable. Its existence is a mere byproduct of the subsidized plant's main activity such as production of heat. None of the parties involved can exercise a legal right of disposition over FESR gas tonnage[17].

Another point worth discussing is how the carbon abatement performance of FESR may be distorted by received Kyotoland abatement calculation methods. By definition, three types of abatement qualify for Kyoto accountancy: "genuine" replacement of fossil carbon dioxide emissions by carbon-neutral emissions ("fossil plant" closes down as "renewable plant" opens up); stepping up of new carbon-neutral production capacity ("renewable plant" opens up, other "fossil plants" stay the same); revamping of dormant carbon-neutral production capacity, especially small hydropower ("renewable plant" re-activated, other "fossil plants" stay the same). Only in the first type, existing "bad" emissions are directly replaced by "good" emissions. In the other two types, "good" emissions increase without an immediately corresponding drop in "bad" emissions. Kyoto accountancy rules define that a new ton of renewable emissions automatically replaces an existing ton of fossil emissions. This may be too idealistic an approach as it implies that supply and demand for energy-related commodities are constants and that the market will always prefer commodities produced in a carbon-neutral way and phase out those that have caused fossil emissions during their production and delivery cycles. In the long run, fossil energy production capacity is indeed likely to decrease in favour of renewable energy production capacity. In the interim,

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[17] In many respects, FESR is a much less commercially oriented instrument than the Austrian JI/CDM Purchase Program. In the Program, also administrated by Kommunalkredit Public Consulting, the government strikes Emission Reduction Purchase Agreements (ERPAs) with sellers of certified carbon dioxide quotas. There, the legal right of disposition over quotas shifts from the project contractor (seller) to the State (buyer) during a C.O.D. transaction. Quotas purchased under the Program are fully tradeable. Their expected market value represents a part of the project's financing package.

however, greenhouse gas reduction account ledgers may become artificially inflated if potential fossil emissions forestalled are counted equal to real carbon substituted.

FESR is considered a cornerstone tool of Austrian federal environment policy for promoting energy efficiency and greenhouse gas abatement. However, as most other subsidy regimes, FESR does not serve one political purpose alone. Apart from harvesting the carbon yield, it is claimed to boost employment in the renewable energies production, supply and delivery sector. FESR also serves as a tool for selectively bestowing subsidies on certain project types depending on prevalent political preference at a given time. Lobbyist factions among producers and suppliers of different renewable energy technologies and fuels (e.g. wind turbines, solar panels, biomass, etc.) can have a strong pull towards biasing the total number of subsidized projects of a given project type.

In the light of 247.5 million Euro (0.1% of GDP) of present value subsidy disbursed to project applicants over the reporting period 1999 to 2004, it is rewarding to explore just how well FESR has delivered as a carbon dioxide reduction vehicle and how prominently an optimized carbon yield has figured on its agenda (Tab.1). Two figures are of interest in this respect: the ratio of "Euro per ton of carbon dioxide equivalent" (Euro/ton CO_2e) gives an indication of the cost-efficiency of a (subsidy) instrument by showing whether cheap project types are preferred over costly ones (Tab.1, column 5); the other figure shows the extent to which the instrument is absorbing the total reduction potential of a given project type (Tab.1, column 7).

Some contention has prevailed about the proper way of calculating the cost-efficiency ratio Euro/ton CO_2e. If a completed FESR project produces an annual abatement of [z] CO_2e, results would be distorted if [Euro subsidy] were simply divided by [z]: since the abatement accrues annually, it can be booked five times onto the Kyoto account ledger during the five-year Kyoto period 2008-2012. One way of acknowledging this fact would be to calculate [Euro of present value subsidy] divided by [tons of annual CO_2e yield] and divide the result by five. Another way (pursued here in column four of Tab.1) is to calculate [Euro of present value subsidy] divided by [5*tons of annual CO_2e yield]. In order to arrive at the overall cost-efficiency rate of FESR, a weighted average needed to be calculated from the single efficiency rates, as projects of the various types vary greatly in number[18]. The result of this exercise is a figure of 16.9 Euro/ton CO_2e overall cost for the projects approved of under FESR during the reporting period 1999-2004.

The Federal Environment Administration disagrees with this calculation mode, arguing that completed FESR projects have service lives of ten years (solar power) up to thirty-five years (small hydro power). As projects continue to yield greenhouse gas abatement over these periods, they argue further, [Euro of present value subsidy] needs to be divided by [a*tons of annual CO_2e yield], whereby [a] denotes the number of service life years and is always [a > 5]. If we were to proceed in this fashion, we would necessarily arrive at very low values for [Euro/ton CO_2e] that would make FESR appear as the most cost-efficient environment policy tool in town[19]. However, as valid as the service life approach may be from a technical point of view, the more unsuitable it proves from legal and budgetary perspectives. There is at present no law compendium this side of the European Union or beyond that regulates a post-2012 Kyoto regime. For lack of a legal basis, budgeting for measures combating climate change during a potential post-Kyoto period cannot take place at this time and hence must not be mingled up with current-period budgeting. By the same token, one is compelled to find objectionable any line of thought that suggests to camouflage a certain cost-inefficiency in a 2008/2012 Kyoto period subsidy instrument by conjuring up a sort of cost-recovery potential in a following period. If a post-2012 Kyoto regime is to be implemented, the continuing abatement power of FESR projects subsidized pre-2012 will indeed benefit the post-2012 Kyoto account ledger until the end of their service lives. This may result in a cushioned Kyoto budget need post-2012, but will have no impact whatsoever on the current funding requirements up until 2012[20].

The other crucial figure besides cost-efficiency is reduction potential. Columns 6-7 in Tab.1 show that the extent to which FESR is absorbing reduction potentials in many project types is obviously rather limited. Two biomass-related project types stand out, though, in showing

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[18] For instance, during the reporting period 2002-2004, FESR approved of subsidies for 609 solar power projects, 1 geothermal power project, 184 thermal insulation projects, 2 landfill gas projects, 818 biomass heating projects (private enterprises), and so forth.

[19] Instead of 138.4 Euro/ton CO_2e, solar power would appear to cost only 69.2 Euro/ton CO_2e in subsidies; hydro power subsidy cost would seemingly drop from 89.8 to 12.8 Euro/ton CO_2e, etc.

[20] A post-2012 budgetary cushion effect will only occur if budget-relevant Kyoto I variables will stay the same in a potential Kyoto II regime. This, however, is not likely to occur. As the abatement requirements imposed on Austria will rather rise than fall, any such cushion brought about by the service life approach would likely be eaten up by the overall rise in funding needs over Kyoto II.

percentages of more than 100% fulfilment of the potentials estimated by the environment administration. This may be due to gross prior underestimation of these two potentials or to other reasons. Where quantifiable, however, the six-year reduction potentials (over the 1999-2004 survey period) of many other project types prove to have been only poorly absorbed by FESR, ranging from 2.1% in thermal insulation to just above 50% in wind power.

We may summarize our main conclusions on FESR as follows:

What kind of an instrument is FESR? FESR is a non-revolving subsidy fund instrument, disbursing non-refundable investment allowance from the federal budget to any natural or juristic person acting as applicant. No part of the granted funds can be recovered by the State.

Is FESR pursuing a cost-priority policy? No, cheap project types are not systematically favoured over costly ones. Despite tremendous cost variance among project types ranging from just 2 Euro/ton CO_2e in thermal waste processing to 500 Euro/ton CO_2e in photovoltaics, subsidy funds are not preferentially committed to the cheap types as long as they are available and only then remaining funds shifted to more expensive types. This seems to underscore a primary trait of FESR in dishing out subsidies until the annual pledging frame runs dry. Unfortunately from a budgetary perspective, this practice of rather unselective disbursing of subsidy funds almost on a first-come-first-serve basis is obviously taking precedent over a coherent cost-efficiency approach[21].

Does FESR more or less fill out existing national reduction potentials of the project types in its portfolio? No, a maximized carbon dioxide yield does not seem to figure prominently on the FESR agenda. In 12 out of 20 project types, only a fraction of the reduction potentials estimated by the environment administration could be tapped during the reporting period by granting FESR subsidies.

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[21] Unlike Austria, the Danish government, in its 2003 climate strategy, emphasized cost efficiency, prioritized the most cost-efficient instruments for carbon dioxide abatement and pledged to stall financing of more costly measures until the cheap ones were implemented. Although Denmark and Austria are burdened with similarly harsh Kyoto reduction goals, Austria has not yet followed suit (cf. chapter 7 and footnote 40).

What is the net greenhouse gas yield of FESR? The overall yield of 14.66 Mt CO_2e accrued over the reporting period 1999-2004 corresponds with an annual yield of 2.93 Mt CO_2e creditable in each one of the five Kyoto period years 2008-2012. Taking the Austrian Kyoto compliance gap of 23 Mt CO_2e in the year 2004 as an example (cf. Fig.10), we see that FESR has only filled 12.7% of that year's gap. If 2004 had been a Kyoto period year in which compliance with the EU burden sharing goal was verified, and if FESR had been the only available instrument serving greenhouse gas abatement, then Austria would have been confronted with a 87.3% compliance gap in spite of the considerable federal financing engagement in that subsidy instrument. Further, if FESR subsidy cost in the reporting period is representative for carbon dioxide abatement prices in the Kyoto compliance period, financing an annual 2004-size gap would cost 388.7 million Euro or 1.94 billion Euro (0.8% of GDP) over the entire compliance period.

CHAPTER 5: Do renewables trigger a "New Deal" in boosting the economy?

Climate-related subsidies may neither be particularly abatement-effective, nor a very cost-efficient investment for meeting international reduction goals. However, they do trigger private investment in the renewable energies technology sector, which in turn will increase domestic value added and create new employment. While this statement will be acceptable to most, the extent to which it applies is quite difficult to quantify. FESR and similar instruments create a favourable environment for investment, even if the ensuing positive effect on the economy cannot be directly attributed to any specific previous disbursement of funds from a subsidy instrument. Likewise, the positive effects emanating from one instrument cannot be easily quantified against those of another. It has been argued that the extent of new value added and new jobs can be deduced from gross output as gross output can be deduced from the private investment that had benefited from subsidies.[22].

However, the dependencies among these variables may not be as linear. Investment in the renewables sector would also occur in the absence of FESR and other subsidy regimes, albeit on a lesser scale. Gross output in that sector would still be bigger than zero even if subsidy levels were zero. Hence, a subsidy-biased approach to explaining the positive contribution that the renewables sector is exerting on the economy may easily lead to a hasty conclusion that no equivalent alternatives to subsidies exist for inducing abatement of Kyoto-relevant emissions and meeting environment goals.

The "positive effect on the economy" under scrutiny is made up of new turnover, new domestic value added and the emergence of new jobs in the wake of plants that will utilize renewable energy sources for the production of heat or electricity ("renewables plants"). Normally, the impact of these three components is measured separately for effects that occur through the production of renewables technologies and for effects that occur through the operation of renewables plants (Haas, Biermayr et al., 2006; Kranzl, Haas et al., 2005).

The first and second components, new turnover and new domestic value added, can be dissected into "direct turnover effects" from the construction of renewables plants, "indirect

[22] In its "Evaluierung der Umweltfoerderung des Bundes fuer den Zeitraum 1.1.2002 to 31.12.2004", the environment administration is using the following causality chain for that reporting period: 140.7 Mio. Euro of disbursed FESR subsidized 679.4 Mio. Euro of environment-relevant private investment; the latter triggered 852 Mio. Euro gross output, corresponding to 416 Mio. Euro of new domestic value added and 6,586 full-time jobs created.

turnover effects" from intermediate input (current purchases of materials and services needed in the construction of plants) and "secondary effects" resulting from an increase in net income. Only effects occurring through the production of renewables technologies are shown in Fig.13 with regard to these two components (Haas, Biermayr et al., 2006). While solid biomass alone accounted for 38.3% of total 2004 turnover and for 40.1% of total 2004 value added, eight other renewable energy sources together brought up the balance. However, all nine renewables technologies included in the survey for 2004 show a remarkably high ratio of value added to turnover ranging between 57.5% for photovoltaics and 74.8% for liquid biomass (Fig.13). By comparison, the total 1993-2003 average ratio of value added to turnover in Austria attained a mere 29.8%[23] with energy on the high end and trade on the low end of the scale with ratios of 53.5% and 16.8%, respectively[24] (cf. Kraus, 2006). A high ratio may be interpreted in various ways: it may be an indication for a staff-intensive production cycle (bigger staff equals more salaries paid) and, often linked with high staff numbers, may hint at a high degree of manufacturing penetration; high levels of required technical know-how reflected in "intelligent products" can be another reason for a high ratio of value added to turnover; further, the ratio will rise if the production plant finds itself in a favourable competitive situation (the ratio would drop if price increases of intermediary input can no longer be absorbed by turnover).

In order to find out which of these potential reasons might account for high value added in renewable heat and energy products, we must take a closer look at the third component contributing to a positive economic effect: employment in the renewables sector; in the studies quoted above, labour effects from the production of renewables technologies and labour effects from operating renewables plants have been evaluated separately (Fig.14; Haas, Biermayr et al., 2006; Kranzl, Haas et al., 2005). Fig.14 mirrors Fig.13 in showing a predominant position of solid biomass, accounting for as much as two thirds of all jobs held in the renewables sector in 2004. This is largely due to a comparatively labour-intensive forestry sector as the main supplier of biomass raw materials. Again, eight other renewable energy sources bring up the rear end of that survey for 2004. The marginal role they play as employment engines can be a result of foreign-produced technologies imported into Austria, such as components for wind generators, possibly entailing a negative domestic labour

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[23] Comprising data for industry, service and trade sectors.
[24] In between figured the building sector (38.3%), industry (31.5%), textiles (28.8%) and services (27.7%).

effect[25]. Besides, the operation of renewable energy plants is not labour-intensive when the energy source feeds the generator automatically (hydropower, photovoltaics, solar power, wind power); nor is maintenance when an absence of moving parts results in only modest mechanical wear and tear (photovoltaics, solar power).

A closer comparison of renewable energy sectors with other sectors of the economy further defies the cliché of renewables as an employment engine. Tab.2 shows that turnover per full-time job is significantly higher and full-time jobs per turnover significantly lower in all nine reviewed renewables sectors than in any of the industry and service sectors under the OeNACE 1995 classification system[26]. This may seem plausible when compared to table header apparel industry, where big workforces remunerated with mediocre pay churn out low-price mass products, or compared to the building sector, where high job numbers are needed for attaining high ratios of manufacturing penetration[27] (as in converting piles of outside-purchased steel and glass into a high-rise). It would seem much less plausible, though, when compared to power supply services, a sector subjected to very similar economic parameters as the renewables sectors[28]. Still, turnover per full-time job in power supply services only amounts to between a half and a third of the figures for the various renewables sectors; necessarily, the figure for full-time jobs per turnover is about three times to twice as high.

The figures compiled in Tab.2 corroborate the hypothesis that renewable energy plants create and sustain only negligible numbers of jobs per turnover. As a consequence, the prevailing high ratios of value added to turnover seen in Fig.13 cannot be explained via an alleged employment engine effect that the renewables sector is often said to exert. Another potential reason for a sector to exhibit a high ratio of value added to turnover would be a high rate of manufacturing penetration (MP). Although no comparative data is known to

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[25] If foreign-produced renewables technologies (cf. wind power) are preferred over domestically-produced ones (cf. small hydropower), the labour effect will be negative, as an increasing dependency on foreign market supply and post-sales services will saturate part of the market with foreign produce and render part of domestic supply redundant.

[26] Fourteen OeNACE sectors have been selected for Tab.2, apparel industry (not surprisingly) being the all-time nadir of turnover per full-time job and power supply services the all-time zenith.

[27] Manufacturing penetration = ratio of (internal production) / [(internal production) + (outside purchasing)].

[28] Figures for power supply services, OeNACE #40, in Tab.2 incorporate supply out of fossil energy as well as renewable energy sources. The fact that renewable energies are already reflected therein makes the discrepancy between #40 figures and renewable energy sector figures even more stunning.

exist, we might speculate that MP in the production of renewables technologies is higher than the usual average 20% rate in "traditional" mechanical engineering: producers of small hydropower generators, landfill gas turbines and heat pumps tend to manufacture their renewable energy machinery according to their own patents, which often requires internal production of components not available through outside purchasing. On the other hand, MP in the operation of renewables plants may be next to zero in wind power, solar power, small hydropower[29], geothermal power and photovoltaics, where no intermediate input needs to be purchased nor improved (refined) as a precondition for the production of the plant's output (heat or energy); the same applies to biomass and biogas plants unless operators do not own the required continuous supply of intermediary input (tree plantations or domestic animals as sources of "renewable fuels") and have to rely on outside purchase. To sum up, MP is likely to contribute to some extent to the high ratios of value added to turnover, is however unlikely to be the decisive factor. A similar verdict may apply when trying to judge whether renewable heat and power are "intelligent products" with a high degree of required professional know-how input. Again, the technology side would seem to merit a designation of "intelligent" rather than the operations side. However, many other sectors of the economy are characterized by high rates of MP and "intelligent" output (e.g. electronics industry) but still do not show particularly high ratios of value added to turnover.

By process of elimination, we arrive at the conclusion that the high ratios of value added to turnover are possibly due to the very favourable competitive situation in which renewables plants operate. First, price increases and availability of intermediary input do not seriously curtail turnover, as intermediary input is in ample supply (biomass), an otherwise unwanted waste product (manure for biogas), or even a free commodity with zero transportation costs (wind, solar power). The decisive factor, however, distinguishing renewables from most other sectors in Austria, is that political preference is shielding them from the shark ponds of competition. Substantial parts of developers' investment costs are defrayed through state subsidies. In addition, power-producing plants receive legally binding guarantees of feed-in tariffs for "green" electricity which far exceed market prices for power. This habit of subsidizing both the construction of the production plant and, once completed, guaranteeing the sale of its product at a preferential price, is what makes value added soar in renewables. Seemingly at least, as subsidy-generated value added can hardly be a healthy and viable contribution to the economy.

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[29] Utilisation of water for energy production in Austria can, however, be subject to payment of a "water toll", charged to the operator of the plant.

Marvelling at the title to this chapter, it may appear far-fetched to juxtapose the 1930s New Deal and present-day Austrian policy on renewable energy. One parallel exists, though: both initiatives set out to boost employment and trigger private investment. However, although Austria has seen renewables plants mushroom from wide to far, the labour effect has remained modest and the sector still appears to be largely accumulating its profits via subsidies.

CHAPTER 6: Why some emitter groups deserve closer attention

We have seen that the dragon (Kyoto goal, Fig.10) has so far been poked with some of the bluntest lances that the realm could muster, ranging from federal subsidies (Tab.1) to a mystical belief in a tax panacea that will one day close all compliance gaps (cf. Figs.11-12 in chapter 3 and Tab.5 in chapter 9). Concurrently, time is running out before 2008, as of when Austria's Kyoto performance will start to count[30]. The government should therefore choose to reprioritize its compliance strategy along the criteria of cost-efficiency, optimal carbon yield and certainty of carbon yield. As importantly, some major emitter groups that seem to have so far been spared from drastic measures must begin to pay their dues to the national emissions account ledger. This may necessitate prior changes of current political priority in the federal provinces of Austria and also in the federal environment and energy administrations.

The Austrian Climate Strategy of 2002 is listing greenhouse gas reduction potentials for eight major emitter groups (in million tons of CO_2e per year)[31]: heating emissions from households and enterprises (4.0); heat and energy-converting industry (2.1); waste processing industry (1.1); transport sector (3.7); industry and producing sector other than conversion of heat and power (1.25); agriculture (0.4); production of fluorinated gases (1.2) and "other sources of carbon dioxide, methane and nitrous oxide" (0.1). In 2002, the intended role of purchases under the flexible Kyoto project mechanisms had not been quantified but has since been set at 7 million tons of CO_2e per year. The total targeted annual reduction goal including purchases would so amount to 20.85 million tons of CO_2e.

Regulatory law is holding the heat and energy industry as well as industry and the producing sector in check via the allocation quotas under the EU emission trading regime (Directive 2003/87/EC, see footnote 6) while massive EU waste and landfill management legislation

[30] Compliance will be evaluated ex post after 2012. Non-compliance in one of the five Kyoto years can be compensated by over-compliance in another, as long as the cumulated tonnage of greenhouse gases emitted between 2008 and 2012, divided by 5, does not exceed the tonnage corresponding to the -13% goal in any of the five years.

[31] At the time of writing, a 2007 Austrian Climate Strategy was being prepared. Reduction potentials to be given therein will vary from the 2002 figures.

curbs highly Kyoto-relevant methane emissions[32]. With regard to fluorinated gases, EU regulatory law is even taking a big step further by aiming at a complete phase-out of all three main fluorinated greenhouse gas compounds[33] by mid 2009 or earlier, notwithstanding attempts by industry lobbyists in 2005 at thwarting the proposal (Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 "on certain fluorinated greenhouse gases"). Through the high degree of regulation, sizeable portions of the proposed reduction potentials in these emitter groups can probably be harvested, not warranting any further interference by the State. However, even if entirely so, this would contribute a relatively meagre 5.75 million tons of CO_2e annually to the total tab of 20.85.

In contrast, the three emitter groups agriculture, heating emissions and transport with a combined potential of 8.1 million tons of annual CO_2e as quoted in the Climate Strategy have so far been much less promising. Emissions from agriculture and heating largely fall under the jurisdiction of the federal provinces, always wary not to enforce too overtly existing methane and nitrous oxide limitations. Transport, on the other hand, has been an example of missed opportunity on the side of the federal administration which has failed to tap the considerable abatement potential of this emitter group and instead concentrated on tax-related measures (cf. chapter 9) and long-term visionary concepts with small chance of pre-2012 implementation ("ride-your-bike"-type of initiatives).

Not an emitter group but a cost-efficient Kyoto compliance aid, the successful Austrian JI/CDM Purchase Program could be operating at an even enhanced yield if its portfolio had not been artificially restricted to exclude certain project types and if the Program's output had not been throttled by fixing ex ante how many million tons of CO_2e it is supposed to land per year.

High-yield measures to curb greenhouse gas emissions from agriculture, heating and transport deserve closer attention, as does the Purchase Program with regard to removing

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[32] Most recent: Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 "on shipments of waste" and Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 "on waste"; most relevant: Article 4 "Gas control" under Annex I of Council Directive 1999/31/EC of 26 April 1999 "on the landfill of waste".

[33] The use and placing on the market of sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) will be gradually restricted within the customs territory of the EU over the period 2007-2008, to be entirely prohibited by mid 2009. Fluorinated greenhouse gases possess the highest global warming potentials (GWPs) of any kyoto-relevant gases: SF_6 has a GWP of 22,200; HFCs of 97 to 12,000; PFCs of 5,700 to 11,900. GWPs indicate the potency of a greenhouse gas as compared to carbon dioxide, having a GWP of 1.

federal red tape. The following five chapters are dedicated to the abatement potential in these hitherto neglected policy areas.

CHAPTER 7: Agriculture; cows need more discipline, soils less fertilizer

Agriculture will probably fail to deliver, in spite of a seemingly modest 0.4 annual megatons of CO_2e expected yield. Community law caps for nitrous oxide emissions from agricultural fertilizers do exist but compliance is much more difficult to verify than compliance with emission caps for industrial plants (cf. Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 "on national emission ceilings for certain atmospheric pollutants")[34]. Farmers generally seem most inclined to cut down on fertilizer use when crop prices slump or when fertilizer prices soar; otherwise, compliance largely depends on good will. Some fertilizer dealers support nitrogen efficiency, but only if they also sell nitrification inhibitors. These compounds slow down one of the chemical reactions leading to nitrate in the soil[35], thereby spreading the fertilizing effect over longer periods of time. As a result, crops need to be fertilized considerably less frequently. However, interest in the use of inhibitors is generally motivated by the avoidance of nitrogen leaching (cost cuts from less fertilizer consumed) and increase in efficiency of nutrient use (cf. Shaviv & Mikkelsen, 1993), rather than by the positive effects of increased groundwater quality and avoidance of greenhouse gas emissions. Response of farmers to inhibitors has remained lukewarm. For an economic benefit to occur, the nitrogen saved from leaching losses by using the inhibitor would have to bring about a yield increase in crops with a value greater than the cost of the inhibitor. Yield increase through the use of nitrification inhibitors has been substantiated (cf. Zerulla, Pasda et. al, 2004) but also refuted (cf. Ebendorfer, Hoefler et. al, 2003). No such controversy seems to reign over the greenhouse gas abatement potential for nitrous oxide through the use of an inhibitor, which is claimed to reduce emissions by up to 50% (BMB+F & DLR, 1999; cf. Zerulla, Pasda et. al, 2004). The leading nitrification inhibitor product is available in Austria (RWA, 2006) and not higher priced than other fertilizers (DLZ, 2006). The

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[34] Directive 2001/81/EC inter alia limits emissions of "nitrogen oxides" ("NO_x"), a summary expression for the highly reactive free radical nitric oxide (NO) and nitrogen dioxide (NO_2), and emissions of ammonia (NH_3). Nitrogen used as agricultural fertilizer contains nitrates ($M^+NO_3^-$), the salts of the nitric acid (HNO_3); oxidation of ammonia also produces nitrates (nitrification). Microbiologically, nitrates are broken down into the Kyoto gas nitrous oxide (N_2O), nitric oxide (NO) or molecular nitrogen (N_2) under gaseous emissions.

[35] Nitrification inhibitor products can only be used on ammonium-based fertilizers. They retard the oxidation of ammonium to nitrite, without affecting the subsequent oxidation of nitrite to nitrate.

financial burden on the farmer may still increase, though, as the inhibitor needs to be used in addition to the regular ammonium fertilizer. Faced with the prospect of incurring this extra expense may so far have deterred farmers from widespread use of inhibitors in Austria, presumably resulting in a high loss of nitrous oxide savings. Farmers could be compensated for purchasing inhibitors through existing special-purpose funds at the disposal of federal provinces for financing kyoto-relevant abatement measures (cf. chapter 8; footnote 45; column 2 of Tab.4). Tapping this dormant potential in time would be especially rewarding given the high global warming potential (GWP) of nitrous oxide of 310 as compared to carbon dioxide with a GWP of 1.

