

# Portugal Fact Sheet

## GENERAL INFORMATION<sup>1</sup>

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### Geography

Location: Southwestern Europe, bordering the North Atlantic Ocean, west of Spain

Capital *name*: Lisbon, *geographic coordinates*: 38 43 N, 9 08 W

Area: *total*: 92,391 sq km (slightly smaller than Indiana)

Climate: maritime temperate; cool and rainy in north, warmer and drier in south

Terrain: mountainous north of the Tagus River, rolling plains in south

Natural resources: fish, forests (cork), iron ore, copper, zinc, tin, tungsten, silver, gold, uranium, marble, clay, gypsum, salt, arable land, hydropower

Land use: *arable land*: 17.29%, *permanent crops*: 7.84%, *other*: 74.87% (2005)

Irrigated land: 6,500 sq km (2003)

### Demography

Population: 10,605,870 (July 2006 est.) (77<sup>th</sup> in world)

Age structure: *0-14 years*: 16.5% (male 915,604/female 839,004)  
*15-64 years*: 66.3% (male 3,484,545/female 3,544,674)  
*65 years and over*: 17.2% (male 751,899/female 1,070,144) (2006)

Median age: *total*: 38.5 years  
*male*: 36.4 years  
*female*: 40.6 years (2006 est.)

Population growth rate: 0.36% (2006 est.)

Birth rate: 10.72 births/1,000 population (2006 est.) (188<sup>th</sup> in world)

Death rate: 10.5 deaths/1,000 population (2006 est.) (59<sup>th</sup> in world)

Life expectancy at birth: *total population*: 77.7 years (52<sup>nd</sup> in world)

Literacy: *definition*: age 15 and over can read and write  
*total population*: 93.3%, *male*: 95.5%, *female*: 91.3% (2003 est.)

### Transportation

Airports: 66 (2006) (only 43 w/ paved runways !!)

Pipelines: gas 1,099 km; oil 8 km; refined products 174 km (2004)

Railways: *total*: 2,850 km

Roadways: *total*: 72,600 km  
*paved*: 62,436 km (including 1,700 km of expressways)  
*unpaved*: 10,164 km (2002)

Vehicle Ownership: 575 passenger cars per 1,000 inhabitants (2004) 5<sup>th</sup> in EU

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<sup>1</sup> Source: CIA World Factbook <https://www.cia.gov/cia/publications/factbook/geos/po.html> and EIA Country Analysis Briefs <http://www.eia.doe.gov/emeu/cabs/portugal.html>

## ECONOMY OVERVIEW

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Portugal is a relatively poor country; in 2003, Portugal had the lowest nominal per-capita GDP of all EU member states. As member of the EU, Portugal has received funds to invest in its infrastructure and help its economy. Between 1986 — 2000 the country had an average real economic growth rate of 3.7% per year. In 2001 Portugal's budget deficit was 4.3% of GDP, breaching the EU ceiling of 3%. After being reprimanded by the European Commission (EC), the Portuguese government introduced an austerity program to reduce the deficit, which stifled economic growth. The budget deficit ceiling is an important constrain to the government's ability to enhance Portugal's economic competitiveness. Low cost producers in Central Europe and Asia have been preferred over Portugal for foreign direct investment. Further, unemployment rate is close to historically high levels, and job-creation has become more challenging with the government's tight budget. In the past two decades Portugal has become an increasingly service-based economy. Many state controlled firms have been privatized and key areas of the economy, such as telecommunications and financial sectors, have been liberalized<sup>2</sup>. The privatization of Galp Energia (public utility) and TAP (airline) was recently announced<sup>3</sup>.

GDP (PPP): \$204.4 billion (2005 est.) (43<sup>rd</sup> in world)  
real growth rate: 0.3% (2005 est) (202<sup>nd</sup> in world)  
per capita: \$19,300

GDP - by sector: *agriculture: 5.3%, industry: 27.4%, services: 67.3%* (2005 est.)