Enteric methane from bovines and other farm ruminants[36] accounts for the other important source of agricultural greenhouse gas emissions. One dairy cow produces 118 kilograms of methane per year which corresponds to 2.478 tonnes of carbon dioxide equivalent per year[37] (O'Mara, 2004). The 2.05 million bovines dwelling in Austria in 2004 (BMLFUW, 2005b) thus produced up to 5 million tonnes of carbon dioxide equivalent annually[38]. In the EU-15, agriculture is the biggest single emitter of methane, amounting to about 45% of total methane emissions; two thirds of which originate from farm ruminants (Moss, Jouany et al., 2000). If about 30% of all EU methane emissions are caused by farm ruminants, it is surprising to note that this important high-GWP gas source has not yet been addressed by Austrian environment politics (cf. footnote 37).

One option would be to accelerate the reduction of cattle heads in Austria, currently at a rate of -4.8% over the five-year period 2000 to 2004 (BMLFUW, 2005b). If the degree of self-sufficiency in beef and dairy products can serve as a measure of the amount of cattle we need in Austria, quite a number of Betsies would have to pass on to the eternal grazing grounds. Self-sufficiency in beef amounts to 142%, 120% in milk and 255% in cheese spread. Taking milk as an example, a decrease in production down to 100% self-sufficiency would cut an excess 538,317 tons of milk. With 5,638 kg of milk per dairy cow and year, this

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[36] Only for chemistry buffs: Anaerobic fermentation in the rumen and hind-gut of ruminants produces methane; plant matter is hydrolysed to amino acids and simple sugars via microbial enzymatic activity in the rumen. Both products are then anaerobically fermented to volatile fatty acids (VFA), hydrogen (H_2) and carbon dioxide (CO_2). Reduction to methane (CH_4) occurs by contact of CO_2 with H_2.

[37] The GWP (global warming potential) of methane is 21 times that of carbon dioxide (GWP of 1).

[38] Not all domestic bovines are dairy cows. Beef cows, bulls, calves, heifers and feedlot cattle are included in the figure of 2.05 million heads, yet produce less methane per head than one dairy cow. Small farm ruminants (Austria: 383,000 sheep and goats in 2004; BMLFUW, 2005b) also produce methane, not included in the figure of 5 million CO_2e.

figure corresponds with a number of 95,480 dairy cows each producing 2.478 tons of CO_2e per year. The abatement potential would hence amount to 0.24 million tons of CO_2e per year (all data for 2003; BMLFUW, 2006).

Another very promising option is a change of cattle feed. Methane in the rumen inflicts an energy loss on the cow of up to 16%, depending on the quality of the feed (Jeroch, Drochner et al., 1999). An appropriate diet shift will therefore increase productivity of the cow while at the same time decrease her methane emissions.

Volatile fatty acids (VFA; cf. footnote 36) appear as fermentation products in the rumen. Fibrous diets promote a reaction of pyruvate[39] to acetate, a VFA, without absorbing the hydrogen present from the anaerobic fermentation process. Methane is formed out of the need to remove that hydrogen from the rumen. Carbohydrate diets, in contrast, shift the reaction of pyruvate from acetate to propionate, another VFA, which uses up much of the free hydrogen in its formation and thereby leaves less hydrogen for reacting to methane. As an alternative to carbohydrate diets, propionate enhancers (chemical precursors to propionate such as citrate or malate) may be added to the feed, resulting in the same hydrogen removal effect. Still another way of instigating a VFA shift to propionate is by limiting the number of protozoa in the rumen, as most bacteria attached to protozoa are methanogens and responsible for much of the methane produced there. Removal of protozoa modifies the bacterial population in the rumen and shifts VFA production to propionate. Removal can be effected by adding certain fats to the bovine diet plan (Newbold, Ouda et al., 2002; Vogels, Hoppe et al., 1980; O'Mara, 2004).

Denmark, like Austria suffering from a gaping Kyoto deficit, has already identified a change in cattle feed as a promising measure. Obviously opting for an addition of fat to the diet for boosting propionate, the methane abatement potential has been estimated at 0.433 million tons of carbon dioxide equivalent per year (UNFCCC, 2004). Given the total number of 671,152 cow heads in Denmark in 2004 (Statistikbanken, 2006), we can deduce a per capita abatement potential of 30.7 kilograms of methane per year, corresponding to 645 kilograms of CO_2e per year. These figures include all types of cattle in Denmark and are therefore much lower than the figures quoted for dairy cows alone (cf. 118 kg CH_4 / 2,478 kg CO_2e in

[39] Pyruvate is the output of the metabolism of glucose (glycolysis); one molecule of glucose (the "simple" sugar from footnote 36) breaks down into two molecules of pyruvic acid. Pyruvate is the carboxylate anion of pyruvic acid.

O'Mara, 2004; see above). If Denmark and Austria are comparable in matters of cattle, there should be a slumbering annual methane abatement potential in the 2.05 million Austrian cattle heads which amounts to 62,965 annual tons of methane or 1.3 million tons of CO_2e. This is more than three times the entire annual agriculture reduction potential proposed by the Austrian environment administration (cf. chapter 6).

In tackling ruminant methane, Denmark has also resorted to cutting the number of cattle heads much more decisively than Austria with a rate of -11.7% over the five-year period 2000 to 2004 (Statistikbanken, 2006) as opposed to the Austrian rate of -4.8% (see above). The relatively small absolute numbers of cattle in Denmark result in an absence of economies of scale with regard to the cost of bovine anti-methane measures. Cattle feed change incurs costs of more than 120 DKK (about 16 Euro) per ton of CO_2e, which was declared the cost-efficiency threshold in Danish climate politics[40] (UNFCCC, 2004). In Austria, however, the higher absolute numbers of cattle should help decrease per-unit costs and make bovine methane a cost-efficient prime target in climate politics.

Implementation of two measures proposed in this chapter (nitrification inhibition and enteric methane management) could yield at least 2.69 million tons of carbon dioxide equivalent per year: 1.39 Mt CO_2e through widespread utilization of nitrification inhibitors[41] and 1.3 Mt CO_2e from cuts in bovine methane. The figure of 2.69 Mt CO_2e far exceeds the 0.4 Mt CO_2e stated for agriculture in the 2002 Austrian Climate Strategy. Alternatively or in addition to these two measures, a further cattle head decrease in Austria would eliminate about 13,000 tons of CO_2e per 1% decrease and year (2004 figures).

[40] Measures up to 120 DKK per ton of CO_2e are to be implemented with priority. Financing of more expensive measures will only begin when others are no longer available or feasible (cf. chapter 4 and footnote 21).

[41] Annual emission of nitrous oxide (N_2O) in Austria: 19,000 tons; agriculture responsible for 59% (= 11,210 tons); four fifths of agriculture N_2O from fertilizer emissions (= 8,968 tons). GWP of N_2O = 310 as compared with CO_2. 8,968 tons * 310 = 2.78 Mt CO_2e per year (Source: data on emissions from UBA, 2004; calculations - Author). If inhibitors reduce N_2O emissions by up to 50% (quotations: see main text), total annual N_2O savings would attain 1.39 Mt CO_2e.

CHAPTER 8: Heating emissions; plentiful funding against leaking buildings

In 2003, households accounted for 26.6% of total final energy consumption in the EU-25[42] and for 12.4% of total carbon dioxide emissions; in Austria, households had a share of 28.5% of final energy consumption or 41.8% if residential and tertiary sector buildings are put together (DG Tren, 2005). This figure exceeds the energy need of industry or transport. Consequently, carbon dioxide emissions from the air conditioning of buildings (heating and cooling) are a prime target for energy efficiency policies of EU member states. The quality of the EU building stock has a long-term direct impact on the rates of energy consumption. Well-insulated buildings retain the desired inside temperatures for longer periods of time with less frequent need for reheating or recooling. New buildings are therefore required to feature an energy performance[43] appropriate for the local climate whereas existing buildings should be retrofitted with insulation materials where feasible (cf. Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 "on the energy efficiency of buildings").

It may not surprise that Northern Europe is more advanced with regard to thermal insulation than Southern Europe. However, even in the South, buildings require heating for 500 (Malta) to 1,915 (Spain) heating degree days[44] (data for 2004; Eurostat, 2006), a fact that is poorly reflected in the energy awareness of the population: mobile electric furnaces provide heating rather than installed facilities while the importance of thermal insulation is little appreciated. Heat losses per square meter loss area is highest in Southern Europe, even though it is coldest in the North. This is due to lower U-values of building components in the North (Petersdorff, Boermans et al., 2002). The U-value is a measure of heat transmission properties through a section of building component when exposed to air on both sides; the U-value is the property to be determined when calculating heat loss through walls, roofs,

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[42] Total final energy consumption (EU-25 countries, 2003) was 1,131.6 million tons of oil equivalent (Mtoe); households accounted for 300.5 Mtoe.

[43] According to Directive 2002/91/EC, "energy performance of a building" is the amount of energy estimated to meet the different needs associated with a standardized use of the building, including, i.a., heating, hot water heating, cooling and ventilation. This amount shall from now on be reflected in an indicator, taking into account insulation, solar exposure, and other factors that influence energy demand.

[44] Heating degree days (HDD) express the severity of the cold taking into consideration outdoor and room temperature. Eurostat uses the following method for calculating HDD: $[(18°C - T_m) * d]$ if T_m is lower than or equal to 15°C (= heating threshold) or HDD are nil if T_m is greater than 15°C. T_m is the mean outdoor temperature over a period of d days; d = 1, as calculations take place on a daily basis. Single HDD are eventually added up to a year for each MS.

ceilings, floors and windows. A low U-value indicates thicker or better-quality insulation. U-values make the influence of outside temperatures on insulation quality comparable among different climatic zones; they are hence a more objective measure for energy efficiency of buildings than the mere thickness of the insulation material. Heat losses in three climatic zones in Europe and corresponding aggregate U-values are shown in Fig.15.

Implementation of Directive 2002/91/EC is beginning to have an impact on the building codes of EU member states with more stringent provisions appearing regarding the limits for heat transmission losses through various building components. The directive does not impose specific U-values on member states but only a general demand for "minimum energy performance requirements" in all buildings. In response, Sweden has spearheaded Europe's strictest insulation standards. In some countries (UK, Austria), the setting of such standards falls into the jurisdiction of regional governments. Tab.3 shows prescribed U-value limits for some selected EU member states and regions including the Austrian federal provinces. Standards for Vienna clearly lag behind, resulting in a considerable loss of potential, as the capital has by far the largest building stock in the country. Applying Swedish standards in all EU-15 member states would cut total energy consumption in buildings by more than 50% (Eurima, 2002). Lack of stringent U-value regulation in member states brings about high rates of energy loss through exterior walls and roofs; Austria has the second worst wall record and figures slightly better in matters of roofs (data for 2001: Eurima, 2002; Fig.16). Consequently, Austria boasts the fourth highest rate of per capita carbon dioxide emissions from human dwellings among twenty reviewed OECD countries (data for 2001: Eurima, 2002; Fig.17).

In the light of high per capita emissions due to comparatively lax insulation standards, the proposed annual Austrian abatement potential of 4 million tons of CO_2e for heating emissions from households and enterprises does not seem excessive, even if fulfilment of this goal would necessitate a cut of 35.4% down from 11.3 Mt CO_2e (cf. Fig.17). Construction standards for new buildings are determined by the nine federal provinces of Austria and laid down in their nine respective building codes. That is why incentives aimed at improving the energy performance of existing buildings likewise fall to the federal provinces rather than the federal state. To enhance cost-efficiency in thermal refurbishment, the building stock with the lowest energy performance should be tackled first: in Austria, these would be buildings constructed between 1961 and 1980 (Schleicher, TU Graz, 2006, pers. comm.).

Harvesting a four-megaton abatement potential will require a massive financial engagement on the part of the Austrian federal provinces. Fortunately, the appropriate allocations have been made available under the "investment aid for housing, environment and infrastructure" heading of the Zweckzuschussgesetz 2001[45] (special-purpose fund law) agreed between the federal state and the federal provinces by means of the intergovernmental revenue sharing mechanism (Finanzausgleich). Apart from measures related to housing and environment, the special-purpose funds can also be tapped for investments in infrastructure. The proportion of funds utilized for each of these three policy areas is solely at the discretion of the federal provinces. At the time of writing (fall 2006), a reporting format had just been agreed between the federal and province governments to allow registering of Kyoto gas tonnage abated through measures financed via the special-purpose funds. Hence, no data had until then reached the treasury, neither on the cost per ton CO_2e, nor on the abated tonnage that these investments have triggered since the inception of the current fiscal equalization period (1 January 2005).

For improving thermal insulation in new building projects, U-value requirements will certainly have to be stepped up in all nine building codes. However, the bulk of abatement potential does not lie in future development projects but in the existing building stock. Thermal refurbishment by replacement or retrofitting of insulation materials, doors and windows will be the most feasible measure. Optionally, a shift from individual oil and gas-based furnaces to biomass-fuelled communal district heating grids would yield considerable gas tonnage but is only realistic and cost-efficient where proprietors of entire blocks of houses are prepared to make the transition.

Disbursement of special-purpose funds usually takes the form of subsidies; however, in order to increase demand of house owners and tenants for energy-efficiency measures, advance financing of full investment costs with an attached preferential loan scheme would also be conceivable. In absence of data from federal provinces, we must rely on figures obtained from the analysis of the Federal Environment Subsidy Regime (FESR) in order to find out

[45] Federal Law Gazette BGBl.Nr. 691/1988, last modified through BGBl. I Nr. 156/2004, to be effective during the current fiscal equalization period (revenue sharing period) from 1 January 2005 to 31 December 2008. § 1 (1) explicitly states that the special-purpose funds are to be dedicated i.a. to measures aiming at reducing greenhouse gas emissions; § 1 (3) specifies that the investment aid is to be used prioritarily for purposes of fulfilling national Kyoto obligations by creating incentives for an improvement of thermal insulation and efficient energy supply in the existing building stock with a view to Directive 2002/91/EC, as well as creating incentives for exceeding building code standards for thermal insulation and efficient energy supply in housing projects; further, creating incentives for a shift to renewable energies and district heating grids.

whether the special-purpose funds can cover the cost burden entailed by an annual 4 million tons CO_2e abatement goal. Thermal insulation under FESR has an average price tag of 156.3 Euro investment allowance per ton CO_2e at a mean subsidy rate of 24.9% (cf. Tab.1); from this, a full investment cost of 627.7 Euro per ton CO_2e can be deduced. Analogously, biomass district heating subsidies under FESR cost 28.3 Euro per ton CO_2e at an 18% subsidy rate (cf. Tab.1); full-cost funding would amount to 157.3 Euro per ton CO_2e. Tab.4 shows the proportion of annual special-purpose allocations to federal provinces that would have to be spent on retrofitting of their existing building stocks, either via thermal insulation, or via shifting from fossil heating to biomass district heating. In Tab.4, the abatement potential of 4 million tons CO_2e is assumed to be proportionally distributed over the federal provinces according to their respective share of special-purpose allocations. Another simplification is the full tonnage can either be harvested by 100% thermal insulation or by 100% fuel switch. If we go along with these two idealizations, we see that a subsidy scheme along the lines of FESR would absorb 35.12% of total annual special-purpose allocations to yield the entire abatement goal through thermal insulation or 6.36% through fuel switch. A full-cost funding cum loan scheme, on the other hand, would exceed available funds by 41% in thermal insulation or would eat up 35.34% in fuel switch (Tab.4).

In reality, federal provinces will have to act on both thermal insulation and fuel switch simultaneously in order to yield the full 4 million ton CO_2e goal. Because of much higher implementation potential, the better part of funding will have to be consecrated to thermal insulation, in spite of the higher cost per CO_2e. The current rate of less than 1% Austrian building stock under thermal refurbishment per year (Climate Strategy 2002) will need to be stepped up dramatically; as a strong supporting measure, the fuel switch rate from oil to biomass (in or out of district heating grids), or from oil to natural gas as an intermediate measure, will have to increase by 20% until 2008 with base year 2006 (Schleicher, TU Graz, 2006, pers.comm). We have seen that funding resources at the hands of Austrian federal provinces suffice indeed for stopping buildings from leaking heat. Federal provinces should not choose to leave the field of heating emissions unploughed but rather make energy-efficiency funding a political priority.

CHAPTER 9: Transport; the invincible juggernaut

Curbing the negative environment and safety effects of road transport in Austria has been a crusade of no return with few political scoring points collected so far. Endowed with a theoretical annual carbon dioxide abatement potential of 3.7 million tons, there are no dam-busting measures in place that would stand even a remote chance of reversing the various negative trends that have prevailed over the past decade. Not only have total Kyoto-relevant emissions of the Austrian transport sector[46] soared since 1990 to attain a fifteen-year high in 2004 (Fig. 18). Equally badly, the two most highly-publicized centrepiece measures of transport-related environment policy have been persistently unsuccessful: shifting the bulk of road freight to rail and discouraging private passenger car transportation in favour of mass and green transport modes[47]. The share of road freight traffic in per cent of total freight ton-kilometers remained roughly the same between 1995 and 2004; the share of private cars in per cent of total passenger-kilometers[48] slightly increased between 1995 and 2003 (Fig.18). In conjunction with these indicators, final energy consumption of petroleum products in Austria has risen by 21% between 1999 and 2004; however, while the use of petrol for Otto engines has steadily hovered around 2 million tons per year between 1999 and 2005, diesel consumption for vehicles (excluding fuel oils for heating) has soared during that same period by 55% from 3.89 to 6.03 million tons per year (Fig.19).

Apart from these nondescript results of transport and environment policies, the lack of success in making Austrian roadways a safer place to drive and walk is even more astounding: with a score of 522 injury road accidents per 0.1 million inhabitants, Austria tops the list of all EU-15 member states; Denmark with a score of only 115 apparently is Europe's safest haven for letting your toddler play outdoors (data for 2004: IRTAD, 2006; Fig.20)[49].

It has been argued that a sharp rise in petroleum taxes and other transport-related taxes, fees and duties will act as a deterrent to road traffic (cf. chapter 3, Figs.11-12). If so, rising

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[46] In Austria, transport sector emissions are almost synonymous with road traffic emissions. Domestic air traffic emissions, railway emissions from diesel locomotives and emissions from inland waterway transportation are negligible.

[47] Rail, public mass transport, car pooling, bicycle, refraining from mobility altogether.

[48] Passenger kilometers = vehicle-kilometers * number of passengers in vehicle.

[49] Austria fares slightly better in the "killed per 0.1 million inhabitants" statistics; NL: 5.0; SE: 5.4; UK: 5.6; DK: 6.8; DE: 7.1; FI: 7.2; IE: 8.4; FR: 9.2; IT: 9.7; AT: 10.7; ES: 11.0; LU: 11.1; PT: 12.3; HU: 12.8; CZ: 13.5; PL: 15.0; GR: 19.3 (all data for 2004: IRTAD, 2006).

tax revenues should correspond with declining numbers of cars on roads, slumping petrol and diesel sales, less transport-related greenhouse gas emissions and a drop in injury road accidents due to emptied motorways. Data in Figs.18-20 might therefore suggest that the tax burden on road traffic in Austria is still too low for holding the taxed activity in check; it might as well indicate that tax levels have been stagnating over a long period of time, allowing road traffic to run rampart. Currently, eight different types of tax, fee and duty are in place: petroleum tax (mostly referred to as "mineral oil tax"), motor vehicle tax, tax on motor vehicle insurance, progressive duty based on fuel consumption of vehicle (NOVA[50]), vehicle registration tax, fee for the use of highways for vehicles below 3.5 tons of gross weight (as of 1997)[51], automated system for charging highway toll to vehicles exceeding 3.5 tons of gross weight (as of 2004) and, for Viennese, charge for obtaining the right of parking a car in the district of the applicant's civil registration without guarantee of available parking space (gradually introduced 1993 to 1999)[52]. Overall revenue out of these eight sources has increased by 65.78% from 4,264 million Euro in 1997 to 7,069 million Euro in 2004 (Fig.21). Cross-referencing these results with data from Figs.18-20 seems to corroborate that transport-related tax hikes were not sufficient in offsetting negative environmental and safety effects. Alternatively, if the often implied dependency between tax hikes and the discouragement of the taxed activity were weaker than expected, any further increases in tax levels would continue not to significantly reduce the negative effects.

Brent crude was priced at around 10 US$ at the end of 1998, 20 US$ at the beginning of 2002, 40 US$ in early 2005, 60 US$ in February 2006, peaked at an all-time high of 78 US$ in August 2006 and has since dropped to 60 US$ by the end of September (Cortal Consors, 2006). Although retail prices for gas station products almost quadrupled in real terms between 1972 and 2006, it is interesting to note that the tax share of retail prices in Germany and Austria has remained stable at around 65-67%. During that same period, the share of product costs has doubled from roughly 14% to 27%; the offset variable being

[50] "Normverbrauchsabgabe"

[51] There are no toll booths on Austrian highways. Car drivers are obliged to purchase an adhesive sticker (called a "vignette") of varying validity periods prior to frequenting high-priority roads.

[52] Since 1999, a limited parking regime has been in place in 10 of the 23 municipal districts of Vienna. A civil registration of the car owner in a certain district is a prerequisite for applying for an adhesive sticker issued at cost, conferring the right to search for a place to park in the respective district only. Aliens to the district, no matter whether foreign number plate holders, non-Viennese Austrians or Viennese residing in a different district, cannot obtain a right to permanently park their car.

ancillary costs[53] whose share of retail prices has dropped from around 21% in 1972 to 6% in 2006, reflecting harsher competition in the inter-EU petroleum market (MWV, 2006)[54]. If ancillary costs are dictated by competition and product costs by current crude oil prices, petroleum taxes are the only regulating valve at the disposal of member state treasuries for either counteracting rising product costs (by lowering petroleum tax burden) or amplifying them (by leaving unchanged or raising tax burden). Fig.21 may indicate that Austria has not followed an offset policy but has rather amplified product cost increases by raising the overall transport-related tax burden in general and petroleum taxes in particular.

Leaves to be answered to which extent higher retail prices (in part caused by an augmented tax burden) and higher product costs really influence consumption. Common belief holds that a distinct price elasticity of demand exists in petroleum products. According to a popular quote, a 1% drop in domestic sales should occur per 2% domestic price increase (cf. BMWV, 1997). At the same time, advocates of price elasticity models concede that customers do not simply refrain from purchasing petrol or diesel but rather evade domestic price increases by shifting to product sources abroad where prices are lower (cf. BMWV, 1997). Evasive purchasing cannot be forestalled unless petrol and diesel prices within the European Union become more harmonized within the cruising range of one car filling. Price harmonization will, however, not see the light of day in the foreseeable future. Attempts at manipulating consumption behaviour via price increases will therefore result in evasive action rather than in a viable reduction of transport-related Kyoto gas emissions in the European Union.

This author finds available studies on price elasticity of demand (PEoD) in petroleum products in Austria to bear a heavy bias towards interpretations in favour of a strong PEoD, suggesting that consumption can be stifled by means of tax/price increases. In an attempt at elucidating the true nature of the relationship bonding consumption to price, Tab.5 sets out to present PEoD values for petrol[55] and diesel sales in Austria (source: FVMI, 2006) against the empirically recorded domestic prices between 1999 and 2005 including taxes. Price data is derived from columns published by OeAMTC[56]. Prices quoted in Tab.5 are average prices

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[53] Costs for transport, storage, keeping of strategic reserves, research, construction and maintenance of gas stations, personnel costs, administration, distribution, and profit.

[54] In the USA, retail prices for regular unleaded consist of 16% taxes, 50% product price and 34% ancillary costs. Average retail price recorded by the AAA (American Automobile Association) for January through September 2006 was 2.7 US$ per gallon (roughly 56 Eurocent per litre).

[55] Unleaded "super", 95 octane.

[56] One out of two automobile associations in Austria (Oesterreichischer Automobil und Touring Club).

over a respective year, concluded from intra-year price data points that have been weighted by the number of days during which individual data points were valid. All shown prices are indexed to June 2006. Market demand for petrol stagnated over the entire investigated seven-year period, demand for diesel doubled and prices for both increased sharply. In order to eliminate a potential distortion effect on price elasticity values caused by that noticeable demand disparity, the same calculations were repeated on a fictitious brand of petroleum product, "composite gasoline", using aggregated consumption and price data from the respective data sets on petrol and diesel[57]. PEoD is expressed through an ε value. $\varepsilon > 1$ denotes that demand is sensitive to price changes ("demand is price elastic"); a high positive PEoD value > 1 suggests that consumers will buy considerably less of a product when its price goes up and considerably more of it when its price goes down. In contrast, an $\varepsilon < 1$ denotes that demand is less sensitive to price changes ("demand is price inelastic"); a very low PEoD hence implies that price changes in either direction have little influence on demand. Usually, PEoD models incorporate many other variables besides the basic price and sales figures; in this light, the two-dimensional approach used for Tab.5 may appear simplistic but was chosen deliberately as only the price/sales dependency was of interest for the investigation at hand.

As can be gauged from Tab.5, the various PEoD values reflecting the consumption-price bond for the three products (including the fictitious composite brand) do not unanimously indicate that demand is either price elastic or price inelastic. Since matching data prior to 1999 was not forthcoming, the analysis had to be limited to the period 1999 through 2005; statistical significance of PEoD trends can therefore not be asserted. Nevertheless, results still serve to cast doubt on the belief that demand in petrol and diesel is invariably price elastic. If it were, even a small time sample would have yielded an unequivocal result to that effect. Since it has not, we may conclude that PEoD with regard to petroleum products is at best inconclusive. As a consequence, the widespread view that demand for these products can be stifled by means of tax/price increases may need to be revised.

Whence cometh the urge of the masses to stubbornly cling to their steering wheels, oblivious to price increases, strangling taxes, prohibitive parking regimes, invisible radar traps, a

[57] Different specific weights of petrol and diesel were not taken into consideration when tons of "composite gasoline" were "mixed" for the purposes of Tab.5.

proliferation in the number of unsynchronized, jam inducing Vienna traffic lights[58] and all other discouragement policies? Is it because freight movement is only cost-efficient on motorways? Maybe commuters are forced to evade infeasible public transport and must rely on private cars? Or do people need joyrides in the secluded confines of their own vehicles as a temporary escape from social stress? Whatever the decisive factor may be, it is remarkable that all policy measures aiming at a reduction in the number of road traffic movements have so far been persistently unsuccessful in achieving most environmental and safety enhancement goals.

Embracing the unpalatable notion that density of road traffic is largely immune to political measures of any kind may be a tough step to take. However, if we do, available financial resources could be redirected to a different approach in transport policy where results are more tangible: fuel switch.

[58] Number of Vienna traffic lights increased from 900 in the 1980s to 1,230 in 2006 while Vienna road grid only expanded marginally (Rechenzentrum der Wiener Verkehrsleitzentrale, pers.comm., 2006).

CHAPTER 10: Fuel switch; summoning the powers of the sugar beet

Fuel switch denotes a substitution of fossil fuels causing environmentally dangerous carbon dioxide and air pollutant emissions by renewable or non-organic fuels that do not[59]. While the driving public will always put up strong resistance against attempts at curbing road mobility, a fuel switch policy will stir no negative sentiment, as long as the substitute fuels are readily available, offered at prices not exceeding those of fossil fuels, and are technically compatible with car engines. The obvious policy goal would therefore be to introduce substitute fuels before the Kyoto commitment period commences and strive at a maximum displacement rate of fossil fuels.

Drawing energy out of any source, no matter whether fossil or renewable, entails oxidation to carbon dioxide and water; the only exceptions being nuclear energy and hydrogen. If one were to choose the best substitute fuels for petrol and diesel from a financial point of view, the crucial parameters would hence be: a high specific calorific value[60], low or no carbon dioxide emissions, domestic availability of the source materials, low ancillary costs involved in their production cycle and feasibility of instant domestic fuel mass production. Tab.6 shows some of these parameters for key energy sources.

With a specific calorific value four times as high as the one for hard coal and zero carbon dioxide emissions, hydrogen appears to be the panacea solution to all Kyoto compliance trouble (Tab.6). That is, if it were not for the first law of thermodynamics which tells us that energy can only be converted from one state to another but cannot be created or destroyed. So, in order to mass produce a supercalorific renewable energy carrier such as hydrogen, we first have to invest fabulous amounts of energy. To date, producing hydrogen as a fuel still requires a substantial input of fossil fuels or electricity: the two most common methods are heating natural gas or by means of electrolysis (running an electrical current through water). Another strategy is to seek out industrial processes where hydrogen appears as a byproduct,

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[59] In fact, most renewable fuels do emit carbon dioxide during combustion which is, however, exempt from reporting in national Kyoto balances as it is considered to correspond to the amount of carbon sequestered from the atmosphere during the growth phase of the source plant.

[60] The calorific value (c.v.) defines the amount of heat released during combustion of a fuel and is measured in units of energy per amount of material. Gross c.v. is determined by reverting all products of combustion including water vapour back to their pre-combustion temperature. Net c.v. is calculated by subtracting the heat of water vapour from gross c.v. For engine analysis, net rather than gross calorific value is used, since most engines cannot utilize the heat contents of water vapour.

as in the production of sodium chlorate in pulp and paper mills. After capture, cleaning and compression, byproduct hydrogen can be used as a vehicle fuel. Capturing hydrogen does not eliminate fossil fuels from the energy equation but at least they are not used primarily for producing the hydrogen.

Yet, the survival of road mobility will not be secured by scavenging hydrogen from paper mills. The key to a bright hydrogen future will rather lie in further progress to be achieved in the fields of microbiology and biochemistry. Green algae and cyanobacteria are capable of splitting water into oxygen and hydrogen via the enzyme hydrogenase. The energy needed in water oxidation is photosynthetic. Hydrogenase catalyzes the reversible oxidation of molecular hydrogen (H_2) and plays a vital role in anaerobic metabolism. In normal life, algae cells show low concentrations of hydrogenase and consequently produce little hydrogen. What they do produce they tend to retain inside the cell as an ideal medium for energy storage. However, the gene encoding the enzyme can be induced artificially: thereby, concentration of hydrogenase in the cell can be stepped up and hydrogen output tripled; subjecting the algae or cyanobacteria to a sulphur-depleted medium induces them to release their product out of the cell[61] (Ghirardi, King et al., 2005; Frey, 2002; Adams and Stiefel, 1998). In the not too distant future, mass production of hydrogen with the aid of green and blue-green algae will be a vision no more: biochemical batteries will turn sunlight into hydrogen[62]. For the current Kyoto compliance period, however, this technology will not be available in time. Remains to be hoped it will take less time to domesticate and optimize output of the helpful single-cell organisms than was needed for turning the milk barren ancestors of dairy cows into the obedient milk machines of today.

If hydrogen is not an immediate option as a car propellant, what others do we have? As shown in Tab.6, liquefied petroleum gas (LPG; mixtures of propane and butane[63]) has lower

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[61] The hydrogen (H_2) production phase is temporary, due to the eventual detrimental effect of sulphur deprivation on all other cell functions. Research has concentrated on cycling of cultures between a sulphur-replete, photosynthetic oxygen (O_2) mode and a sulphur-depleted H_2 photoproduction mode.

[62] The maximum theoretical efficiency of storing sunlight as high-energy hydrogen (H_2) molecules is approximately 13%. For sustained H_2 production, photosynthetic single-cell organisms need to produce H_2 gas directly from water at maximum efficiency. This is currently a major obstacle to the development of a commercially viable hydrogen battery, as the hydrogenase enzyme shows a strong oxygen (O_2) sensitivity. Further microbiological advances will be required to achieve efficient coupling of photosynthetically generated reductants with H_2 gas production.

[63] Propane and butane are saturated hydrocarbons with boiling points of -42°C and around 0°C, respectively. Their specific calorific values are almost equal (see Tab.6). The propane/butane ratio in LPG can be regulated depending on the ambient temperature at the foreseen place of consumption:

carbon dioxide emissions per energy unit than engine petrol or diesel. In a properly tuned spark ignition engine, it is a good fuel substitute. Achieving an optimal ratio of fuel to air is easier with LPG than with conventional petrol, resulting in more complete fuel combustion. This gives LPG excellent clean burning properties with minimal exhaust particulate emissions. LPG has been used effectively in municipal bus fleets in Vienna and elsewhere in Austria[64]. While most feasible for short-range closed circuit operation with a limited number of LPG fuel stations, widespread use in private cars is conceivable. Propagation of LPG might become a priority for Austrian transport politics as this would represent a significant intermediary step towards a renewable fuel shift via a less harmful fossil fuel[65].

Our mission here, however, shall be to investigate whether Austria is showing any potential for achieving a genuine vehicle fuel shift from fossil to renewable energy sources in the near future. According to Article 3 of the EU Biofuels Directive[66], member states are to ensure that a 2% proportion of biofuel petrol and diesel for transport purposes be placed on their markets by the end of 2005 and 5.75% by the end of 2010 (percentages to be calculated on the basis of calorific value). Austria has surpassed these EU reference values: an "Austrian Fuel Decree"[67] prescribes a mandatory biofuel contents of all sold petrol and diesel of 2.5% by 1 October 2005, 4.3% by 1 October 2007 and 5.75% by 1 October 2008. The main renewable substitute for fossil petrol is bioethanol[68] and for fossil diesel biodiesel RME (see Tab.6); biodiesel FAME from recycled greases has only a minor market share and lacks the quantities of raw material needed for mass production. To explore feasibility of a fuel shift, we must first get an estimate of the quantities of petrol and diesel that are likely to be consumed over the next couple of years. In Tab.7, an original fuel demand forecast in

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the lower the temperature, the higher the share of propane to attain a higher vapour pressure of the mixture.

64 All mass transport buses of Vienna municipality run on LPG (Graef & Siemens NL 243 M12/M18, MAN NL 273 T2/T3/M18, Graef & Steyr (Volvo) NG 235 M18, a.o.); first Vienna trial runs with LPG replacing petrol date back to 1963. Vienna LPG buses consume roughly 1 litre LPG per 1 km.

65 LPG is not yet available as a private car fuel in Austria. As of September 2005, 80 LPG refuelling points were in operation in and around London. Because of significantly lower cost, LPG is widely preferred over petrol and diesel in CEE Europe and CIS countries; in the Caucasus, most Soviet-built Volga, UAZ, GAZ and Lada cars have been converted to accept LPG only.

66 Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 "on the promotion of the use of biofuels or other renewable fuels for transport".

67 417th Decree of the Federal Minister of Agriculture, Forestry, Environment and Water Management of 9 November 2004 (Oesterreichische Kraftstoffverordnung).

68 Bioethanol is marketed with an "E" prefix, denoting the percentage of bioethanol over fossil petrol in retail: an E10 would be a mixture of 10% bioethanol and 90% fossil petrol; E100 is pure bioethanol.

GWh (UBA, 2003; quoted in Tribl, 2005) has been converted into demand in litres fossil fuels and, further, into litres substitute fuels. The latter conversion is important as renewables show lower calorific values than fossil fuels (cf. Tab.6). Hence, higher volumes of biodiesel and bioethanol are needed for achieving the same calorific output as the respective fossil fuels.

Next, we have to verify the extent to which source plants for the production of the biofuel quantities given in Tab.7 are available for that purpose in Austria. Biodiesel is predominantly made out of rape seed (*Brassica napus L.*), a species of the family Brassicaceae which also encompasses the mustard, horseradish, cress and cabbage plants. In a catalysed reaction, a triglyceride (rape seed oil) and methanol result in glycerine and rape seed methyl ester (RME; biodiesel)[69]. Source plants for bioethanol can be a wide array of feedstocks including sugar cane, sugar beet, bagasse[70], switchgrass (*Panicum virgatum L.*, Poaceae), sunflower, potatoes, wheat, maize, barley, hemp and cellulose wastes. In Austria, sugar beet, soft winter wheat (*Triticum aestivum L.*) and maize are the main sources. Plant material is refined into starch, liquefied, starch hydrolysed into glucose, fermented, distilled and dehydrated up to a 96% ethanol and 4% water azeotrope. Fermentation emits carbon dioxide that is offset by the carbon uptake of the source plant while growing.

Tab.8 shows the relevant Austrian data of 2005 for rape seed, sugar beet, soft winter wheat and maize comprising degrees of self-sufficiency, hectares under cultivation, production in tons and yield in kilograms per hectare (BMLFUW, 2006). Most conveniently, existing surplus volumes of these crops could be turned into biofuels. However, due to a gaping 50% import dependency in rape seed, no surpluses are available for biodiesel production. While surpluses do exist in sugar beet and soft winter wheat, the corresponding combined volume of bioethanol only amounts to an annual 278 million litres, equalling 191 million litres of fossil petrol and a kyoto-relevant abatement effect of 0.33 million tons of carbon dioxide equivalent per year (based on the data for 2005). This quantity suffices for covering the legally prescribed 5.75% mandatory biofuel contents of petrol to be achieved by October 2008 but represents as little as 7.92% of the projected theoretical consumption of bioethanol E100 in 2007 of 3.512 billion litres (cf. Tab.7; Tab.8).

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[69] One ton of oil and 110 kg of methanol produce one ton of biodiesel and 110 kg of glycerine.

[70] Bagasse is the biomass residue from sugar cane processing. Apart from the production of bioethanol, bagasse can be used as a primary fuel source for sugar mills. Heat energy released from bagasse combustion suffices for combined heat and power cogeneration, the heat being used in the sugar mill, the power sold to feed the outlying electricity grid.

In order to increase domestic bioethanol yield, set-aside land in Austria could be cultivated with sugar beet up to a theoretical maximum of 95,000 hectares[71] (data for 2005; BMLFUW 2006). Sugar beet should be preferred over rape seed, soft winter wheat and maize because of much higher yield in crop per hectare (see Tab.8) which offsets the lower yield of ethanol per ton of crop (see conversion factors in Tab.8). Productivity of one hectare of sugar beet is quoted as between five and eight cubic metres of bioethanol as compared to wheat and other cereals yielding only between 2.5 and four cubic metres per hectare (Henniges, 2005). In addition to potential set-aside land, the acreage currently under sugar beet used for sugar production may decline gradually between 2006 and 2010 as a result of the recent reform of the EU sugar market, thereby potentially freeing part of the present beet acreage for bioethanol production. Council Regulation (EC) No 318/2006 of 20 February 2006 "on the common organization of the markets in the sugar sector" has decreed plummeting reference prices for white sugar by 47% from 631.9 Euro per ton in 2006 to 335.2 Euro per ton in 2010; too, the minimum beet price will gradually drop by 20% from 32.86 Euro per ton in 2006 to 26.29 Euro per ton in 2010[72]. Around 60% of the ensuing income losses for sugar beet farmers are scheduled to be compensated by another type of payment [73] (cf. BMLFUW 2006). Yet, a growing demand for domestic bioethanol may lead to market price hikes which in turn may induce farmers to cut sugar production and consecrate part of their beet harvest to biofuels. Apart from conversion of ex-sugar capacity to bioethanol, even an outright expansion of beet production exceeding the sugar quota (formerly called "C-beet") would be legal. Pursuant to Articles 3-4 and Annex of Commission Regulation (EC) No 967/2006 of 29 June 2006 "laying down detailed rules for the application of Council Regulation (EC) No 318/2006 as regards sugar production in excess of quota", the usual penalty ("levy") of 500

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[71] Pursuant to Article 1 and Annexes I-III of Commission Regulation (EC) No 2461/1999 of 19 November 1999 "laying down detailed rules for the application of Council Regulation (EC) No 1251/1999 as regards the use of land set aside for the production of raw materials", land set aside may be used for the production of, inter alia: maize (corn) other than seed (CN# 1005 90 00), other cereals other than seed (CN# 1008 90 90), rape or colza seed other than for sowing (CN# ex 1205 00 90) and sugar beet provided that sugar is not produced from it (CN# 1212 91). End products that may be produced from these raw materials include: products intended for direct use in motor fuel and all agricultural products used as fuel for energy production.

[72] See Chapter 1 "Prices", Articles 3 and 5, of Council Regulation 318/2006. Interestingly, the country-specific sugar quotas have not been reduced; the quotas to be allocated to sugar mills ("undertakings producing sugar") equal the total of the A and B quotas allocated to mills under the now repealed predecessor Regulation (EC) No 1260/2001 of 19 June 2001 (see Article 7 and Annex III of Regulation 318/2006 and Article 11 of repealed Regulation 1260/2001).

[73] The single farm payment scheme ("Einheitliche Betriebspraemie") has been eligible for sugar growers since 2006.

Euro per ton of surplus sugar is not charged inter alia when the surplus is used in the manufacture of bioethanol[74].

Beet farming for ethanol rather than for sugar will take off on a large scale as soon as the minimum price for quota beet (see footnote 72 and Tab.9) will fall below the price that petrol wholesalers are willing to pay for a litre of bioethanol. Just how much that is cannot yet be gauged from real transaction prices as the European ethanol beet market is still in its infancy and existing price quotes are hardly comparable. However, it may be safe to predict that wholesalers will set their stop-buy-limit for beet ethanol at a level that corresponds with the current purchase price of fossil petrol. For them, paying more for a renewable energy carrier than for a fossil one would make no sense, even if the biofuel stems from domestic production that helps decrease import dependency. In order to find out more about the stop-buy-limit, prices per energy contents will have to be compared rather than prices per litre, as one litre of bioethanol contains less energy than one litre of fossil petrol. No current or potential future taxes, ancillary costs, government subsidies for biofuels or agricultural subsidies have been added to the cost data shown in Tab.9 and Fig.22.

Beet farmers should be able to make higher profits selling quota beet (former "A-beet" and "B-beet") or surplus beet (former "C-beet") to bioethanol producers than they would make if they sold quota beet to sugar producers at minimum post-reform prices as soon as the product cost curve for fossil petrol rises above the one for beet ethanol (Tab.9 and Fig.22). This may occur in 2008 if the retail price for fossil petrol will then not be lower than 1.25 Euro per litre[75] (or earlier if fossil petrol product cost increases earlier). This statement rests on the assumptions that 1) rising fossil petrol product cost will also push up bioethanol product cost; 2) bioethanol markets start heating up as buyers (petrol wholesalers) strive to avoid high cost on fossil fuel markets while sellers (beet farmers) strive to avoid income losses from the sugar market reform; 3) domestic capacity for processing additional beet into bioethanol will increase as needed; 4) agricultural subsidies granted to beet farmers for compensating sugar income losses will not significantly distort the fossil and biofuel markets by artificially closing the price gap shown in Fig.22 in favour of continuing sugar production at full throttle.

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[74] "Bioethanol" as defined under Regulation No 318/2006: undenatured ethyl alcohol of 80% volume or higher (CN# 2207 10 00) or denatured ethyl alcohol of any strength (CN# ex 2207 20 00).

[75] Or around 4 Eurocent per kWh. Calculations in Tab.9 and Fig.22 assume that retail prices for fossil petrol in Austria consist of 27% product cost: cf. chapter 9 and MWV, 2006.

Summing up the existing annual domestic potential for bioethanol production in Austria, Tab.10 arrives at a figure of 1.1 billion litres of bioethanol, corresponding to a fossil petrol substitution of 757 million litres and an avoidance of 1.3 million tons of carbon dioxide equivalent. The fact that 1.1 billion litres of bioethanol only represent 31.4% of the projected domestic need for bioethanol of 3.512 billion litres in the year 2007 (cf. Tab.7) may give rise to disappointment as it can be interpreted as a 68.6% bioethanol import dependency. However, the figure fares quite well when compared with the current de facto 100% import dependency on petroleum products.

On the other hand, from the environmental benefit point of view, we should not conceal that biofuel production does not only avoid carbon dioxide emissions by preventing direct consumption of fossil fuels but is also the reason for new fossil fuel emissions: when considering the entire production cycle from harvesting and transporting the raw materials and intermediate products to the combustion of the end product, bioethanol ex sugar beet or wheat is quoted as causing 40% process emissions of carbon dioxide for each 100% abatement of fossil carbon dioxide emissions[76] (PWC/IFP, 2002). Supporting measures for reducing collateral damage from incidental Kyoto emissions should hence accompany all policy initiatives related to the promotion of a fuel switch. Such measures would include cutting down on the use of fertilizers, keeping transport routes from crop field to ethanol plant short and avoid importation of raw materials from non-sustainable sources.

In the early days of automotive transport, ethanol rather than fossil petrol was destined to become its driving force. Henry Ford, the inventor of car mass production and its famous first product, the Model T, declared in 1925 that ethanol was "the fuel of the future" [77](New York Times, 1925). Driven by his political ambition to create a new market for farm products, Ford pointed out the technical advantages of bioethanol over gasoline: in the 1920s, petroleum had a lower octane rating than ethanol, was detrimental to human health due to the addition of a toxic octane-enhancing agent (tetra-ethyl lead), was more likely to explode, created carbon residues in combustion chambers of engines, needed pipelines for crude oil

[76] Figures in quoted study are in grams carbon dioxide per energy unit (megajoule).

[77]Quote: "... The fuel of the future is going to come from fruit like that sumach out by the road, or from apples, weeds, sawdust – almost anything [...] There is fuel in every bit of vegetable matter that can be fermented. There is enough alcohol in one year's yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a hundred years ..." Interview of Henry Ford appeared in the New York Times, 20 September 1925.

distribution and had to be chemically standardized in refineries. Still, petroleum won the upper hand over vegetable fuel in the 1920s, as oil lobbyists were successful in preventing the US government from lowering alcohol taxes while, at the same time, they began saturating the market with cheap fuel from new oil fields. They also made sure that research expenditure for improving the quality of petroleum products multiplied while research into renewables ground to a standstill. Today in Austria, we should therefore seize the opportunity to right part of the wrong done to bioethanol fuel almost a century ago.

In contrast to substitution of fossil petrol with bioethanol, this author will not advertise a fuel shift from fossil diesel to biodiesel. Reasons are manifold. First, the degree of self-sufficiency in the production of rape seed only reaches 50% in Austria and most of the annual harvest is absorbed by the domestic oil industry (cf. Tab.8). Second, most Austrian acreage and climates are unsuitable for rape seed cultivation as the plant is highly exploitative of soils and needs levels of mineral fertilizer that can hardly be justified under a sustainable farming policy (Tab.11). Rape seed requires a 13-fold input of (di-)phosphorus pentoxide, 7.5-fold input of potassium oxide and 5-fold input of magnesium oxide as compared with the respective amounts of mineral fertilizers needed to grow sugar beet (Lachemie, 2006; Tab.11). Because of high amounts of energy needed in fertilizer production, rape seed shows an unfavourable energy balance twice as low as that of fossil diesel[78]. Increased fertilizer consumption also steps up emissions of highly kyoto-relevant nitrous oxide (N_2O) emissions (cf. chapter 7), thereby annihilating part of the carbon dioxide abatement effect. To make matters worse, emissions of nitrogen oxides (NO_x) from biodiesel combustion are even 10% to 30% higher than those of fossil diesel[79] (McCormick, 2005), thus thwarting EU emission limits for air pollutants (see Directive 2001/81/EC; footnote 34). Third, yield in kilogram rape seed per hectare is very low (2,965 kg/ha in 2005: cf. Tab.8); suitability of soils left aside, substitution of the forecast 2007 need of fossil diesel with 8,326 million litres of biodiesel (cf. Tab.7) would necessitate an expanse of arable lands amounting to 6.26 million hectares or 454% of the total 2005 Austrian acreage of cultivated and set-aside lands totalling 1.38

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[78] The energy balance [k] is the ratio of the calorific value [x] of a fuel (amount of energy set free during combustion) to the amount of energy [x'] necessary to produce the fuel, including energy used in the cultivation of biofuel source plants, transportation, refining, and others. It proves difficult to draw credible information on [k] values for biodiesel from literature, as most quotes are placed by the biofuel industry. It is certain, though, that the [k] value for biodiesel is positive and may lie at around 3.1. This would be twice as low as the [k] value for fossil diesel of 6.7 (quoted in Taupp, 2001).

[79] Used in pre-1998 diesel engines, pure biodiesel (E100) is quoted as causing nitrogen oxide emissions 10% higher than those of fossil diesel. Used in diesel engines compliant with 2004 standards, NO_x emissions are quoted to be 30% higher. The quoted study refers to US "standards".

million hectares[80] (2005 acreage: BMLFUW 2006). Pursuing a biodiesel policy would consequently plunge Austria into a complete oilseed import dependency no better than the current one on crude oil. Import of biofuels or their source crops from Brazil and other emerging economies in the Tropics cannot be justified, as vast areas of rainforest are cleared each year to make way for the new biofuel cash crops; massive additional carbon dioxide emissions from the ensuing tropical wastelands outweigh any Kyoto gas abatement effect garnered by the substitution of fossil fuels with biofuels of such provenance.

To cut a long story short: there is indeed demonstrable potential in Austria to produce enough quantities of bioethanol from domestic sugar beet and soft winter wheat to reduce an annual 1.3 million tons of carbon dioxide equivalent transport emissions by substitution of fossil petrol. The balance quantity of domestically consumed bioethanol or its source plants would need to be imported from sustainable non-tropical sources; import dependency would still be high at 68.6% but lower than the current de facto 100% one on crude oil. In contrast, domestic mass production of biodiesel is not a viable option, nor is import from tropical sources.

[80] Given the conversion factors: [2.965 tons of rape seed / 1 ha], [396 kg biodiesel / 1 ton rape seed], [0.883 kg / litre biodiesel] and a projected 2007 domestic need of 8,326 million litres of biodiesel.

CHAPTER 11: Unbridling the flexible Kyoto mechanisms

All other parameters aside, investment of tax payers' money into flexible Kyoto mechanism projects (cf. footnote 9 in chapter 1) today is a more cost-efficient way of accruing gas tonnage abatement for the State than relying on federal subsidy regimes such as FESR (cf. chapter 4). While the average subsidy (investment allowance) per ton of carbon dioxide equivalent under FESR amounts to 16.9 Euro (calculated from a Kyoto year approach, cf. chapter 4 and Tab.1), typical current prices under the Austrian JI/CDM Purchase Program would lie around eight to ten Euros as of October 2006[81] (cf. footnote 17). Yet, the potential yield of the Program has been willfully bridled in two ways: when the Program saw the light of day in 2003, its portfolio was limited by excluding certain project types; further, with a view to obeying the so-called "supplementarity principle", the yield was capped ex ante at 7 million tons of carbon dioxide equivalent to be purchased per year or 35 million tons over the Kyoto period.

The project portfolio was designed to encompass purchases of ERUs and CERs (Emission Reduction Units and Certified Emission Reductions) from JI and CDM projects, respectively, either through direct ERPAs (cf. footnote 17) with sellers or via carbon facilities acting as intermediaries between sellers and the Program. The portfolio has since been expanded to also allow purchases of AAUs[82] under Article 17 of the Kyoto Protocol. Another type of emission reductions, RMUs[83] from agricultural and forestry projects conducted domestically and via JI projects, continues not to be eligible under the Program. RMUs from carbon capture and storage projects (CCS[84]) would be especially promising but currently share the fate of all RMUs under the Austrian Program.

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[81] Topical prices as agreed between the Program and sellers in ERPAs (cf. footnote 17).

[82] Assigned Amount Unit, under the Marrakech Accords of the Kyoto Protocol, is an accounting unit of one ton of carbon dioxide equivalent, which can be traded among countries with a Kyoto goal.