Labor force: 5.52 million (2005 est.), *agriculture: 10%, industry: 30%, services: 60%* (1999)

Unemployment: 7.6% (2005 est.) (71<sup>st</sup> in world, w/ #1 at 0%)

Inflation rate 2.3% (2005 est.) (consumer prices)

Budget: *revenues: \$78.84 billion, expenditures: \$90.27 billion*

Public debt: 63.9% of GDP (2005 est.)

Agriculture - products: grain, potatoes, tomatoes, olives, grapes; sheep, cattle, goats, swine, poultry, dairy products; fish

Industries: textiles and footwear; wood pulp, paper, and cork; metals and metalworking; oil refining; chemicals; fish canning; rubber and plastic products; ceramics; electronics and communications equipment; rail transportation equipment; aerospace equipment; ship construction and refurbishment; wine; tourism

Industrial production growth rate: 0% (2005 est.) (148<sup>th</sup> in world)

Exports: \$38.8 billion f.o.b. (2005 est.)

Exports - commodities: clothing and footwear, machinery, chemicals, cork and paper products,

Exports - partners: Spain 26%, France 13.1%, Germany 12%, UK 8%, US 5.4%, Italy 4.3% (2005)

Imports: \$60.35 billion f.o.b. (2005 est.)

Imports - commodities: machinery and transport equipment, chemicals, petroleum, textiles, agricultural products

Imports - partners: Spain 29%, Germany 13.5%, France 8.5%, Italy 5.2%, Netherlands 4.3%, UK

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<sup>2</sup> Source: CIA World Factbook <https://www.cia.gov/cia/publications/factbook/geos/po.html> and EIA Country Analysis Briefs <http://www.eia.doe.gov/emeu/cabs/portugal.html>

<sup>3</sup> Portugal Country Report, 2006. Economist Intelligence Unit – The Economist, London, UK

## ENERGY OVERVIEW<sup>4</sup>

Minister of the Economy Carlos Manuel Tavares da Silva

Electricity – production/consumption: 44.32 billion kWh produced / 44.01 billion kWh consumed (2003 est)

Electricity – exports/imports: 3.1 billion kWh exported / 5.9 billion kWh imported (2003 est)

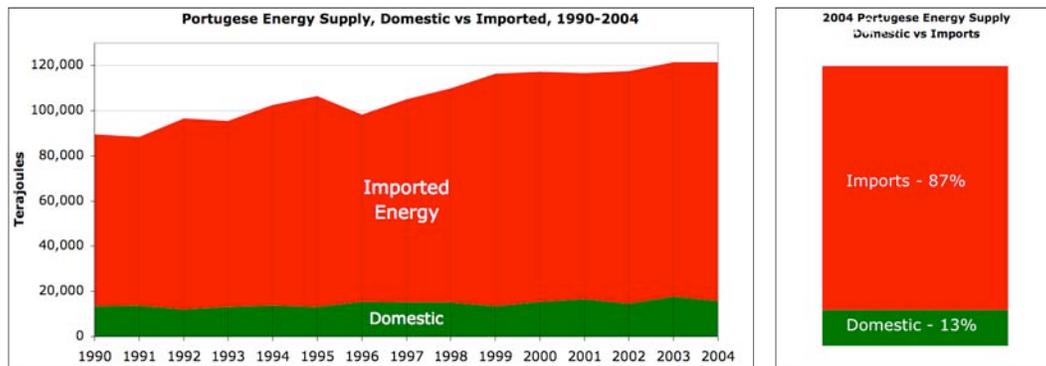
Electric Generation Capacity: 10.4 GW (thermal 60%; hydro 38%; biomass, solar, wind 2%) (2002 est)

Oil 326,500 bbl/day consumed in 2003; No production or reserves;

Crude Oil Refining Capacity: 304,172 bbl/day (2004 est)

Natural gas: 2.983 billion cubic meters consumed in 2003; No production or reserves