[83] Removal unit, under Article 3.3 (forestry) and Article 3.4 (agriculture) of the Kyoto Protocol, is an accounting unit of one ton of carbon dioxide equivalent from LULUCF projects (Land Use, Land Use Change and Forestry), whereby carbon sequestration by vegetation and soils ("carbon sinks") is being credited to Kyoto goals of countries. Eligibility of carbon sinks was agreed upon at COP-6b of the UNFCCC but is limited to the current Kyoto period. It follows an elaborate methodology fleshed out at COP-7 in Marrakesh. While some types of LULUCF projects are admittedly precarious from an ecological point of view, a general ban on all acquisition of RMUs by the Program is certainly not in order.

[84] Carbon capture and storage is an approach to mitigating carbon dioxide from large stationary sources such as power plants by capturing the gas, compressing it and permanently storing it away in deep geological formations, exhausted coal beds and oil wells or in the form of carbonates. The IPCC

Apart from limitations on the project portfolio, the Federal Environment Administration has decided that flexible Kyoto fulfilment must not exceed 50% of the total abatement tonnage required for complying with the Austrian Kyoto goal and that the balance of 50% be brought up by domestic greenhouse gas limitation. As a basis for this claim, the "supplementarity principle" as laid down in Decision 15/CP.7 of UNFCCC COP-7 in Marrakesh is quoted which holds that "... *the use of the [flexible] mechanisms shall be supplemental to domestic action* ..." and that the latter "... *shall thus constitute a significant element of the effort made by each Party* ..." to meet its Kyoto goal. The words "supplemental" and "significant" clearly point at an intended crucial role of domestic fulfilment but do certainly not prejudge 50/50 fulfilment shares of domestic efforts and projects abroad. In fact, the Kyoto compendium of rules even foresees a "cost efficiency principle" which would seem to suggest otherwise: Article 3 (3) of the UN Framework Convention on Climate Change (UNFCCC) holds that "... *policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost* ...". Cost efficiency of measures related to climate policy implies that their marginal costs of abatement be harmonized among industrial sectors and between industrial sectors and the Kyoto Party (the State). A government that wraps red tape around the use of flexible project mechanisms thus contravenes the cost efficiency principle as it interferes with the harmonization of marginal costs (cf. Fig.8, chapter 1, and ETSG, 2005).

Apart from a questionable 50/50 doctrine, formidable obstacles stand in the way of government limitation policies: EU Environment Administrations tend to calculate the permissible import quotas for JI/CDM emission reduction units along the tonnage gap between the base year (1990) greenhouse gas emissions of a Member State and its 2012 Kyoto goal. However, as shown in Figs.23-25, this method is highly distortive of the market and lets one Member State group grossly benefit to the detriment of three others ("Group 3", Fig.25), as it would permit these Member States to import quotas that exceed their entire necessary reduction efforts. In contrast, other Member States would be granted much lower than needed quotas ("Group 1" including Austria; Fig.23), even a "negative" import quota signifying a de facto exclusion from the use of flexible mechanisms ("Group 2", Fig.24) or a

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estimates that CCS has a potential amounting to 10-55% of the total carbon mitigation effort until 2100. As yet, however, the energy needed for compressing carbon dioxide tilts the energy balance of CCS projects unfavourably against this new type of sinks project.

zero import quota for Member States with a 0% Kyoto goal[85] ("Group 4": Finland and France; no figure). As a consequence, if limitation policies were to be pursued at all, import quotas would need to be calculated from the tonnage gap between the business-as-usual emissions (BAU emissions[86]) of a MS and its 2012 Kyoto goal, as this guarantees that the actual need of a Member State for Kyoto project imports can be met (ETSG, 2005).

Some EU Member States do not comply with a 50/50 doctrine (Tab.12, Fig.26). When deciding on the Austrian priorities regarding the share of import quotas over the tonnage abated domestically, the behaviour of other MS will be crucial as Austria must not be put at a disadvantage by a costly self-imposed "domestic-first" policy while other MS reap the cost benefits of their stepped up national flexible Kyoto programs. Given the highly disparate Kyoto reduction goals of Member States resulting in a noticeable discrepancy of fulfilment ease among them, countries with high goals such as Austria cannot afford to renounce their chances at fully exploiting cost-efficient alternatives, as they are otherwise faced with a limited roster of financially feasible domestic reduction options. In 2004, eight Member States quantified the role they intend to allocate to flexible Kyoto fulfilment during the period 2008-2012[87] (Tab.12, Fig.26). Of these eight MS, four announced higher shares of flexible Kyoto tonnage imports over domestic fulfilment than did Austria. Remarkably, three MS (Ireland, Italy and Netherlands) feature much lower Kyoto goals. Luxembourg, NL and Italy would be in breach of the "50/50 doctrine" if these Member States interpreted the Kyoto rule compendium in a way that forbids flexible fulfilment beyond 50% of total reduction goals. In order to avoid market distortion and take better advantage of cost savings afforded by a thorough participation in the flexible Kyoto regime, Austria should abandon her strict adherence to the supplementarity principle and follow suit.

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[85] Since 1990 emissions [x tons] and 2012 Kyoto goals [y tons] represent the same figure in FI and FR, their respective Kyoto reduction goals amount to 0%. If the permissible import quota for JI and CDM certificates is fixed at no matter what percentage [α] of the total tonnage needed for compliance, the quota will always be zero if calculated along the lines of: [$(x-y)*\alpha$]. Note: a 0% reduction goal does not mean a zero needed reduction effort, as BAU (business-as-usual) emissions of these MS are higher than their 1990 emissions (same situation as in "Groups 1 and 2"; Figs.23-24).

[86] BAU indicates the amount of greenhouse gas emissions that a MS would produce if no Kyoto-relevant abatement strategies were in place. Since BAU is a realistic measure of the actual emission situation of a MS at a given time, the distance of BAU to Kyoto goal should be the basis for all deliberations on possible import restrictions, that is if a restrictive approach is deemed appropriate at all.

[87] In this case, the years 2008-2012 refer to the second emissions trading period under the EU Emissions Trading Directive 2003/87/EC of 22 July 2003, not to the Kyoto compliance period. Announcements were made by MS in their respective first National Allocation Plans (NAP I) under the Trading Regime referring to the intended use of flexible mechanism quotas during the future NAP II period.

Stepping up both scope and yield of the Austrian JI/CDM Purchase Program will necessitate federal funding in excess of the currently available spending frame as guaranteed by the Federal Environment Subsidy Law[88]. Yield of tons carbon dioxide equivalent per Euro of public funds is higher in the Program than in the domestic subsidy regime FESR. The federal funding priority should therefore shift to the Program. In case new allocations become available, they should be dedicated to flexible Kyoto fulfilment If not, current allocations to FESR should be redirected to the Program. Time is running out as all emission reduction purchase agreements (ERPAs) for projects will have to be finalized by the end of the year 2007 at the latest, in order to maximize the rates of carbon return over the Kyoto period[89].

[88] "Umweltfoerderungsgesetz", BGBl I 2003/71 and I 2005/57, § 6 (2d).

[89] A project concluded with the Austrian Program before or in 2007 that becomes operational in the same year will yield a return over the entire Kyoto commitment period 2008-2012. A project operational in 2008 will only have a limited return over the years 2009-2012.

CONCLUSIONS: Approaching constraints on a shoestring budget

So far, Austria has not fared too well in performing a tightrope walk towards her ambitious Kyoto reduction goal. The more distant the goal becomes, the higher will be the funding required for meeting it in time before 2012. Emission reduction goals decreed by the EU acquis communautaire and future provisions on monetary sanctions for noncompliance confront the federal state with an unpalatable choice of having to "pay a lot now (pre-2012) or pay a staggering amount later (post-2012)". Although caught between a rock and a hard place in this fashion, Austrian politics has not yet tapped all potential sources of carbon abatement that are both affordable and feasible from budgetary and technical points of view. Further, in some areas (such as transport politics, federal subsidies, double dividend), political priority has centred too much on dogma than on reliable strategies. The mission of this study has been to point out these policy areas, explore their hitherto dormant potential and, where possible, estimate cost and carbon yield. The principal findings can be summarized in the following recommendations:

Abandon "double dividend dogma" as cornerstone strategy of Austrian environment and renewable energy policies

The "double dividend" has been a widespread political dogma and is supposed to translate tax adjustments and public subsidies into decreases in negative environmental effects such as the emission of Kyoto greenhouse gases. As it turns out, however, the interactions between tax revenue, subsidies and the intended environmental yield may be more erratic than generally believed. Hikes in subsidies and taxes may hence not reflect linearly on a decrease of the negative effect. As a consequence, the tax-subsidy policy tool should be subjected to further investigation in order to elucidate its purported effectiveness.

Restructure federal environment subsidy regime

The carbon abatement yield harvested by the federal environment subsidy regime in Austria has been modest when juxtaposed with the sizeable budgetary contribution it has received. Subsidies prove ineffective in meeting the reduction potentials in the various project types. The regime works along an obsolescent scheme, involving a non-revolving fund which disburses non-refundable investment allowance that cannot be recovered by the State even in part. Cheap project types are not systematically favoured over costly ones but subsidies granted mostly on a first-come-first-serve basis. It is strongly recommended that the federal subsidy regime be restructured along a revolving fund concept serving projects first that show an optimized ratio of subsidy cost per ton carbon dioxide equivalent. New allocations of federal budget to the subsidy regime should be stalled until restructuring has resulted in an enhanced cost-yield efficiency.

Stop crediting subsidy regimes with undue secondary effects

Subsidy regimes are often said to entail valuable secondary effects on the economy besides triggering the private investment needed for completing a subsidized project. The purported positive other effects include an increase in new turnover, new domestic value added and the emergence of new domestic employment. Because of these purported other effects, the Federal Environment Administration has raised the cost-efficiency rating of the Austrian federal environment subsidy regime by a flat 38% above the rating it would receive if calculated purely along a cost-yield standard. This study has investigated whether the regime is credited with these positive secondary effects with good reason and found remarkably high ratios of value added to turnover (V/T ratios) in the surveyed renewable energy technologies that are eligible for subsidy. By process of elimination, the study arrives at the conclusion that the favourable competitive situation in which many renewables plants operate may be a reason for high V/T ratios. The employment engine effect is rather modest and the sector seems to increase profits on subsidies. Hence, a higher cost-efficiency rating due to alleged secondary effects seems hardly in order and should be abandoned in favour of a clear cost-yield analysis, allowing for unbiased comparison among the various Kyoto-relevant emission abatement policies.

Step up rate of cost-efficient flexible Kyoto fulfilment

As an alternative to the federal subsidy regime, budget allocations to the Austrian JI/CDM Purchase Program should be stepped up beyond the current spending frame as the Program features higher rates of carbon return per investment than do subsidies. Concurrently, Austria should follow the example of other EU Member States and abandon her strict adherence to the 50/50 doctrine limiting the use of flexible Kyoto mechanisms. The project portfolio of the Program should be extended as well. This study points out the main operational reasons why the 50/50 doctrine distorts the emission certificate market to the financial detriment of Austria. Increased federal funding for carbon purchases would ideally be offset by a lowered spending frame for federal subsidies.

Additional measures in agriculture can yield 2.69 million tons of carbon dioxide

This study proposes two measures in the field of agriculture that should be implemented as soon as possible: a widespread use of nitrification inhibitors, reducing the consumption of mineral fertilizers and cutting emissions of highly Kyoto-relevant nitrous oxide (N_2O) by up to 50% would yield an extra 1.39 megatons of carbon dioxide equivalent per year; the financial burden on farmers would increase as inhibitors have to be purchased in addition to the regular ammonium fertilizers. However, farmers are already legally obliged to observe a strict ammonia (NH_3) discipline under EU Directive 2001/81/EC, a requirement not sufficiently enforced by the governments of the Austrian federal provinces. Since oxidation of ammonia i.a. results in nitrous oxide emissions, a stricter enforcement of ammonia standards together with a mandatory use of nitrification inhibitors could bring home the abatement potential. The other measure proposes a reduction of enteric Kyoto-relevant methane (CH_4) emissions from bovines and other farm ruminants by changing their diet plan; expected yield: 1.3 megatons of carbon dioxide equivalent per year. A further decrease in cattle heads supplements this measure. Required funding for curbing agricultural greenhouse gas emissions would have to be provided by the Austrian federal provinces as part of their contribution to the national Kyoto goal.

<u>Additional measures against heating emissions can yield 4 million tons of carbon dioxide</u>

Since households account for an important share of total final energy consumption, the thermal insulation quality of the Austrian building stock is a prime concern to climate policy. Stricter U-values (a measure for heat transmission properties) will have to be introduced in the respective building codes of the Austrian federal governments. However, the bulk of the abatement potential lies in the existing building stock. Thermal insulation and the extension of biomass district heating grids are the two main measures for yielding the proposed annual abatement of 4 million tons of carbon dioxide equivalent. Funding is available through the annual special-purpose allocations to federal provinces. Costs in federal province subsidy regimes are not known to the federal administration; if cost data for subsidizing building stock refurbishment under the federal regime is comparable to that under the federal province regime, a share of 35.12% of annual special-purpose allocations to federal provinces would suffice to harvest the entire annual abatement goal through thermal insulation of the existing building stock. Buildings constructed between 1961 and 1980 should be tackled first as these feature the lowest rates of energy performance.

<u>Abandon "price elasticity dogma" of petroleum products in transport politics</u>

Many Austrian transport policy initiatives aiming at a reduction in the number of road traffic movements by motor vehicles have been inconclusive over the past decade. Necessarily, attached climate policy measures in the transport sector towards a reduction of transport-related greenhouse gas emissions have been equally unsuccessful. The blame for this failure is to be put on the political adherence to a wide array of discouragement policies in an abortive attempt at stifling the urge of the masses to move people and freight around in private combustion engine cars. A dogma of the advocates of movement restriction has been a firm belief that a price elasticity of demand (PEoD) exists between consumption levels and price levels of petroleum products. According to this logic, a tax or price increase should always be followed by a slump in consumption; a tax or price cut by a hike. This study has tried to ascertain whether a PEoD pattern can be substantiated on the basis of Austrian data on diesel and petrol consumption as well as retail prices using a simplified two-dimensional model only reflecting these two variables. Results may serve to cast doubt on the belief that demand in petrol and diesel is invariably price elastic. As a consequence, the widespread view that demand for these products can be stifled by means of tax/price increases may need to be revised.

Additional measures towards fuel switch can yield 1.3 million tons of carbon dioxide

If efforts at restricting mobility cannot, a sustainable transport concept aiming at widespread substitution of fossil fuels with renewable fuels can indeed bring about a decrease in traffic-related greenhouse gas emissions. Hydrogen appears to be the most suitable alternative fuel, especially when judged by its high specific calorific value. However, mass production of hydrogen as a car fuel is delayed by pending achievements in natural sciences and hence not a promising policy option for the period 2008-2012. Investment in hydrogen technology research could pay off in the medium turn, though. On a quest to find the ideal alternative, this study examines the potential for fossil fuel substitution in Austria on the basis of domestic availability of source plants for biodiesel and bioethanol production. Starting from a fossil fuel demand forecast for Austria, the corresponding volumes of biofuels were calculated and cross-referenced with the domestic supply of potential source plants. Biodiesel production from rape seed is not advocated in this study due to a total lack of domestic self-sufficiency in this crop, unsuitability of Austrian soils, excessive fertilizer need and numerous other negative ecological aspects of rape seed cultivation. In contrast, bioethanol production from surplus sugar beet and soft winter wheat from crops beyond the self-sufficiency thresholds and from cultivation of sugar beet on set-aside lands could cover 31.4% of the projected domestic need for bioethanol in 2007 (assuming a 100% fossil fuel substitution goal). The study also points out that post-sugar-reform prices for quota beet will be lower than prices potentially offered by bioethanol production plants or wholesalers, thereby creating an incentive for beet farmer to rather sell to the alternative fuel industry. The carbon dioxide abatement effect that corresponds with the 31.4% domestic bioethanol self-sufficiency volume in litres amounts to 1.3 million tons of carbon dioxide equivalent per year.

ANNEX: Figures & Tables

Hier bitte Low-Carbon-Figures-0107.doc + Low Carbon-Figures11,12,23-25-0107.ppt einfügen.
Anschließend Low Carbon-Tables-0107.doc einfügen.

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Acknowledgements

Thanks are due to Andreas Mayrbaeurl for his help in the retrieval of OeNACE sector data, taming price elasticity statistics and for critically reading the manuscript.

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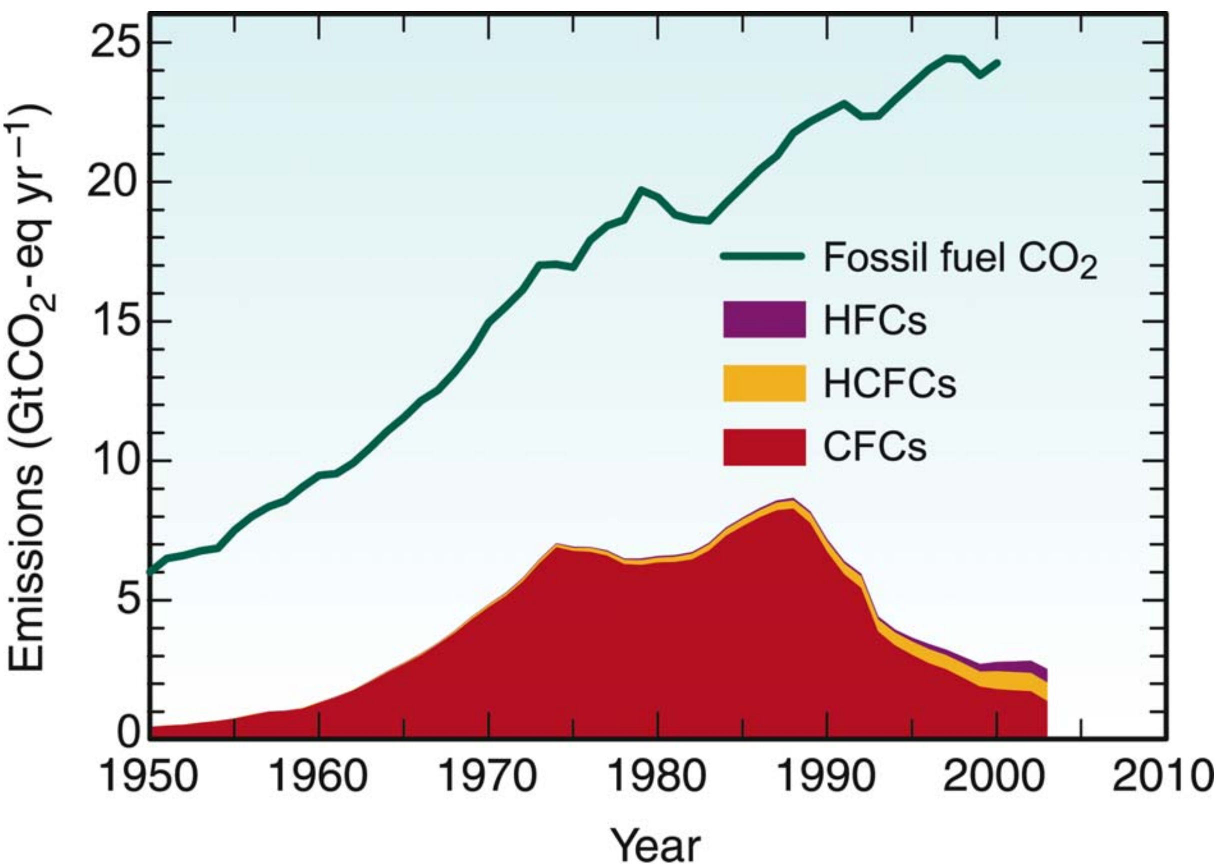
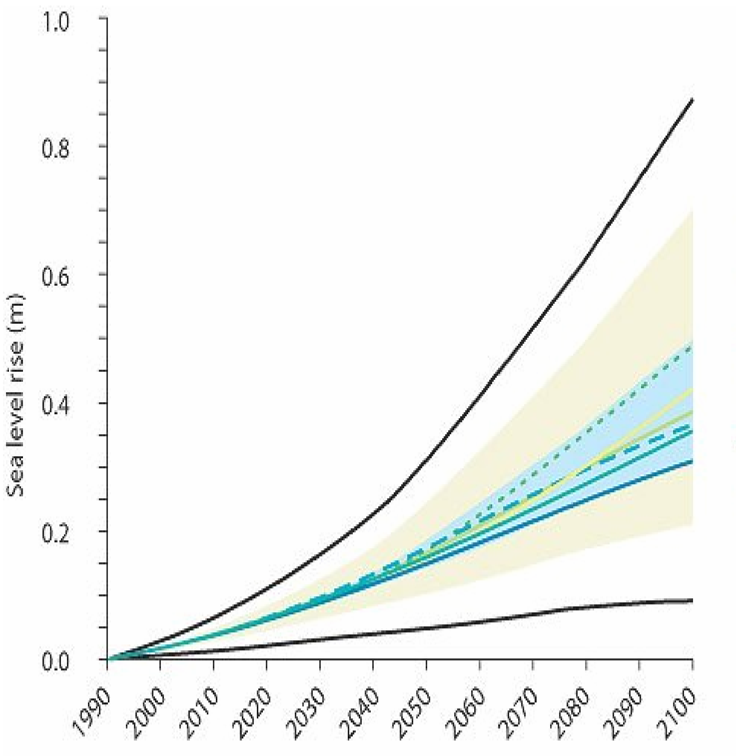


Fig.1: Fossil energy consumption is climate change is fossil energy consumption. While other sources of greenhouse gas emissions will be negligible by 2010, combined fossil fuel emissions from coal, oil and gas will continue to increase; methane and nitrous oxide emissions not shown (Source: original figure - IPCC, 2000).



+ 1 m: Cairo, Istanbul, NYC, LA, Buenos Aires

+ 0.9 m: Bangladesh (north), Hong Kong

+ 0.85 m: Osaka, Mumbai, Calcutta

+ 0.8 m: Venice, Tokyo, London

+ 0.75m: USA (Florida / Louisiana coastlines)

+ 0.7 m: Maldives, Bangladesh (south)

+ 0.65 m: Antigua & Barbuda, St. Kitts & Nevis

+ 0.6 m: Tuvalu, Kiribati, Marshall Islands, Niue

Fig.2: Low-lying island states and coastal areas may be uninhabitable or will vanish by the year 2100 as a result of ice cap melting due to global warming. Projected average sea level rise according to various scenarios and corresponding major expected locations of land loss. Land loss has already started to occur in the Pacific region; currently most badly affected is the Republic of Tuvalu (Source: original figure – IPCC, 2000; locations of land loss added by Author on basis of respective national data).

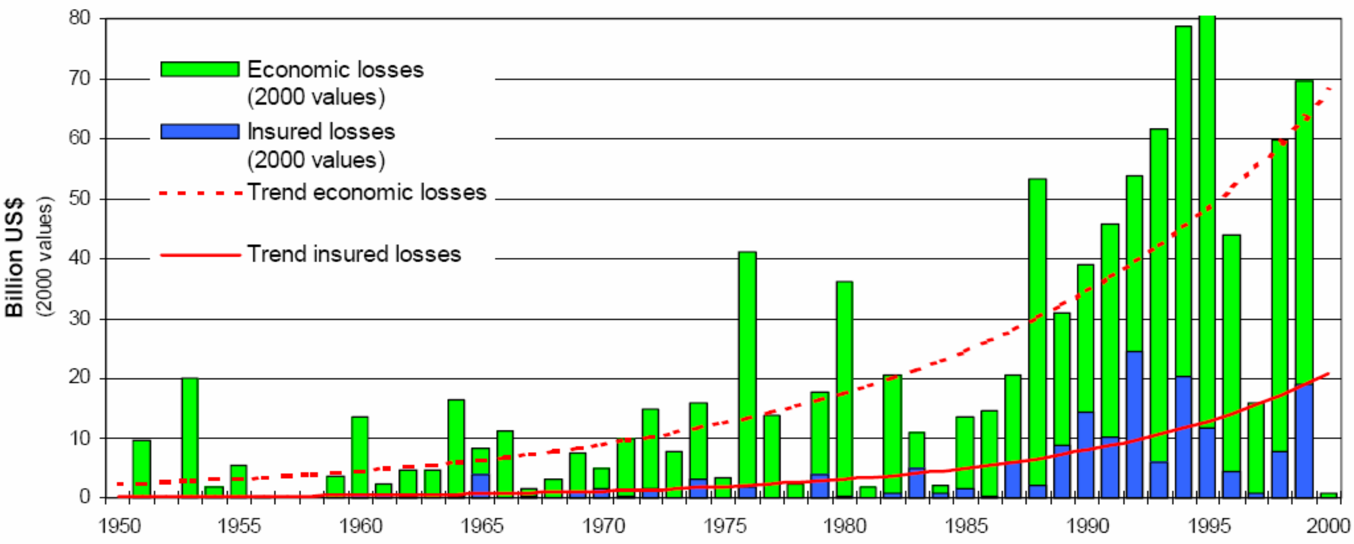


Fig.3: Worldwide weather-related economic and insured losses 1950-2000 with trends; see also Fig.4 (Source: original figure - Munich Re, 2001).

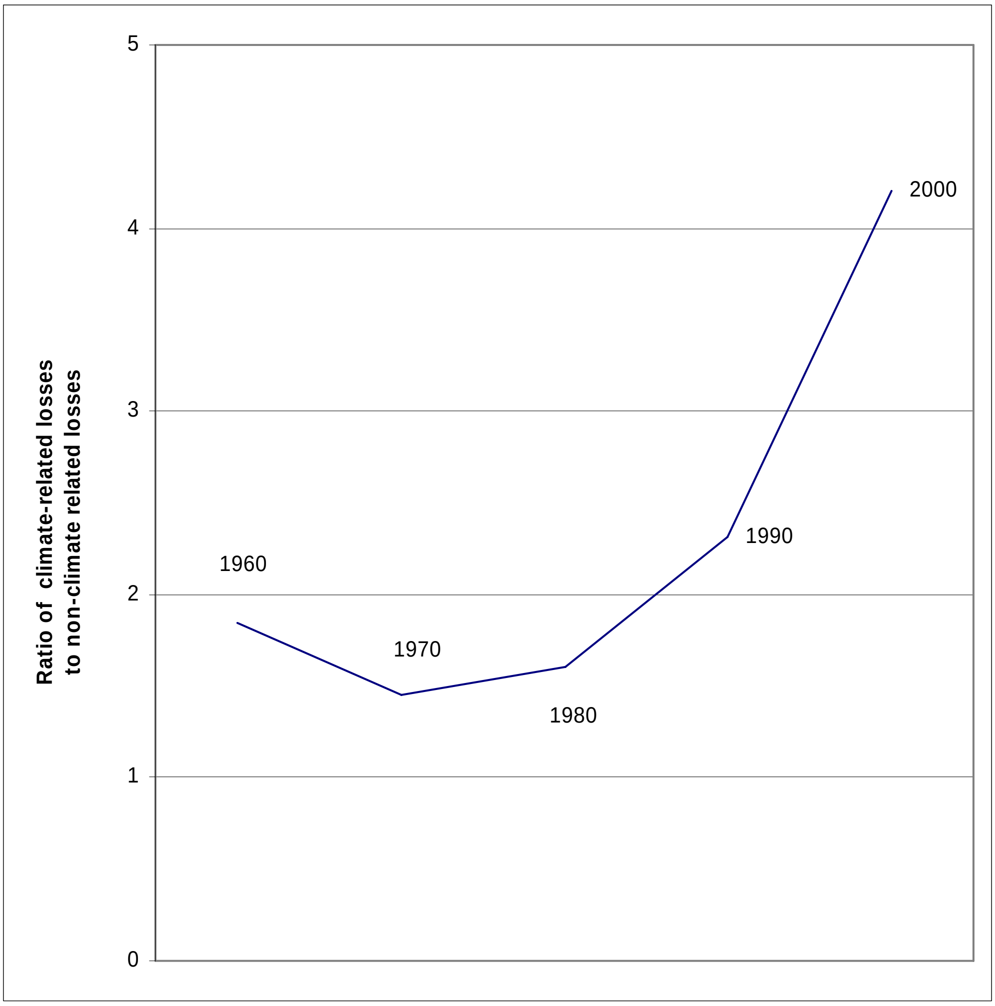


Fig.4: A sharp rise: ratio of climate-related losses to non-climate-related losses, comprising insured and non-insured (Source: data from Fig.3 and Munich Re, 2006; this compilation – Author).

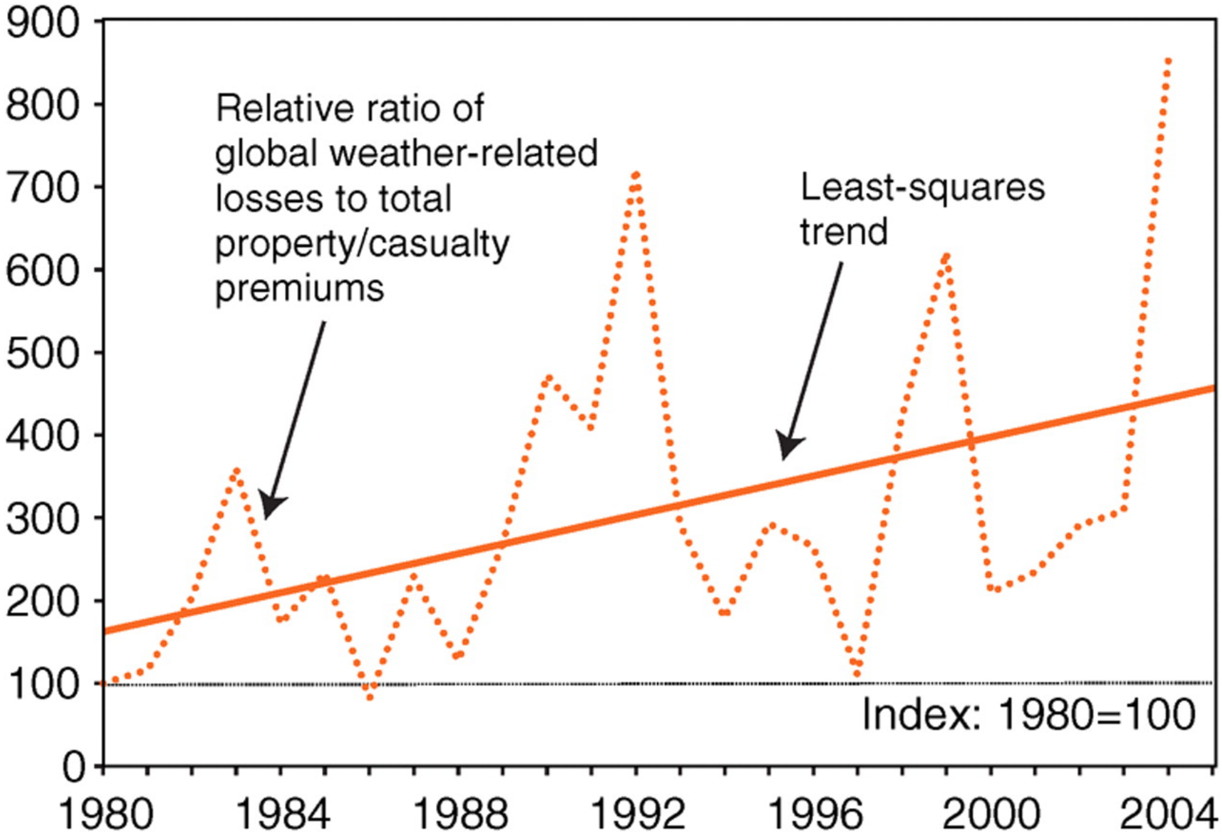


Fig.5: Impending turmoil in the insurance industry: the ratio of worldwide weather-related losses to premiums has been rising steadily since the 1980s (Source: original figure - Mills, 2005).

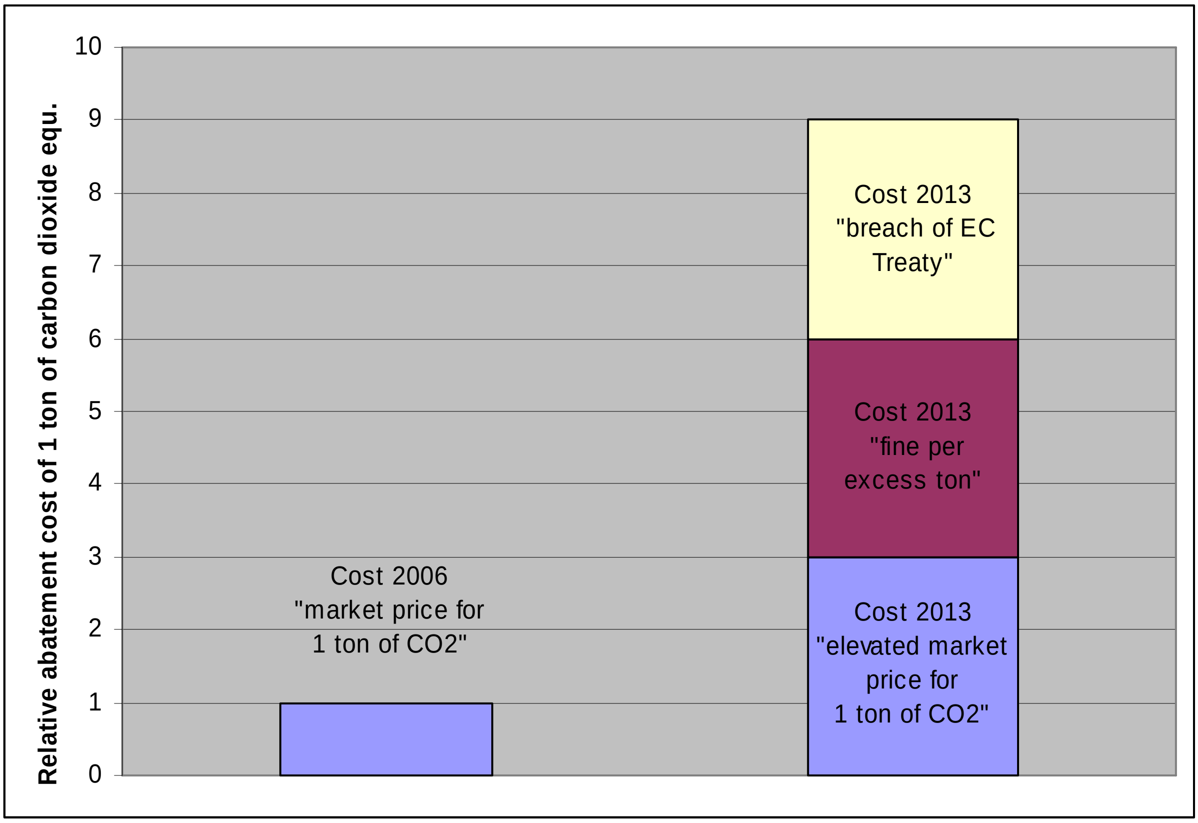


Fig.6: The "Kyoto threat" to EU Member State treasuries; "pay a lot now or pay a staggering amount later". This abstract scenario shows a hypothetical cost-cost ratio of 1:9 in favour of tackling climate-relevant investment rather now than later (Source: Author).

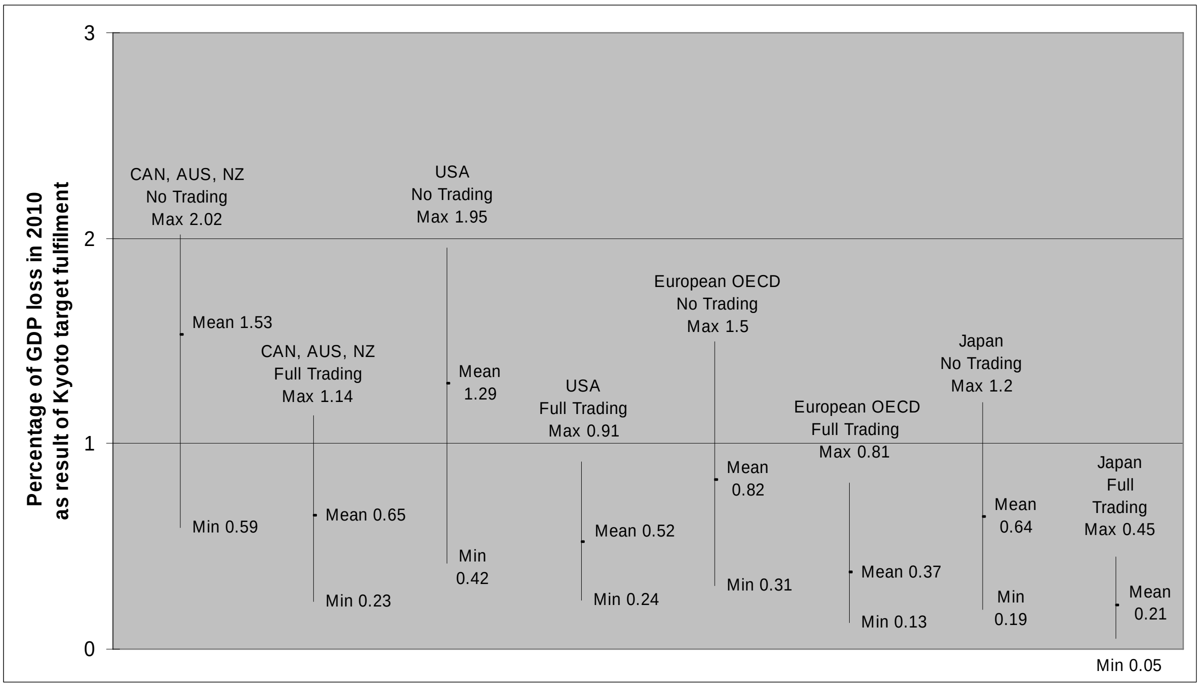


Fig.7: GDP losses of OECD countries in 2010 assuming 100% compliance with respective country greenhouse gas reduction goals under the Kyoto Protocol and future Protocol ratification by Australia and USA. Economic impact can be severely reduced if full trading options under Articles 6, 12 and 17 of the Protocol are exploited (Source: data from IPCC, 2001).

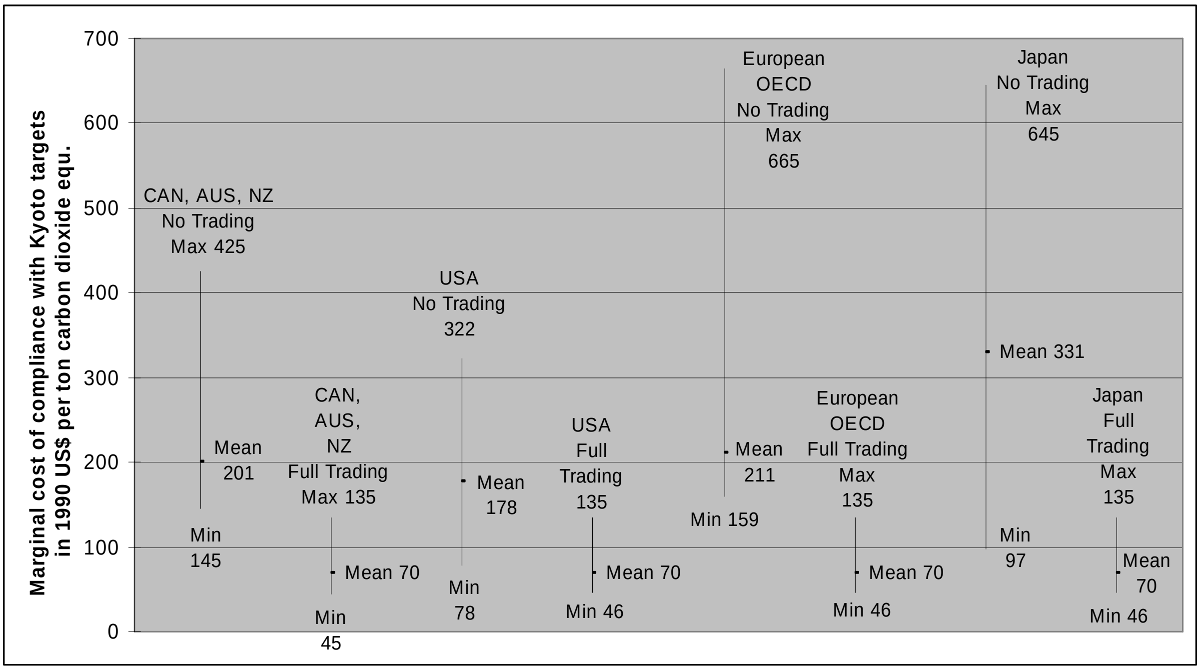


Fig.8: Marginal costs for OECD countries assuming full compliance with respective country greenhouse gas reduction goals under the Kyoto Protocol and future Protocol ratification by Australia and USA; in 1990 US$ per ton of carbon dioxide. Marginal costs are higher under the "no trading" scenario in countries with a long history of high environmental standards. Under the "full trading" scenario, marginal costs decline sharply and vary little over OECD regions (Source: data from IPCC, 2001).

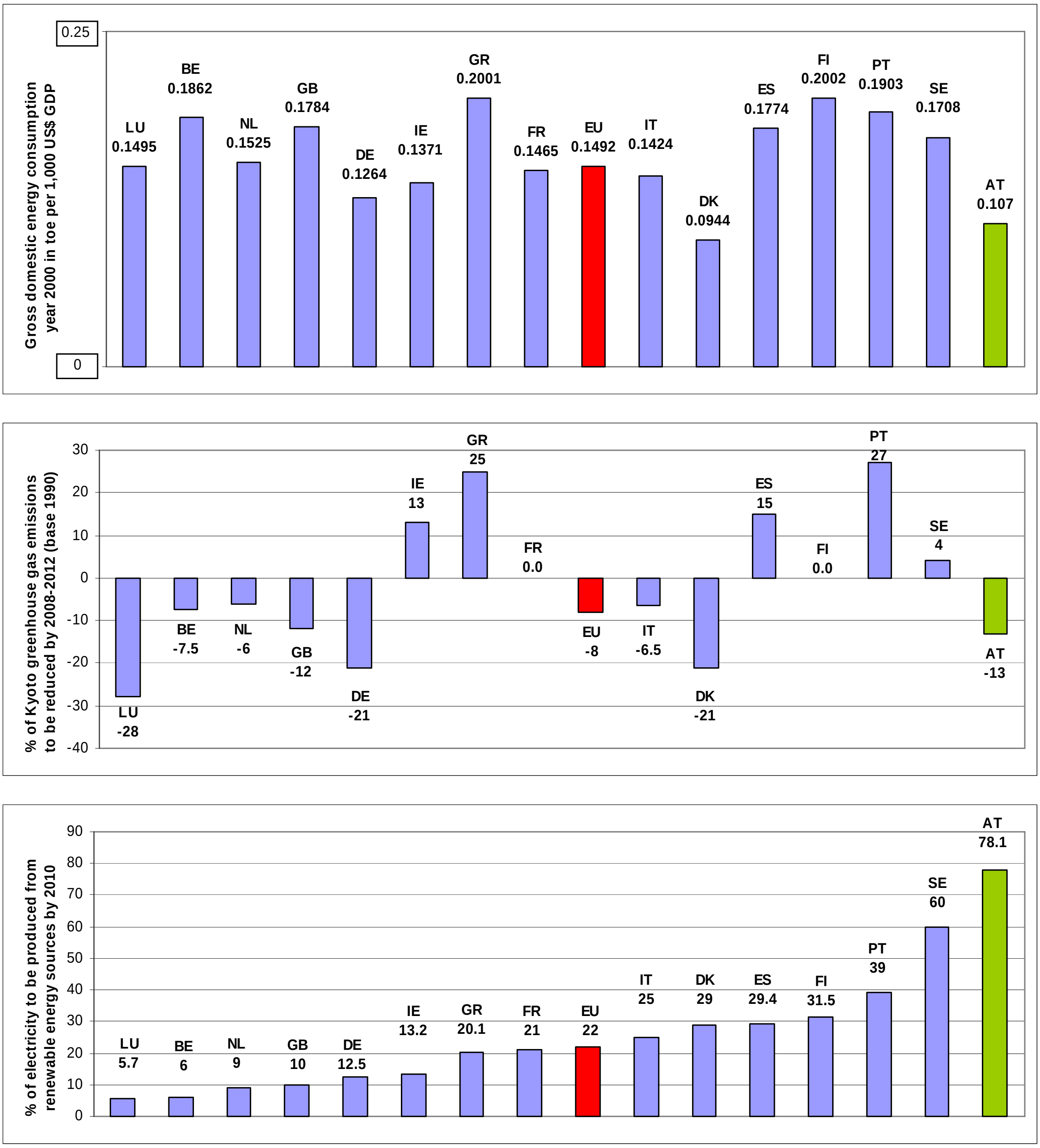


Fig.9: As early as 2000, Austria had been the second most energy-efficient EU Member State (expressed in tons of oil equivalent per 1,000 US$ GDP). Obvious even then, easy-to-achieve further increases in energy-efficiency would not be forthcoming until 2008/2012; upper third of figure. Incongruously, in 2002, Austria (along with DK) accepted heavy Kyoto burdens, suggesting high further energy-efficiency potential. In contrast, IE, GR, ES, PT and SE were "rewarded" for low energy-efficiency by unambitious reduction goals; center of figure. Incongruity continued when Austria accepted a renewable energy goal more than three times as high as the EU average; lower third of figure. (Source: data for upper third - BMWA, 2004; remainder: EU acquis communautaire; this compilation – Author).

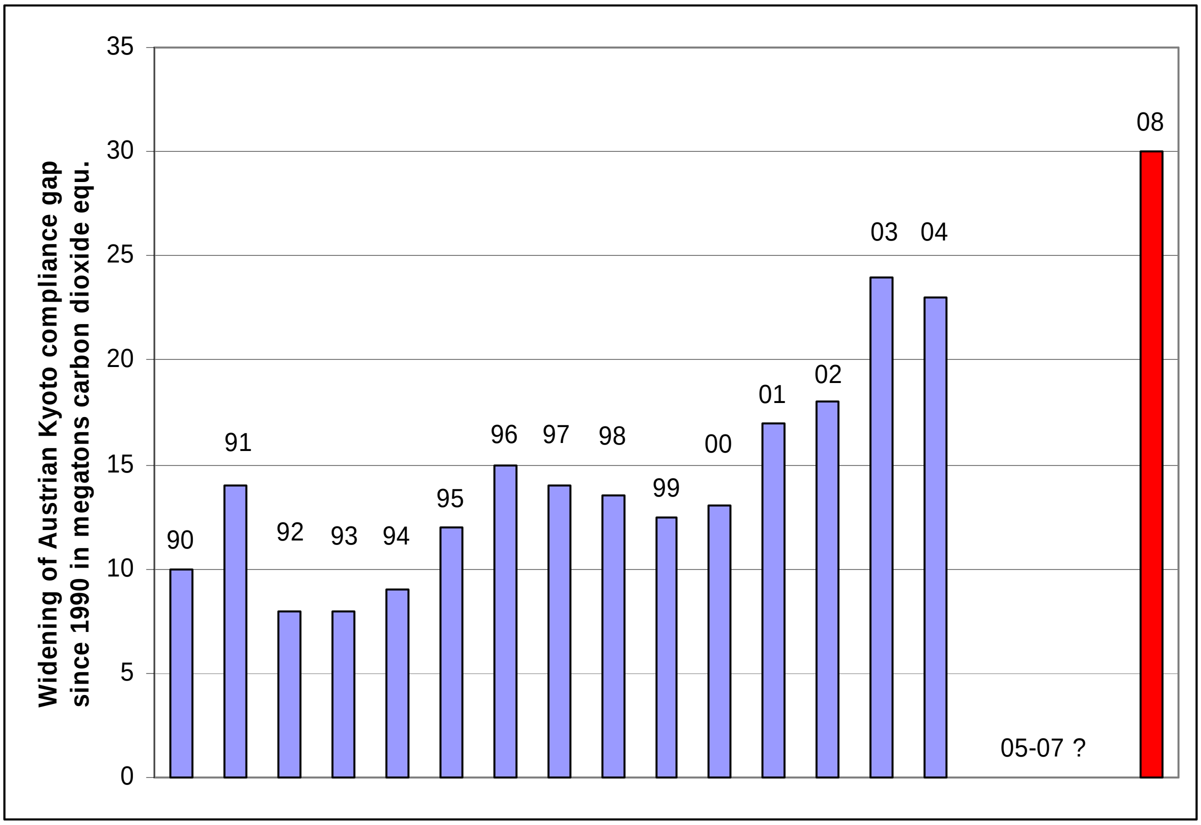


Fig.10: "Kyoto compliance gap" denotes distance of Austrian greenhouse gas reduction goal 2008/2012 pursuant to EU Kyoto burden sharing agreement (68.7 megatons carbon dioxide equivalent) to actual emissions. Amounting to 10 megatons in 1990, the gap had widened to 23 megatons by 2004. At present, data for 2005-2007 are under debate. Projection of 30 megaton gap for 2008 is not endorsed by Austrian environment administration (Source: data for 1990-2004 – UBA, 2006; figure for 2008 - Schleicher, TU Graz, pers.comm.).

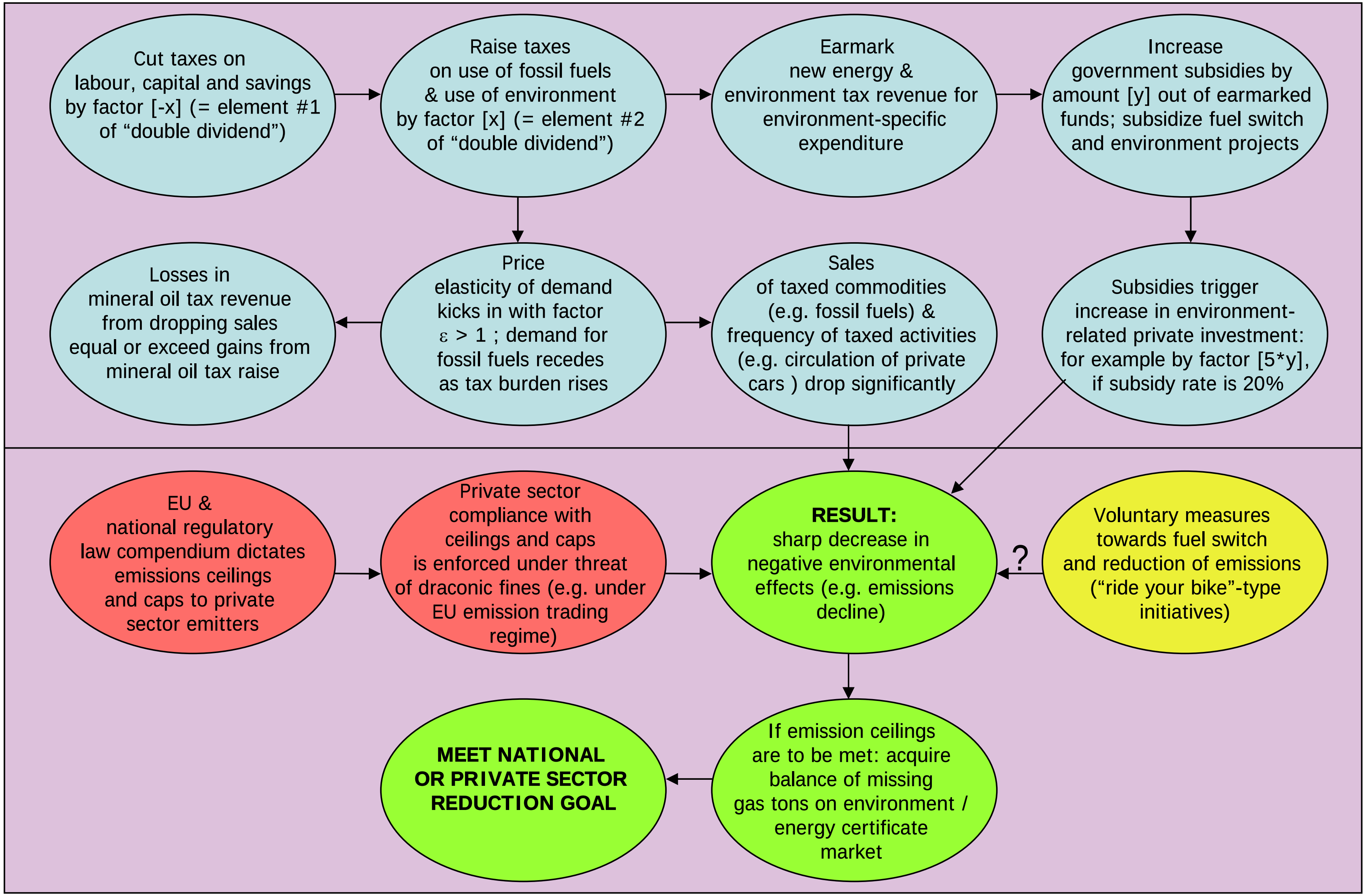


Fig.11 (upper half): Ideal textbook notion of how “double dividend” is supposed to translate tax adjustments and subsidies into decrease in negative environmental effects; (lower half): Decrease is further complimented by private sector compliance, certificate trading and, potentially, effects as a result of voluntary measures to add up to fulfilment of national or private sector reduction goals (Source: Author).

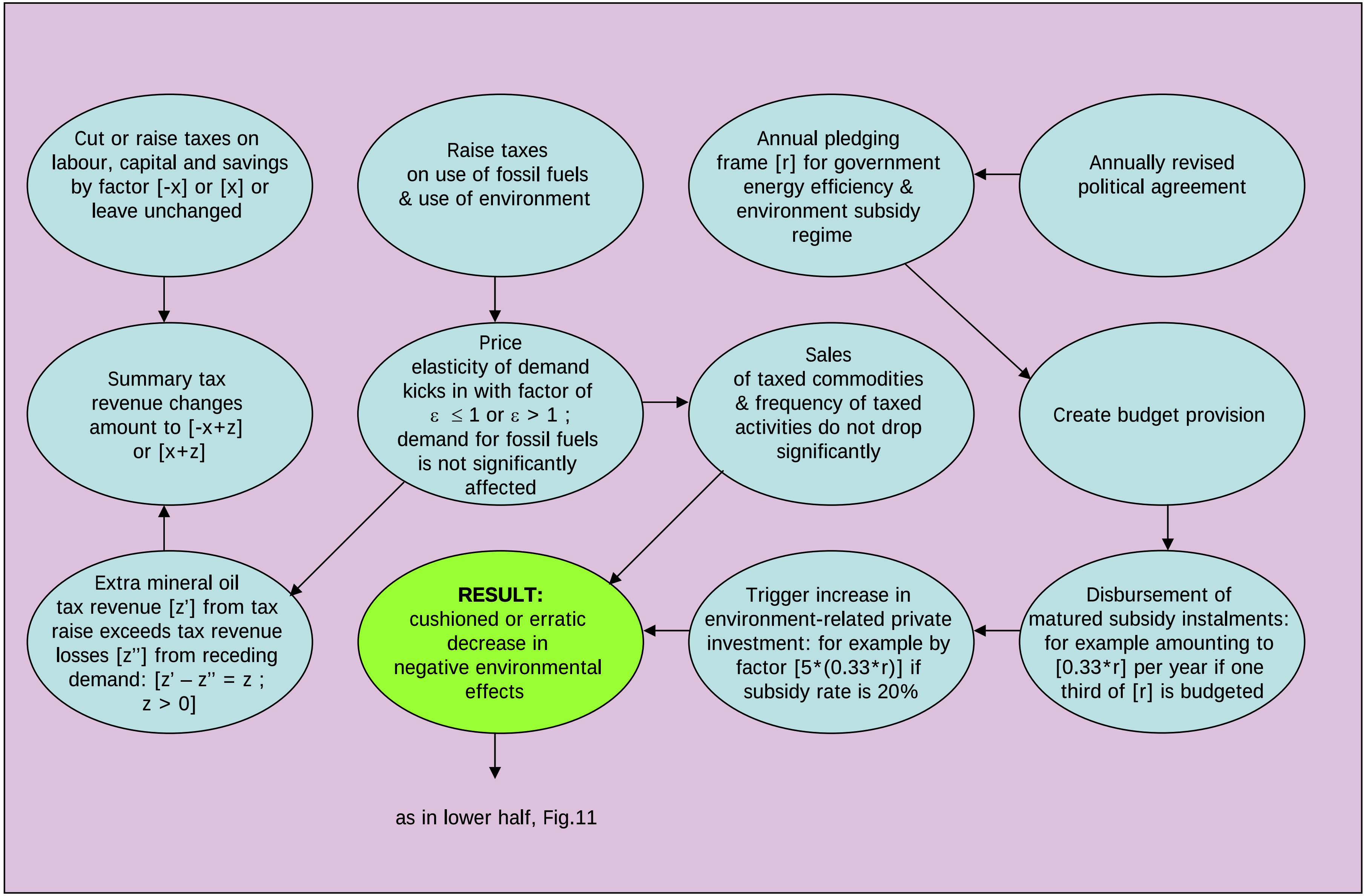


Fig.12: Revision of upper half of Fig.11, showing more realistic interaction between taxes and subsidies, subsequently resulting in a more cushioned or erratic contribution to decreasing negative environmental effects than suggested in previous figure (Source: Author).

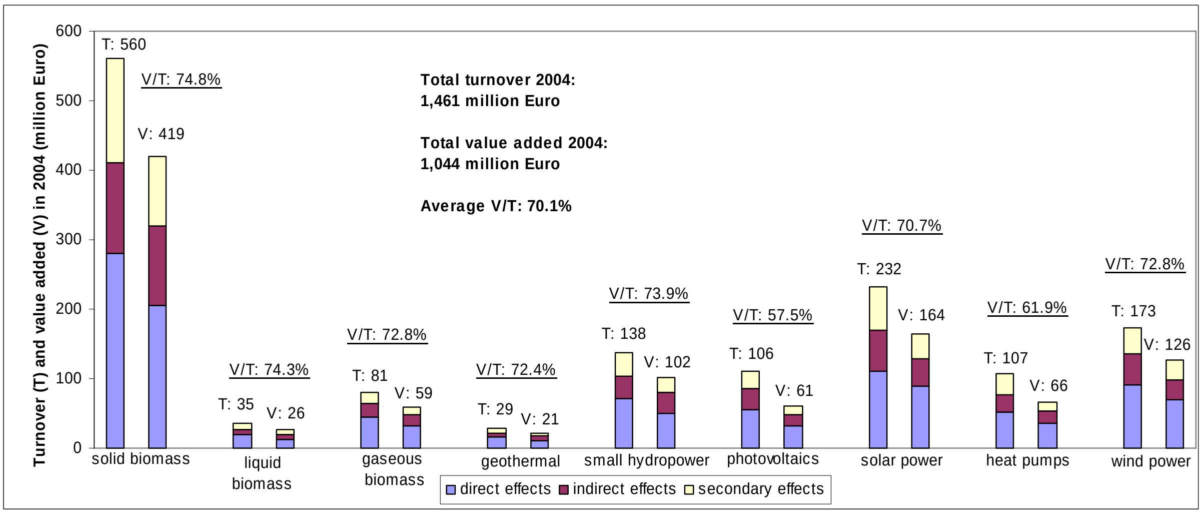


Fig.13: Turnover and value added from the production of renewable energies technology in Austria in 2004; solid biomass attracts the lion's share with eight other technologies bringing up the balance (Source: data from Haas, Biermayr et al., 2006).

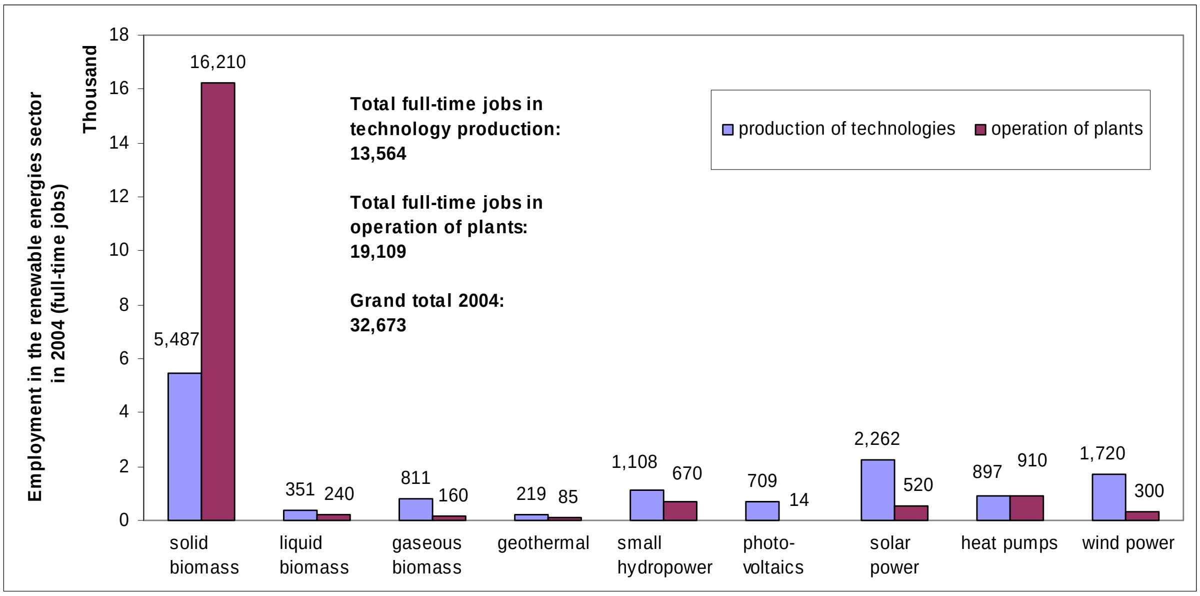


Fig.14: In 2004, the renewable energies sector created or sustained 32,673 full-time job equivalents in Austria; solid biomass accounted for two thirds. The 16,210 jobs in the operation of solid biomass plants include labour needed for the supply of biomass raw materials and for the maintenance of plants (Source: data from Haas, Biermayr et al., 2006; Kranzl, Haas et al., 2005).

	U-values Southern Europe in W/m²K	U-values Central Europe in W/m²K	U-values Northern Europe in W/m²K
Exterior wall	0.6	0.5	0.2
Roof	0.5	0.4	0.15
Floor	0.5	0.5	0.15

Northern Europe: FI, SE, NO / Central Europe: BE, DK, DE, FR, GB, IE, LU, NL, AT, CH / Southern Europe: PT, ES, GR, IT

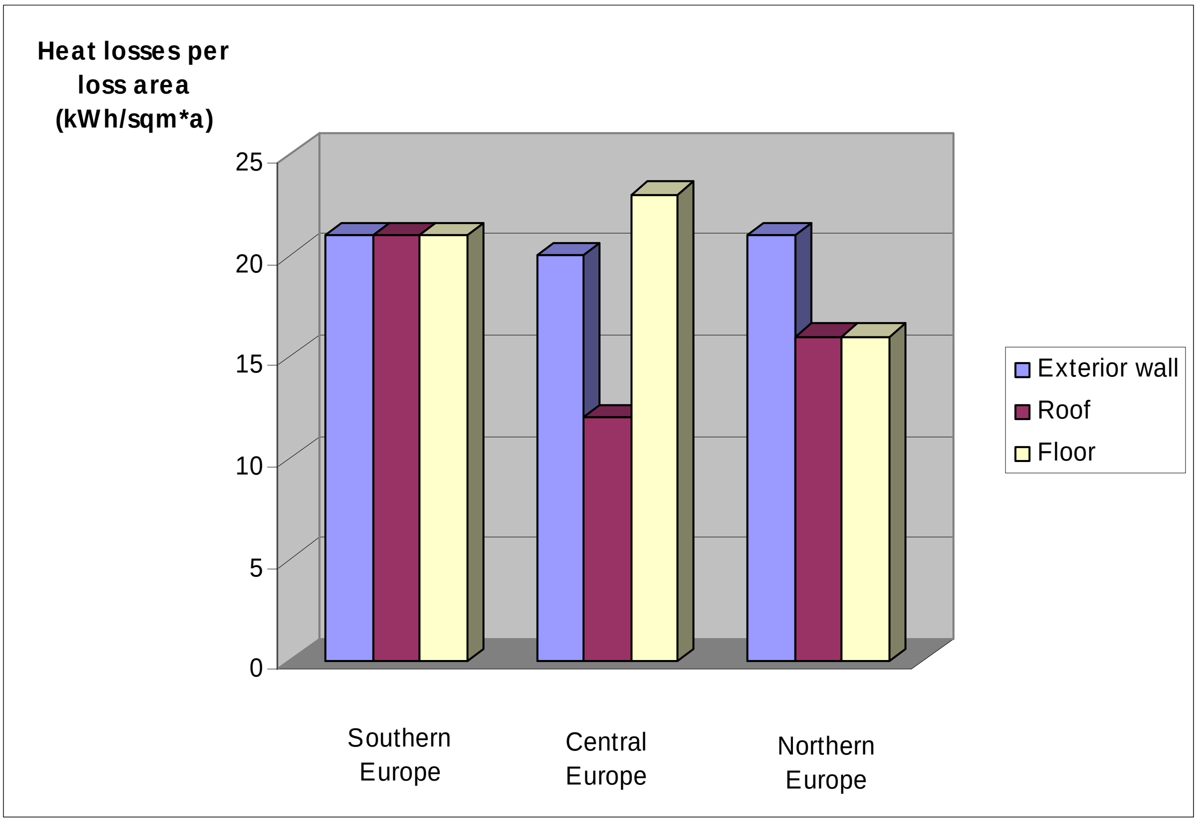


Fig.15: U-values as a measure of heat transmission properties of walls, roofs and floors and heat losses per square meter loss area, both for three climatic zones in Europe (data for buildings constructed post-1991); high U-values correspond to high energy losses expressed by heat losses per loss area (kilowatt-hours per square meter and year). Heat losses through roofs and floors are considerably higher in Southern Europe than in Northern Europe. Central European countries show a high potential for reducing heat losses through walls and floors (Source: data from Petersdorff, Boermans et al., 2002).

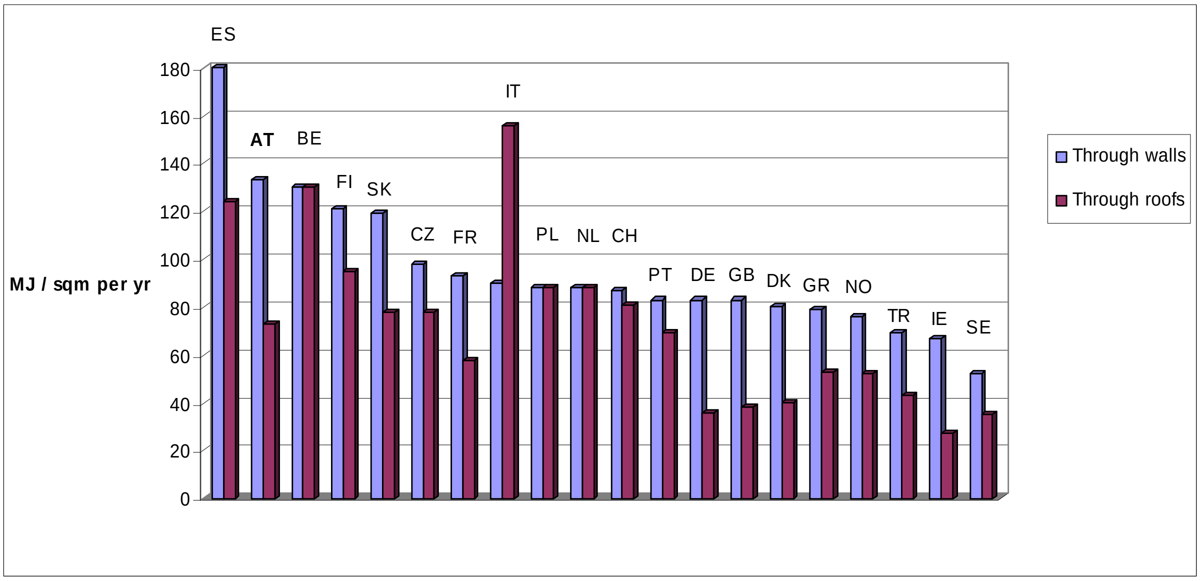


Fig.16: Energy loss through walls and roofs in megajoule per square metre per year for EU and other OECD countries in 2001. Austria scores second worst place with regard to walls; could also do better in the roof department (Source: data from Eurima, 2002).

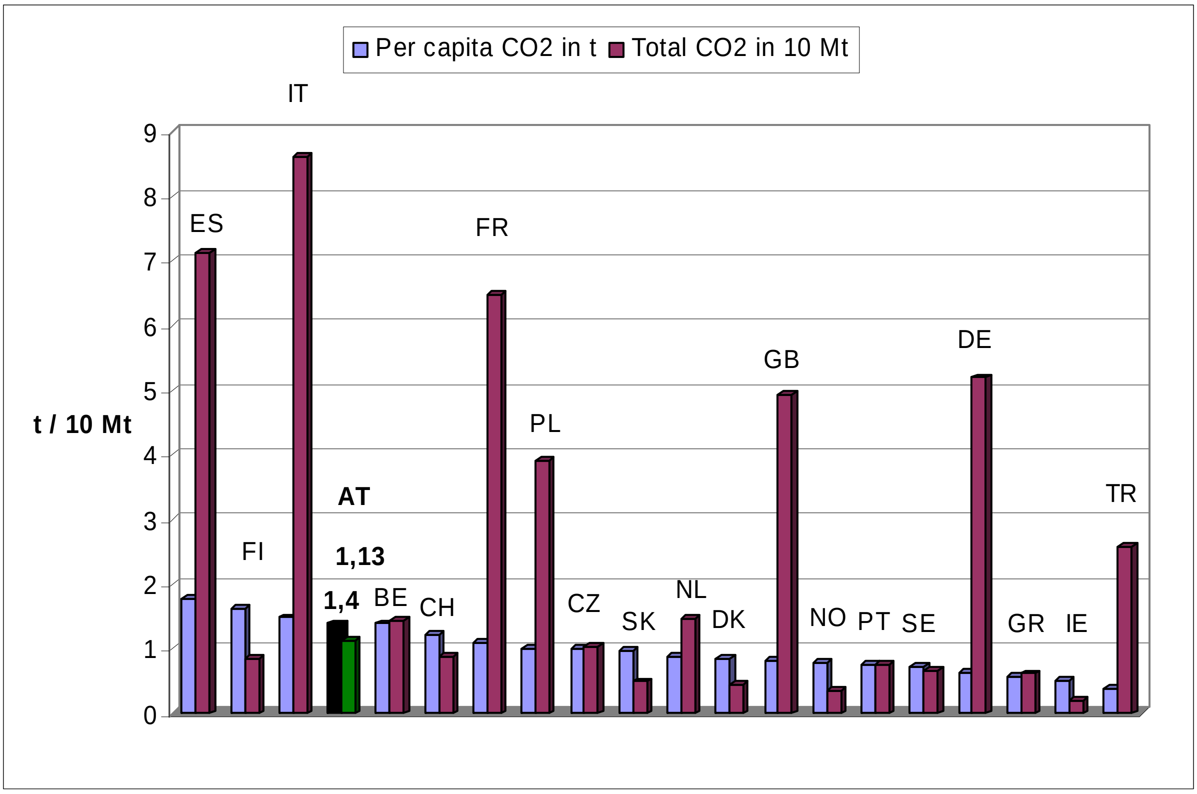


Fig.17: Per capita carbon dioxide emissions (in tons of CO_2e per year) and total carbon dioxide emissions (in 10 megatons of CO_2e per year) from human dwellings for EU and other OECD countries in 2001; Austria shows fourth highest per capita emissions of 1.4 tons per year at an emissions total from human dwellings of 11.3 million tons of CO_2e per year (Source: data from Eurima, 2002).

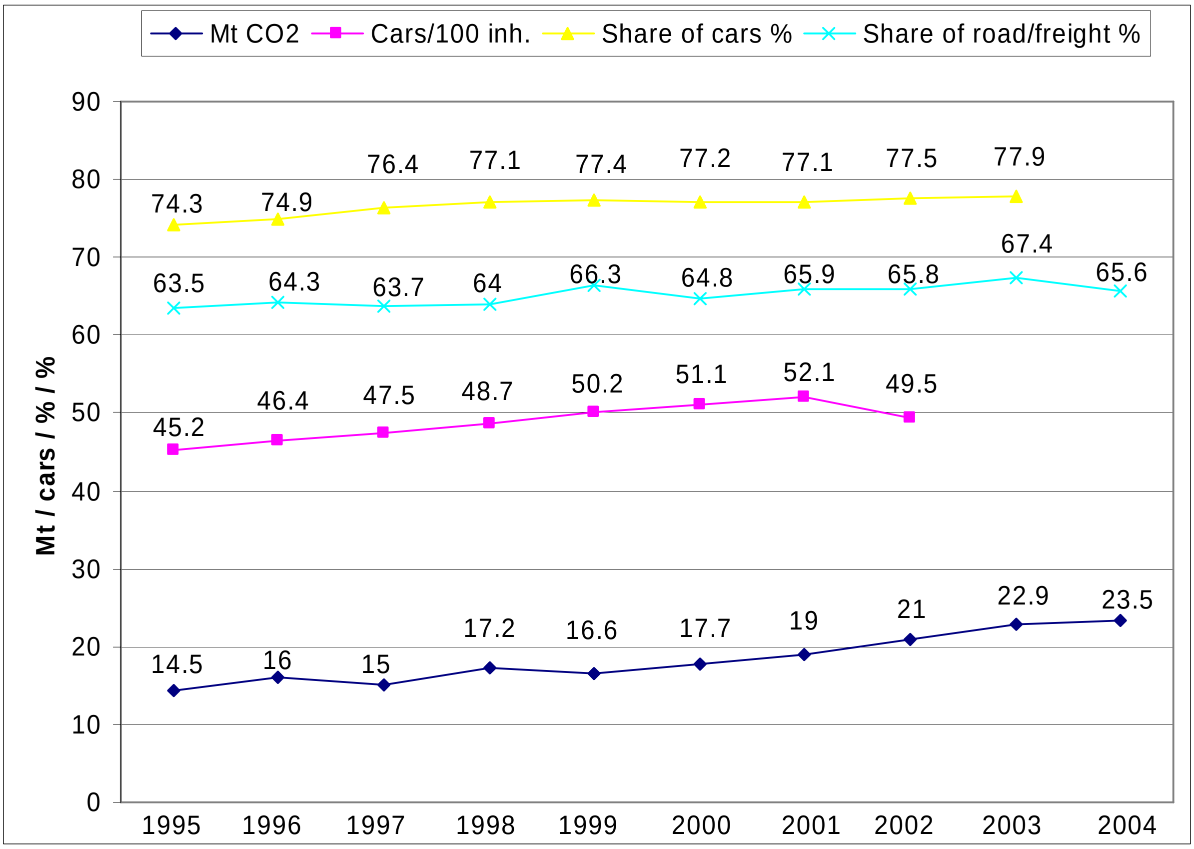


Fig.18: Austrian transport indicators out of bounds. From bottom to top: total carbon dioxide emissions from transport increased steadily between 1995 and 2004 from 14.5 to 23.5 million tons of CO_2e; number of passenger cars per 100 inhabitants rose from 45.2 in 1995 to 49.5 in 2004; share of road freight traffic in % of total freight ton-kilometers did not decline between 1995 (63.5%) and 2004 (65.6%) despite highly-publicized campaigns for boosting rail freight; share of private cars in % of total passenger-kilometers increased from 74.3% in 1995 to 77.9% in 2003 despite massive attempts at discouraging private transportation (Source: data on CO_2 emissions - UBA, 2006; remainder – Eurostat, 2006b; this compilation - Author).

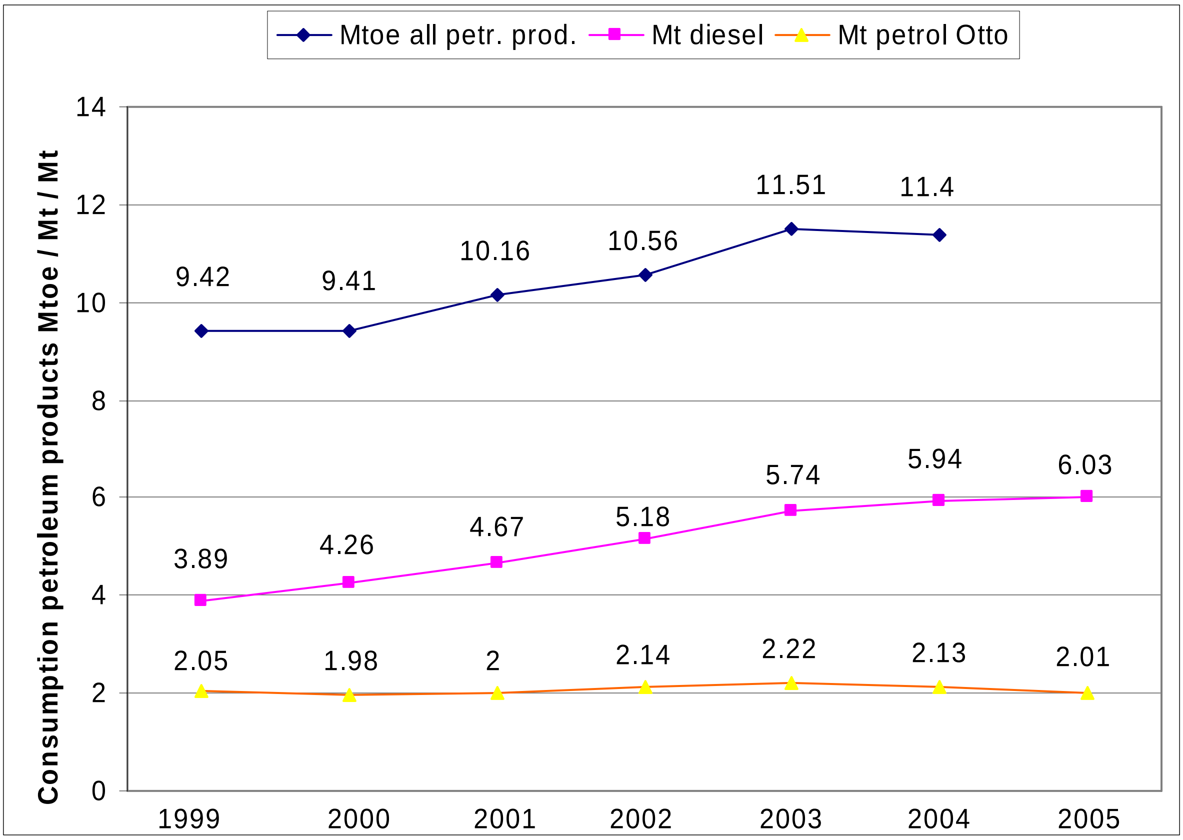


Fig.19: Consumption of petroleum products in Austria; final energy consumption in million tons oil equivalent has risen by 21% from 9.42 to 11.4 Mtoe between 1999 and 2004, comprising liquefied petroleum gases (LPG), refinery gas, Otto engine petrol, kerosenes, jet fuels (gasoline and kerosene types), naphta, gas oil (diesel), residual fuel oil, white spirit, lubricants, bitumen and petroleum coke, excluding input for energy production; consumption of diesel for vehicles has increased by 55% between 1999 and 2005 from 3.89 to 6.03 Mt; use of petrol for Otto engines has stagnated during that same period, hovering around 2 Mt per year (Source: data on final energy consumption – Eurostat, 2006c; remainder for 1999 to 2004 – FVMI, 2006; remainder for 2005 – on basis of petroleum tax revenues, Austrian Treasury; this compilation - Author).

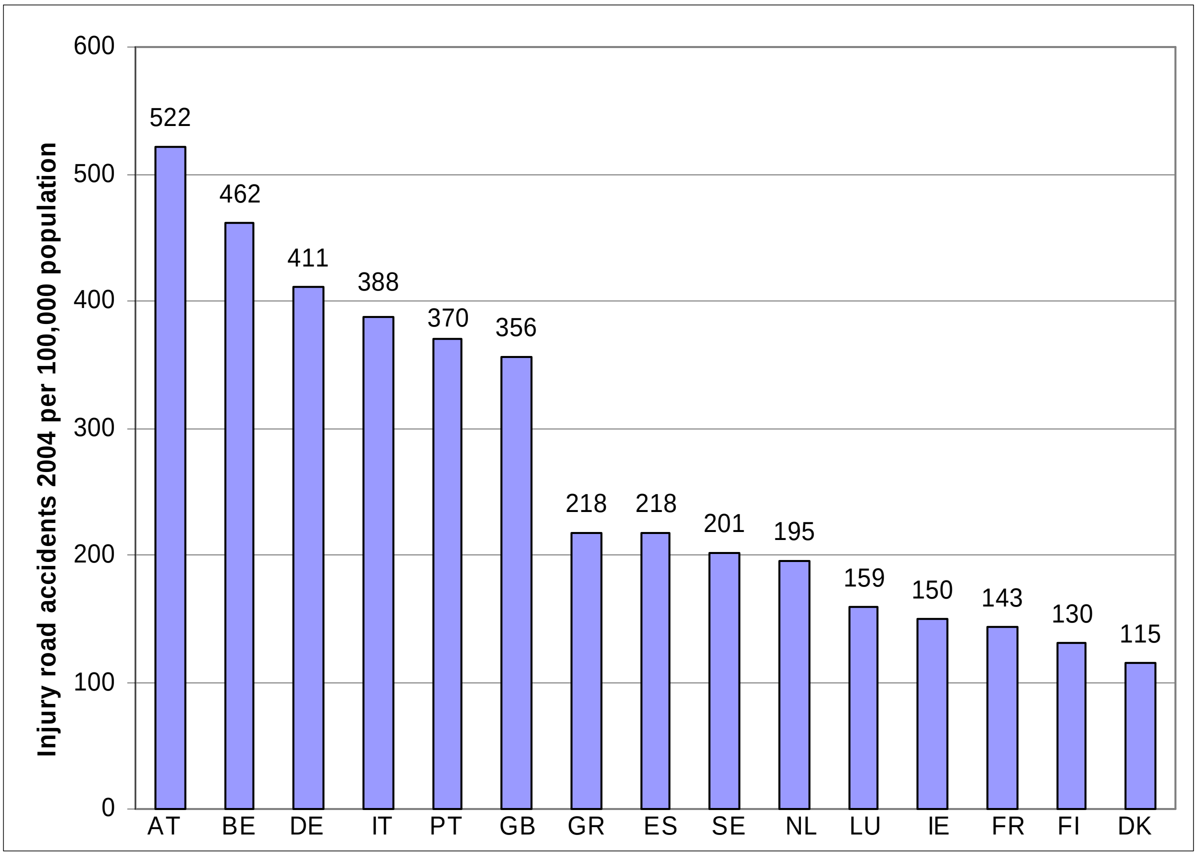


Fig.20: Yet another indication for failed transport politics? Austria scores worst at EU-15 road safety with 522 injury road accidents per 0.1 million population (Source: IRTAD, 2006; data for 2004 except IE and NL 2003, BE 2002, GR 2000).

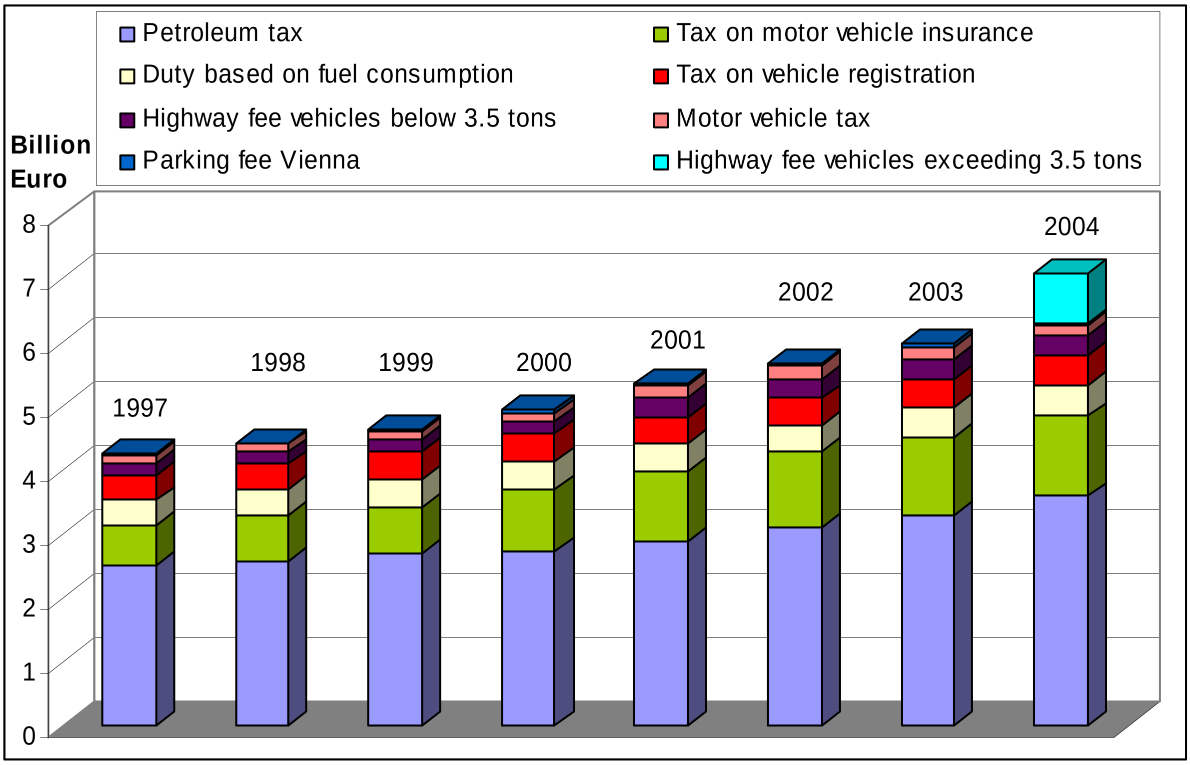


Fig.21: Revenue from transport-related taxes, fees and duties in Austria increased by 65.78% between 1997 (4,264 million Euro) and 2004 (7,069 million Euro); explanation on individual types of revenue see text. Cross-referencing with data from Figs. 18-20 allows interpretation that tax hikes were not sufficient in counteracting negative environmental and safety effects. Alternatively, if supposed link between tax hikes and discouragement of taxed activity were weaker than expected, further tax increases would continue not to reduce negative effects significantly (Source: data from OECD/EEA, 2006; except for data on fuel-consumption based duty – Statistik Austria, 2004b; data on highway fee for vehicles exceeding 3.5 tons – Asfinag, 2005-2006; this compilation -Author).

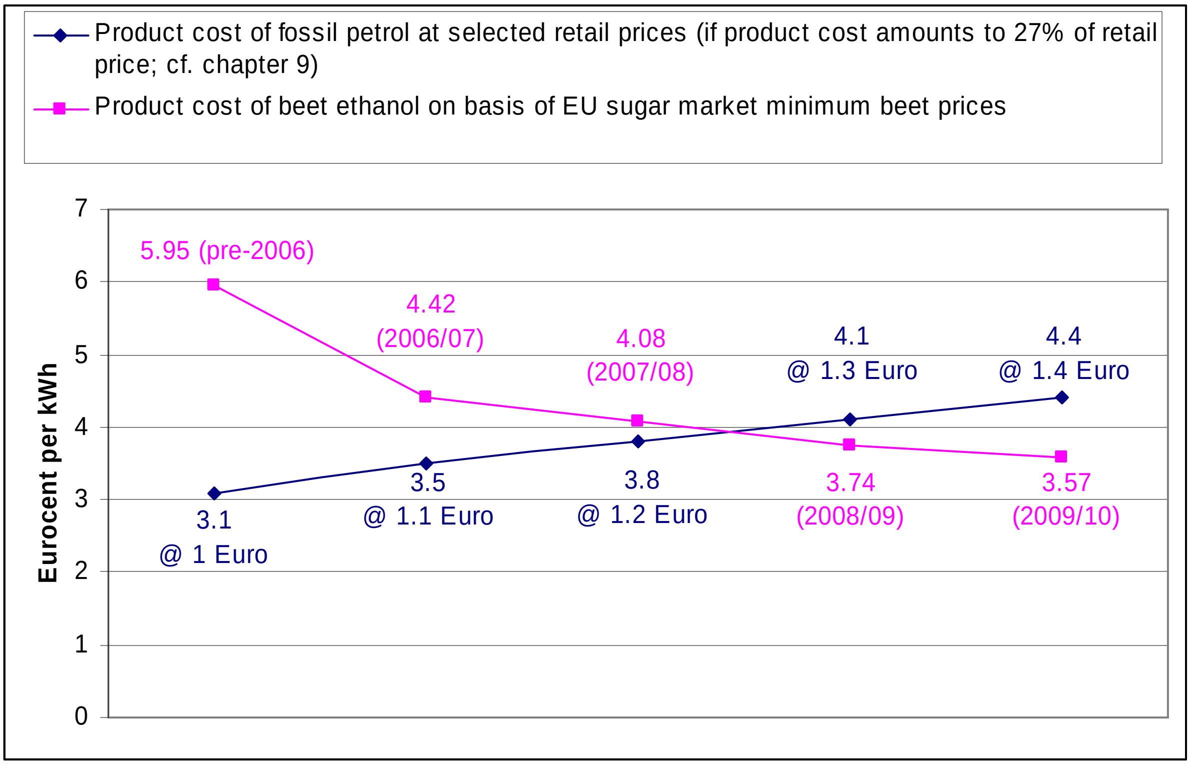


Fig.22: Product cost of beet ethanol derived from minimum sugar beet prices before and after EU sugar market reform compared with product cost of fossil petrol at selected retail prices expressed in cost per energy unit (Eurocent per kWh). Beet farmers can make a higher profit selling quota beet (former "A-beet" and "B-beet") or surplus beet (former "C-beet") to petrol wholesalers than selling quota beet to sugar producers at minimum post-reform beet prices if fossil petrol cost curve rises above beet ethanol cost curve. This will occur as soon as fossil petrol product cost has risen sufficiently high (for example in 2008 if retail price for fossil petrol were not lower than 1.25 Euro per litre). Assumption: product cost of fossil petrol is 27% of retail price, cf. chapter 9; conversion factors: see Tab.7. Model excludes taxes, ancillary costs and subsidies. For a table display of data see Tab.9 (Source: data from Tab.9; this compilation – Author).

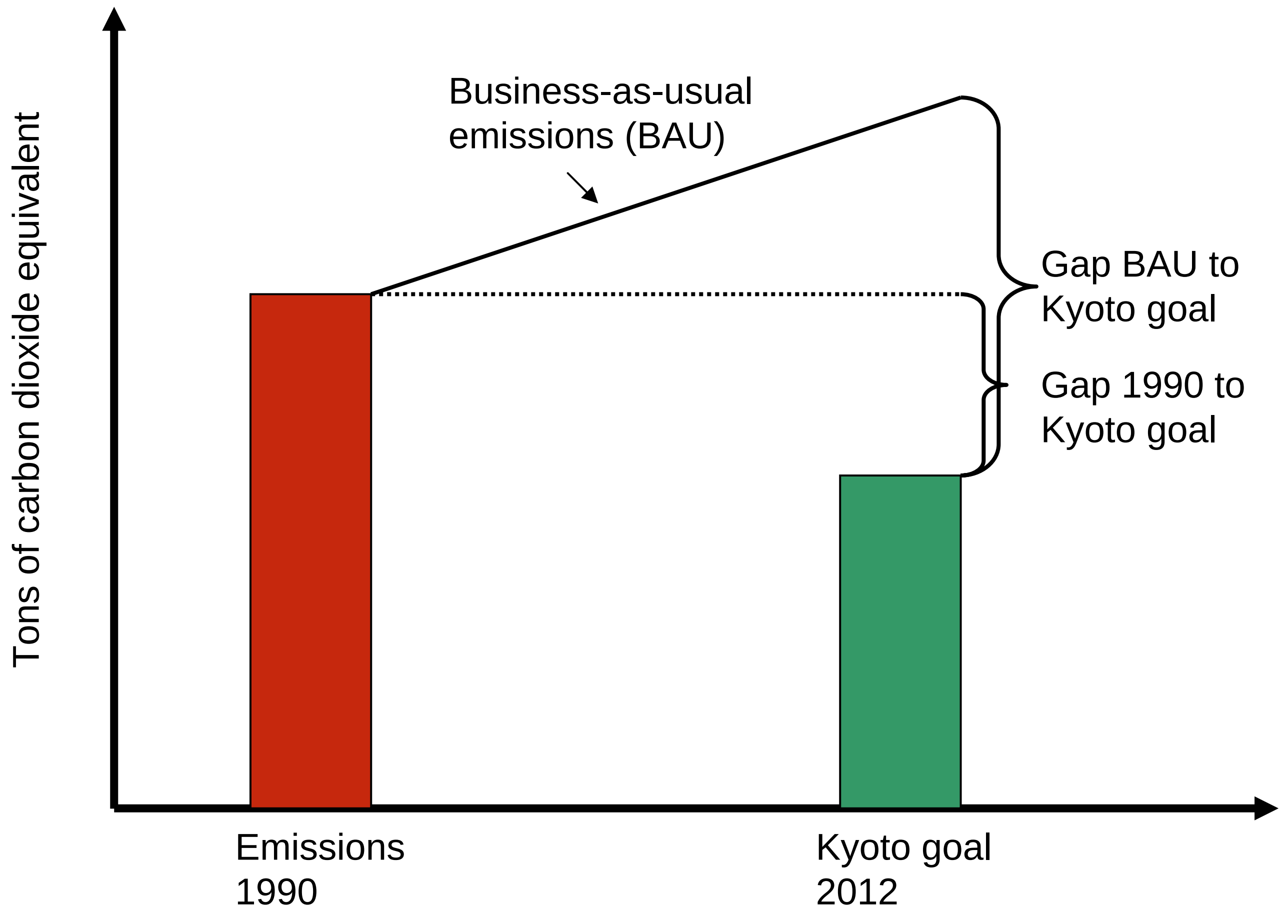


Fig.23: Member State group 1 (Austria, Denmark, Italy, Netherlands, Belgium, Slovenia); Kyoto goal 2012 is lower than base year (1990) emissions with sharp rise of BAU emissions. A 50% government-induced limitation on the use of flexible Kyoto project mechanisms calculated from the "Gap 1990 to goal" would not reflect the high need of this Member State group for emission reduction units from JI and CDM projects (Source: redrawn after ETSG, 2005).

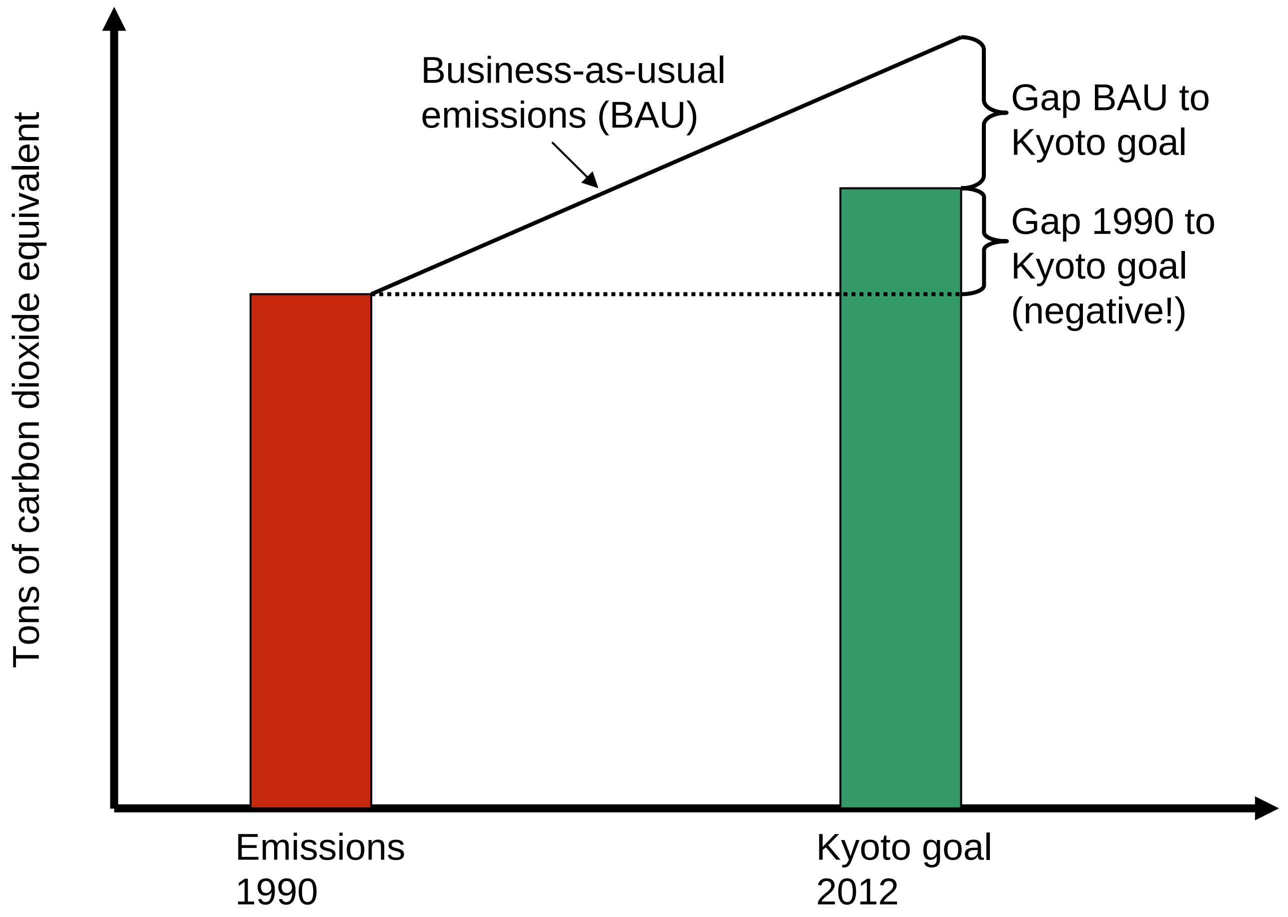


Fig.24: Member State group 2 (Portugal, Greece, Spain, Ireland, Sweden); Permissible Kyoto goal emissions 2012 are higher than base year (1990) emissions (negative compliance goal) with sharp rise of BAU emissions. A 50% government-induced limitation on the use of flexible Kyoto project mechanisms calculated from the “Gap 1990 to goal” would result in a **negative** import quota for emission reduction units from JI and CDM projects. In fact, this Member State group would be excluded from taking part in the mechanisms (Source: redrawn after ETSG, 2005).

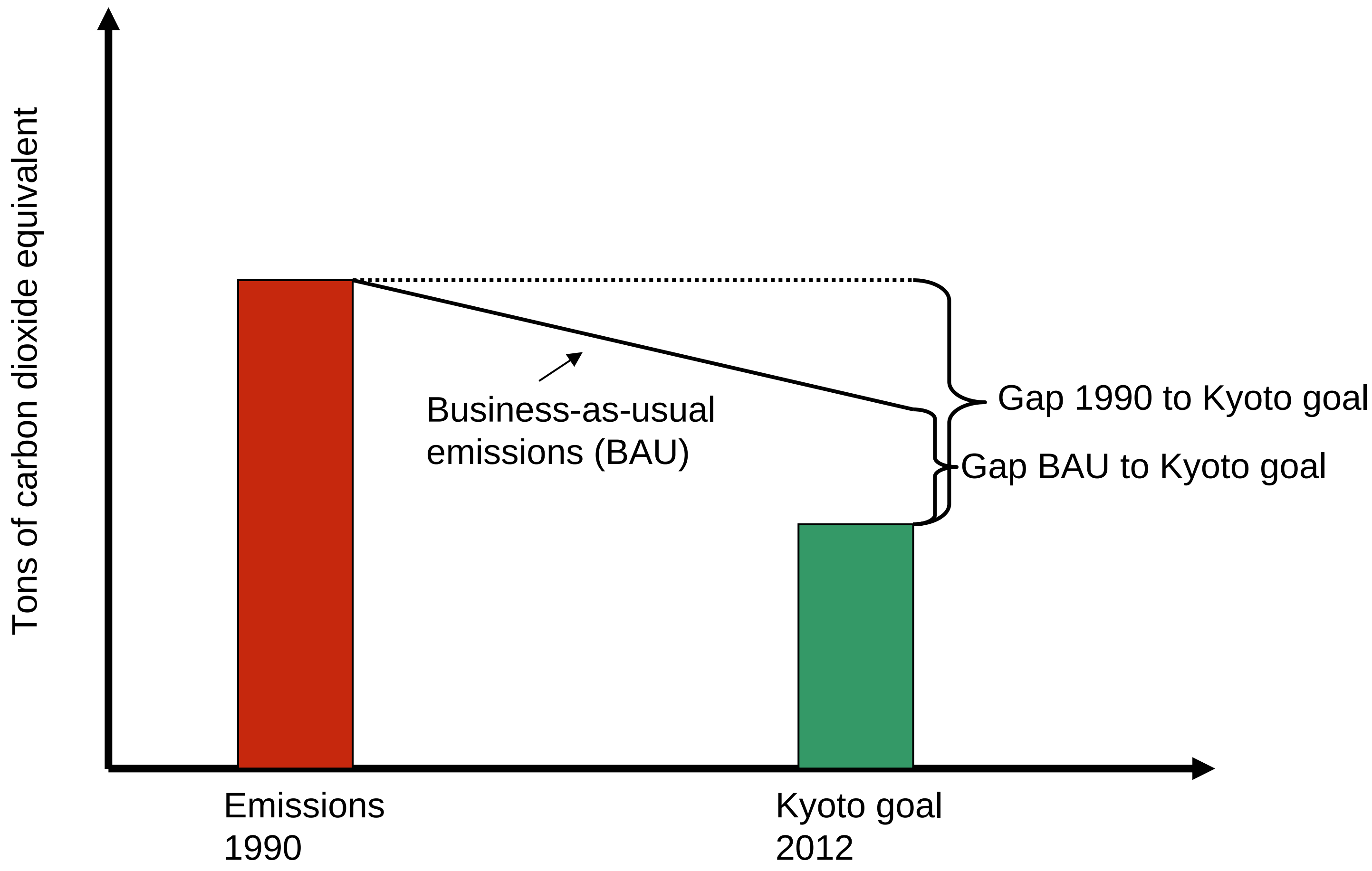


Fig.25: Member State group 3 (Germany, Luxembourg, UK, all new CEE MS except Slovenia); Kyoto goal 2012 is lower than base year (1990) emissions with decline of BAU emissions. A 50% government-induced limitation on the use of flexible Kyoto project mechanisms calculated from the "Gap 1990 to goal" would result in a permissible import quota for emission reduction units from JI and CDM projects that far exceeds the total necessary reduction effort of these Member States; they would grossly benefit to the detriment of other Member State groups (Source: redrawn after ETSG, 2005).

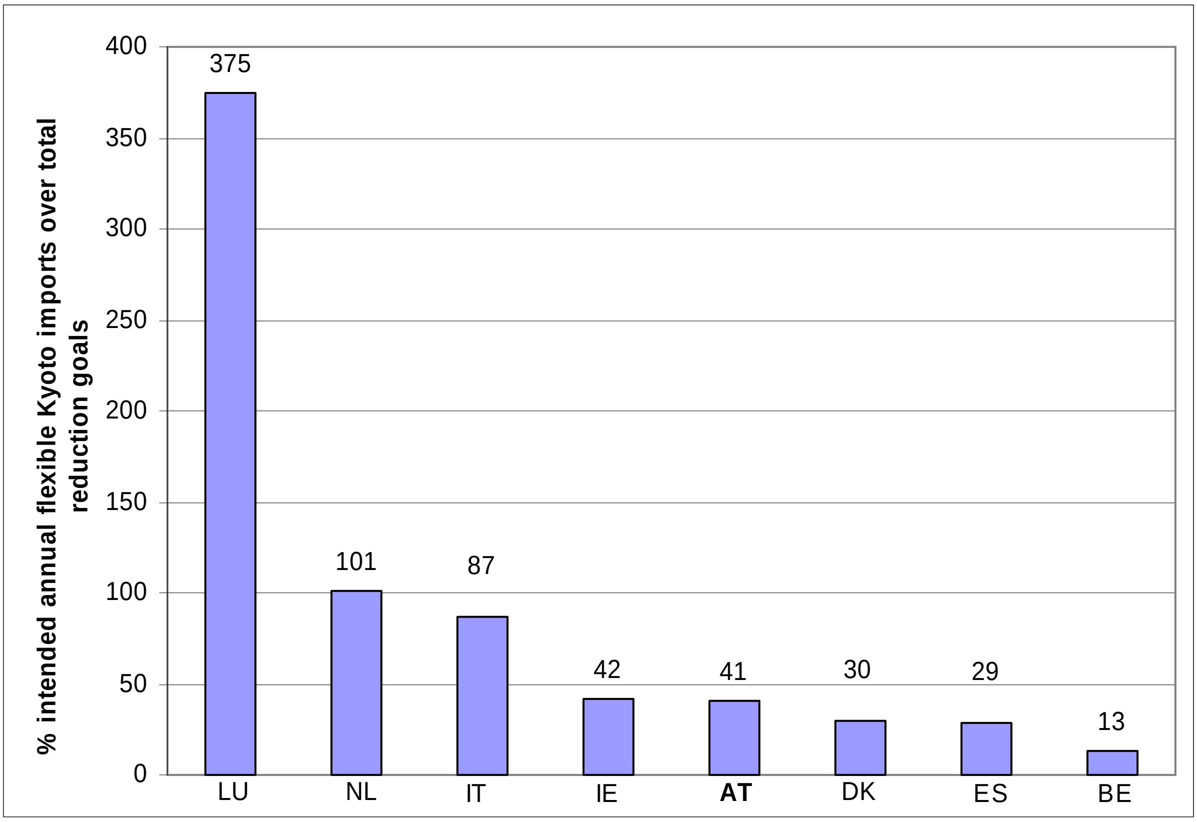


Fig.26: Flexible Kyoto import disparity in the EU on the basis of data announced by eight Member States in 2004. Although IE, IT and NL feature much lower Kyoto reduction goals than Austria (cf. Fig.9), they intend to use higher shares of cost-efficient flexible fulfilment over respective total reduction goals. LU, NL and IT would be in breach of the "50/50 doctrine" if flexible fulfilment beyond 50% of total reduction goals were forbidden. In order to avoid market distortion among Member States and take better advantage of flexible Kyoto cost savings, Austria should follow suit and increase her flexible percentage beyond the 41% announced in 2004 (Source: data from Tab.12, columns 6-7).

Project type under Federal Environment Subsidy Regime (FESR)	Present value subsidy 1999-2004 (Mio. €)	Average subsidy rate (%)	Yield accrued '99-'04 creditable over 5 Kyoto years (ktons CO_2e)	Average investment allowance (€ per ton CO_2e)	Emission reduction potential over six years '99-'04 (ktons CO_2e)	Yield accrued '99-'04 in % of 6-yr potential
Solar power (heat)	9.4	29.2%	67.9	**138.4**	300	**22.6%**
Geothermal power (heat)	2.5	21.5%	74.8	**33.4**	600	**12.5%**
Photovoltaics (power)	0.3	31.6%	0.6	**500.0**	n.q.	**n.q.**
Wind power (power)	10.2	19.1%	1,201.7	**8.5**	2,400	**50.1%**
Biogas (heat/power)	6.8	29.0%	98.4	**69.1**	1,800	**5.5%**
Landfill gas (heat/power)	0.6	22.3%	84.6	**7.1**	n.q.	**n.q.**
Small hydro power 10MW	20.7	25.0%	230.5	**89.8**	1,500	**15.4%**
Biomass district heating	37.3	18.0%	1,319.4	**28.3**	3,000	**44.0%**
Biomass heating private enterprises	42.6	20.5%	1,589.3	**26.8**	1,200	**132.4%**
Biomass CHP(heat/power)	30.9	21.8%	1,740.3	**17.8**	600	**290.1%**
"Other climate-relevant projects" (N_2O, SF_6)	18.3	24.0%	5,729.3	**3.2**	n.q.	**n.q.**
Natural gas CHP (heat/power)	2.1	26.5%	52.9	**39.7**	1,200	**4.4%**
Establishment of district heating networks	2.7	25.5%	84.0	**32.1**	3,600	**2.4%**
Thermal insulation	9.8	24.9%	62.7	**156.3**	3,000	**2.1%**
Energy saving measures private enterprises	11.2	22.3%	450.0	**24.9**	6,000	**7.5%**
Air purification measures (kyoto-relevant in part)	23.1	17.8%	686.8	**33.6**	n.q.	**n.q.**
Thermal waste processing (heat/power)	1.9	30.0%	959.9	**2.0**	6,600	**14.5%**
Processing harmful waste	15.8	28.5%	174.2	**90.7**	n.q.	**n.q.**
Decreasing commercial transport emissions	1.2	19.0%	52.9	**22.7**	600	**8.8%**
Refrigerant shift (replace HFKW, FKW, SF_6)	0.1	29.8%	3.3	**30.3**	n.q.	**n.q.**
TOTAL	**247.5**		**14,663.5**			
WEIGHTED AVERAGE				**16.9**		

Tab.1: Yield, cost and realized potential of Austrian Federal Environment Subsidy Regime (FESR) 1999 to 2004. Discussion of table see text (Source: data from BMLFUW, 2005a; calculations and compilation – Author).

Selected sectors (OeNACE 1995 classification #)	Renewable energy sector	Turnover in € per full-time job (2004)	Full-time jobs per million € turnover (2004)
Apparel industry (#18)		2,094	477.5
Building sector (#45)		4,293	232.9
Textile industry (#17)		7,531	132.8
Glass/ceramics, rock/stone (#26)		9,746	102.6
Ferrous products (#28)		9,840	101.6
Rubber & plastics products (#25)		10,723	93.3
Wood processing industry (#20)		11,108	90.0
Food & beverages industry (#15)		13,101	76.3
Chemical industry (#24)		14,895	67.1
Mechanical engineering industry (#29)		20,233	49.4
Oil & gas extraction industry (#11)		21,739	46.0
Paper industry (#21)		22,354	44.7
Water supply services (#41)		35,770	28.0
Power supply services (#40)		47,843	20.9
	Liquid biomass	99,715	10.0
	Gaseous biomass	99,877	10.0
	Wind power	100,581	9.9
	Solid biomass	102,059	9.8
	Solar power	102,564	9.8
	Heat pumps	119,287	8.4
	Small hydropower	124,549	8.0
	Geothermal power	132,420	7.6
	Photovoltaics	149,506	6.7

Tab.2: Turnover and labour intensity in various industry and service sectors in 2004: turnover per full-time job is significantly higher and full-time jobs per turnover significantly lower in all renewable energy sectors as compared to any industry and service sector under the OeNACE 1995 classification system. In renewables, labour intensity obviously reaches the bottom end of the scale. Hence, the prevailing high ratios of value added to turnover in renewables (cf. Fig.13) cannot be explained via an alleged employment engine effect (Source: data on OeNACE sectors - Statistik Austria, 2004a; data on renewables derived from Figs.13-14; this compilation - Author).

EU-MS / region	Roof	Exterior wall	Basement floor	Window
Sweden	0.15	0.15	0.15	1.25
Denmark	0.15	0.25	0.15	1.25
England & Wales	0.21	0.35	0.25	2.1
Netherlands	0.3	0.25	0.25	2
Poland	0.4	0.6	no requirements	3
Austria:				
Vienna Fed. Prov.	0.25	0.5	0.45	1.9
Upper Austria	0.25	0.5	0.45	1.9
Styria	0.2	0.45	0.4	1.9
Vorarlberg	0.25	0.35	0.4	1.8
Carinthia	0.25	0.4	0.4	1.8
Lower Austria	0.22	0.4	0.4	1.8
Tyrol	0.2	0.35	0.4	1.7
Salzburg	0.2	0.35	0.4	1.7
Burgenland	0.2	0.38	0.35	1.7
Figures denote upper U-value limits in Watt per square meter per degree Kelvin temperature difference				

Tab.3: Upper U-value limits according to building codes of selected EU member states and regions. Vienna federal province is lagging behind with requirements as compared to those of most other MS, regions and even other federal provinces of Austria (Source: data on Austrian Federal Provinces - Bauordnung fuer Wien, Niederoesterreichische Bauordnung, etc.; data on Poland - Dziennik Ustaw, 1997-1999; remainder – EST, 2002).

		4 Mtons of CO_2e per year through thermal insulation		4 Mtons of CO_2e per year through shift to biomass district heating	
Federal province	**Annual 2005/08 special-purpose allocation (SPA) in €**	**SUBSIDY: 35.12% of SPA/year at 156.3 € per ton CO_2e (in €)**	**FULL COST: 141% of SPA/year at 627.7 € per ton CO_2e (in €)**	**SUBSIDY: 6.36% of SPA/year at 28.3 € per ton CO_2e (in €)**	**FULL COST: 35.34% of SPA/year at 157.3 € per ton CO_2e (in €)**
Vienna	464,253,000	163,045,654	654,596,730	29,526,491	164,067,010
Lower A.	299,788,000	105,285,546	422,701,080	19,066,517	105,945,079
Upper A.	285,651,000	100,320,631	402,767,910	18,167,404	100,949,063
Styria	238,160,000	83,641,792	335,805,600	15,146,976	84,165,744
Tyrol	138,943,000	48,796,782	195,909,630	8,836,775	49,102,456
Carinthia	114,470,000	40,201,864	161,402,700	7,280,292	40,453,698
Salzburg	112,593,000	39,542,662	158,756,130	7,160,915	39,790,366
Vorarlberg	75,436,000	26,493,123	106,364,760	4,797,730	26,659,082
Burgenland	51,206,000	17,983,547	72,200,460	3,256,702	18,096,200
Total	**1,780,500,000**	**625,311,601**	**2,510,505,000**	**113,239,802**	**629,228,698**

Tab.4: Austrian federal provinces could cover full subsidy cost needed for triggering annual 4 million tons CO_2e abatement of heating emissions by investing part of existing 2005-2008 annual special-purpose allocations (SPA): 35.12% of SPA/year if implementation by "thermal insulation only" or 6.36% if by "fuel switch to biomass district heating only". In reality, both measures would have to be combined, taking note of higher potential in thermal insulation. Data on Euro per ton CO_2e taken from federal subsidy scheme (FESR), as respective data on federal provinces is not known to Treasury. Full-cost funding would exceed available SPA by 41% in the "thermal insulation only" scenario (Source: data on SPAs per federal province – Aenderung des Zweckzuschussgesetzes 2001; calculations and compilation – Author).

Year	Petrol consumption (tons)	Petrol price (€ per litre)	Diesel consumption (tons)	Diesel price (€ per litre)	"Composite gasoline" consumption (tons)	"Composite gasoline" price (€ per litre)
1999	2,047,400	0.792	3,892,000	0.626	2,969,700	0.709
2000	1,980,400	0.927	4,262,100	0.776	3,121,250	0.852
2001	1,998,200	0.895	4,674,800	0.755	3,336,500	0.825
2002	2,141,700	0.840	5,175,400	0.718	3,658,550	0.779
2003	2,222,500	0.864	5,741,600	0.729	3,982,050	0.797
2004	2,133,000	0.930	5,936,000	0.801	4,034,500	0.866
2005	2,008,297	1.021	6,025,261	0.936	4,016,779	0.979

	Petrol		Diesel		"Composite gasoline"	
Change from year (n) to year (n+1)	PEoD (ε) values	ε > 1 or ε < 1	PEoD (ε) values	ε > 1 or ε < 1	PEoD (ε) values	ε > 1 or ε < 1
1999 to 2000	0.1918	< 1	0.3969	< 1	0.2537	< 1
2000 to 2001	0.2609	< 1	3.5720	> 1	2.2186	> 1
2001 to 2002	1.1675	> 1	2.1857	> 1	1.7294	> 1
2002 to 2003	0.0091	< 1	7.1503	> 1	3.9290	> 1
2003 to 2004	0.5275	< 1	0.3431	< 1	0.1524	< 1
2004 to 2005	0.5982	< 1	0.0890	< 1	0.0337	< 1

Tab.5: Attempting to unravel the relationship bonding petroleum product consumption to retail price: upper half of table shows consumption and price data for petrol, diesel and fictitious reference product "composite gasoline" in Austria from 1999 to 2005 (details on price data see text); lower half gives figures on price elasticity of demand (PEoD) for same products and period. Results: PEoD for petrol seems to hint at inelastic demand; PEoDs for diesel and "composite gasoline" are inconclusive, giving as many data points for elastic as for inelastic demand. Although sample is too small for asserting statistical significance, the two-dimensional approach only reflecting consumption and price may hint at absence of elastic PEoD (Source: data on product tonnage sales – FVMI, 2006; price data – OeAMTC, 2006; calculations – Author; this compilation – Author).

		Specific carbon dioxide emissions when burned	
Energy source	Specific calorific value at 298°K (MJ/kg)	(gCO_2/MJ)	(gCO_2/kg)
Hydrogen	120	0	0
Hard coal	30	93	2,762
Brown coal briquettes	20	98	1,911
Engine diesel	43	74	2,639
Light fuel oil	41	74	2,623
Heavy fuel oil	43	78	3,119
Engine petrol	43	72	2,333
Methane*	** 50	** 56	** 1,777
Ethane	48	n.a.	n.a.
Propane, butane (LPG)	46	58	2,337
Biodiesel RME***	37	defined as 0	defined as 0
Biodiesel FAME****	36	defined as 0	defined as 0
Bioethanol E100	27	defined as 0	defined as 0
Olive kernels	20	defined as 0	defined as 0
Wood pellets	18	defined as 0	defined as 0
Straw	17	defined as 0	defined as 0
Peat, paper, dry wood	15	defined as 0	defined as 0
Fresh wood	7	defined as 0	defined as 0
Car tyres	32	quite high and frowned upon in most communities	

* … Natural gas from CIS countries contains 98% methane, 1% ethane, propane a.o, 1% inertial gases; North Sea natural gas contains 89% methane, 8% ethane, propane a.o., 3% inertial gases; "town gas" contains 19-21% methane, 51% hydrogen, 9-18% carbon monoxide, 10-15% inertial gases.

** … for natural gas from CIS countries.

*** … The mono alkyl ester of long-chain fatty acids (typically C18) derived from renewable lipid sources such as rape seed with methanol (RME: rape seed methyl ester).

**** … The mono alkyl ester of long-chain fatty acids (C12-C22) derived from naturally occurring vegetable oil, tallow, animal fats and recycled greases (FAME: fatty acid methyl esters).

Tab.6: Specific calorific values (megajoule per kg at 298°K or 25°C) and carbon dioxide emissions (grams carbon dioxide per megajoule and per kg) of fossil and renewable energy sources (Source: data from Deutsches Umweltbundesamt, 2006; Agrarplus, 2006; IEA, 2006; conversions from toe/ton – Author; this compilation – Author).

Year	Forecast consumption diesel in million litres	Corresponding volume of biodiesel in million litres	Forecast consumption petrol in million litres	Corresponding volume of bioethanol E100 in million litres
2006	7,376	7,951	2,465	3,594
2007	7,724	8,326	2,409	3,512
2008	8,071	8,701	2,354	3,432
2009	8,418	9,075	2,299	3,352
2010	8,765	9,449	2,243	3,270
	Conversion factors diesel	Conversion factors biodiesel	Conversion factors petrol	Conversion factors bioethanol
	11.78 kWh/kg	10.25 kWh/kg	11.59 kWh/kg	7.41 kWh/kg
	0.832 kg/l	0.883 kg/l	0.742 kg/l	0.794 kg/l
	9.8 kWh/l	9.05 kWh/l	8.6 kWh/l	5.9 kWh/l
	CCF*: 1 litre diesel = 1.078 litres biodiesel		CCF: 1 litre petrol = 1.458 litres bioethanol	
	CCF: 1 litre biodiesel = 0.928 litres diesel		CCF: 1 litre bioethanol = 0.686 litres petrol	

* … CCF = calorific conversion factor

Tab.7: Consumption forecast for diesel and petrol in Austria 2006-2010 in GWh (UBA, 2003; quoted in Tribl, 2005) has been converted to forecast in litres. Based on lower calorific values of biofuels (see conversion factors), corresponding volumes of biodiesel and bioethanol E100 were calculated. Original forecast in GWh assumes that current stagnation in petrol consumption will aggravate into sales declines and current rise in diesel consumption will continue (Source: calculations and compilation – Author).

2005	Degree of self-sufficiency in %	Hectares under cultivation	Production of crops in tons	Yield in kilogram crops per hectare
Rape seed	50	35,022	103,839	2,965
Sugar beet	135	44,690	3,083,792	69,004
Soft winter wheat	152	262,960	1,374,222	5,226
Maize	86	167,226	2,020,955	12,085
Conjectures on basis of figures for 2005	Surplus production of crops in tons per year	Surplus production in litres biofuel per year	Corresponding volume of fossil fuel in litres per year	Carbon dioxide abatement effect in tons CO_2 per year
Rape seed	0	0	0	0
Sugar beet	799,502	100,692,947	69,075,362	119,569
Soft winter wheat	470,129	177,630,605	121,854,595	210,930
Maize	0	0	0	0
TOTAL		**278,323,552**	**190,929,957**	**330,499**
	Conversion factors rape seed	Conversion factors sugar beet	Conversion factors soft winter wheat	Conversion factors maize
	396 kg biodiesel per 1 ton crop	100 kg ethanol per 1 ton crop	300 kg ethanol per 1 ton crop	370 kg ethanol per 1 ton crop
	0.883 kg/l	0.794 kg/l	0.794 kg/l	0.794 kg/l

Tab.8: Surplus production of sugar beet and soft winter wheat in Austria in 2005 could have been processed into 278 million litres of bioethanol, equaling 191 million litres of fossil petrol and a kyoto-relevant abatement of 0.33 million tons of carbon dioxide equivalent. Lack of self-sufficiency in rape seed prevents domestic production of biodiesel out of surpluses. 278 million litres biofuel represent 7.92% of the projected theoretical consumption of bioethanol E100 in 2007 of 3.512 billion litres (cf. Tab.7). As little as 7.92% may seem, the legally prescribed mandatory biofuel contents of petrol (5.75% by 10/2008) is covered by domestic surpluses of the two crops (Source: data on crops – BMLFUW, 2006; calculations and compilation – Author).

	Minimum beet price in Euro per ton	Product cost in Eurocent per litre beet-produced bioethanol	Product cost per energy unit in Eurocent/kWh
Sugar beet before sugar market reform	43.63	35	5.95
Sugar beet 2006/2007	32.86	26	4.42
Sugar beet 2007/2008	29.78	24	4.08
Sugar beet 2008/2009	27.83	22	3.74
Sugar beet 2009/2010	26.29	21	3.57
Fossil petrol @ 1 Euro retail price			3.1
Fossil petrol @ 1.1 Euro retail price			3.5
Fossil petrol @ 1.2 Euro retail price			3.8
Fossil petrol @ 1.3 Euro retail price			4.1
Fossil petrol @ 1.4 Euro retail price			4.4

Tab.9: In the wake of the EU sugar market reform, minimum sugar beet prices will start tumbling as of the market year 2006/2007. As a result, sugar beet per energy unit will sell cheaper on the sugar market than beet-produced bioethanol per energy unit on the biofuel market assuming that rising product cost of fossil petrol will also push up bioethanol product cost (comparisons in Eurocent per kWh). If buyer (petrol wholesaler) can avoid increasing fossil product cost and seller (beet farmer) can avoid income loss from sugar market reform, the bioethanol market is likely to heat up soon. This will occur as soon as fossil petrol product cost has risen sufficiently high (for example in 2008 to around 4 Eurocent per kWh or 1.25 Eurocent retail price per litre fossil petrol, cf. Fig.22). For fossil petrol, 27% of retail price was assumed as product cost (cf. chapter 9). Shown product costs exclude taxes, ancillary costs and subsidies; conversion factors: see Tab.7. For a graphic display of table data see Fig.22 (Source: cell B2 – BMLFUW, 2006; cells B3-B6 – Council Regulation (EC) No 318/2006; conversions in remaining cells – Author).

Source of crop	Tons of crop per year	Corresponding volume of bioethanol in litres per year	Corresponding volume of fossil petrol in litres per year	Carbon dioxide abatement effect in tons CO_2 per year
Surplus sugar beet and soft winter wheat (see Tab.8)	799,502 beet + 470,129 wheat	278,323,552	190,929,957	330,499
Sugar beet on all 950 km^2 of set-aside land	6,555,380	825,614,610	566,371,622	980,389
TOTAL	**7,354,882 beet + 470,129 wheat**	**1,103,938,162**	**757,301,579**	**1,310,888**
Yield per 1% of beet currently used for sugar	22,843	2,876,940	1,973,581	3,416

Tab.10: Maximum potential for bioethanol production in Austria. If all surplus sugar beet and soft winter wheat are used and the entire acreage of set-aside land is cultivated with sugar beet, the theoretical domestic annual bioethanol volume could attain 1.1 billion litres which would equal 757 million litres of fossil petrol; 1.3 million tons of carbon dioxide equivalent per year could be abated or avoided. The achievable volume of bioethanol represents 31.4% of the projected domestic need in 2007 (Source: data on surplus - Tab.8; acreage of set-aside land in 2005 – BMLFUW, 2006; remainder – Author).

Crop	Need of fertilizer in kg for achieving 100 kg crop yield		
	P_2O_5 (P_4O_{10}) (Di-)phosphorus pentoxide	K_2O Potassium oxide	MgO Magnesium oxide
Sunflower (*Helianthus annuus*)	2.5	10.0	1.8
Summer or winter rape seed (*Brassica napus*)	2.6	6.0	1.0
Soy bean (*Glycine max*)	2.9	5.7	1.7
Peas (*Pisum sativum*)	1.4	4.0	0.5
Oat (*Avena sativa*)	1.1	3.6	0.4
Red clover (*Trifolium pratense*)	0.7	3.0	0.5
Lucerne (*Medicago sativa*)	0.7	3.0	0.4
Maize (*Zea mays*)	1.1	2.5	0.4
Rye (*Secale cereale*)	1.1	2.6	0.4
Barley (*Hordeum sp.*)	1.1	2.3	0.4
Triticale (*x Triticosecale*)	1.1	2.3	0.4
Soft winter wheat (*Triticum aestivum*)	1.1	2.0	0.4
Potatoes (*Solanum tuberosum*)	0.2	0.8	0.2
Sugar beet (*Beta vulgaris*)	0.2	0.8	0.2
Fodder beet (*Beta vulgaris*)	0.1	0.6	0.1

Tab.11: Fertilizer need of various field crops in Central Europe. In general, oil plants show a higher need for mineral fertilizers than cereals and cereals a higher need than potatoes and beets. A 100 kg harvest of rape seed requires a 13-fold input of (di-)phosphorus pentoxide, 7.5-fold input of potassium oxide and 5-fold input of magnesium oxide as compared with the respective amounts of mineral fertilizes required for a 100 kg harvest of sugar beet. Large-scale rape seed cultivation is hence a major source of soil acidification and of kyoto-relevant nitrous oxide emissions (cf. Chapter 7). The high amounts of energy needed for producing fertilizers render the energy balance (energy output over energy input) of fuels extracted from oil plants unfavourable; see text (Source: Lachemie, 2006; this compilation – Author).

	Greenhouse gas emissions in 1990 (base year) in Mt CO_2e	Kyoto reduction goal 2008-2012		Emissions forecast for 2010 in Mt CO_2e p.a.	Compliance gap in Mt CO_2e p.a. (emissions forecast minus Kyoto reduction goal)	Intended coverage of compliance gap via flexible Kyoto mechanisms in Mt CO_2e p.a.
		in %	in Mt CO_2e			
LU	12.7	-28.0	9.1	9.9	0.8	3.0
NL	212.0	-6.0	199.3	219.0	19.7	20.0
IT	521.0	-6.5	487.1	540.1	53.0	32.5 – 60.0 (Ø 46.2)
IE	53.4	+13.0	60.3	69.1	8.8	3.7
AT	**77.6**	**-13.0**	**67.5**	**84.4**	**16.9**	**7.0**
DK	69.0	-21.0	54.5	79.8	25.3	7.7
ES	207.0	+15.0	238.1	307.0	68.9	20.0
BE	141.0	-7.5	130.4	150.1	19.7	2.5
Note: all data as believed accurate by Member States in 2004. Data presented in table may not comply with newer data presented elsewhere in this paper.						

Tab.12: Intended role of flexible Kyoto tonnage imports over total reduction goals for period 2008-2012 as forecast by eight EU Member States in 2004. Four MS announced higher shares of flexible Kyoto imports than Austria, although three of these (Ireland, Italy and Netherlands) feature much lower Kyoto goals. For a graphic display of flexible Kyoto import disparity in the EU, see Fig.26 (Source: conception of table – ETSG, 2005).

Imprint:
Published, owned and edited by Federal Ministry of Finance
HR Development and Internal Communications
Himmelpfortgasse 8, A-1015 Vienna
Designed and printed by “Printing Office of the Federal Ministry of Finance”
Vienna, March 2007
www.bmf.gv.at