Coal Consumption: 6.3 Mmst (all imported, 2004 est); 40 million short tons of reserves (2001 est)

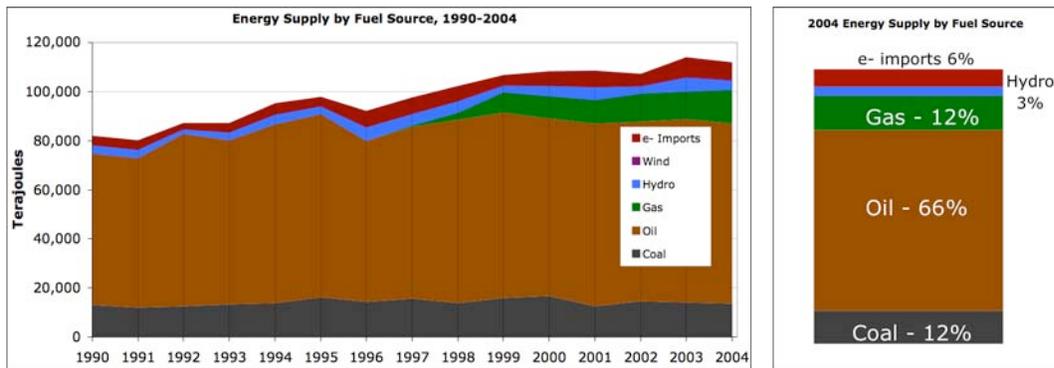


Source: Portuguese Directorate General for Geology & Energy <http://www.dge.pt/main.asp?IdTemas=11>

Portugal has extremely limited domestic energy reserves. It imports about 90% of its energy requirements, much of which is oil (66% in 2002). The largest domestic energy resource is hydropower, which is unreliable because its contribution depends on rainfall. For example, in 2002 domestic hydropower accounted for 7% of Portugal's total primary energy consumption, dropping from 13% in 2001. Energy imports, mainly natural gas from Algeria, are transported through Spain via pipelines while oil arrives at the country's Sines and Porto terminals. Natural gas was introduced in Portugal's energy mix in 1996. In 1998, Portugal began importing liquefied natural gas (LNG) from Nigeria, which is regasified at Spain's Huelva LNG terminal. The Portuguese government has been promoting the development of renewable energy resources, such as wind, mini-hydro (under 10 megawatts-MW), wave and biomass. In April 2004, the Portugal and Spain formally inaugurated Mibel, a regional market within the broader EU internal electricity market. The Portuguese government is also trying to liberalize its oil and natural gas holding company, Galp Energia, and auctioning its remaining stake in formerly state-owned utility Electricidade de Portugal (EdP)<sup>5</sup>.

<sup>4</sup> EIA Country Analysis Brief, <http://www.eia.doe.gov/emeu/cabs/portugal.html>

<sup>5</sup> EIA Country Analysis Brief, <http://www.eia.doe.gov/emeu/cabs/portugal.html>



Source: Portuguese Directorate General for Geology & Energy <http://www.dge.pt/main.asp?IdTemas=11>

**Oil:** No proven commercially viable oil reserves. Despite decades of exploration activity, Portugal has yet to discover a commercially viable oil deposit. It has two refineries, located in the coastal cities of Sines and Porto, and owned / managed by Petr6leos de Portugal (Petrogal), which have a combined capacity of 304,174 bbl/d. In April 1999, the Portuguese government created the holding company Petr6leos e G6s de Portugal, SGPS, S.A. (Galp) to operate and manage the country's oil and natural gas industries. Galp holds shares from Petrogal, G6s de Portugal (GdP, gas distribution) and Transg6s (natural gas import, transmission and sales company). In April 2003, the Portuguese government approved a plan to demerge and to privatize Galp by restructuring the holding company's assets. These measures will consolidate the company's natural gas assets under GdP, including Transg6s. Galp will continue to own Petrogal's upstream (oil production in Brazil and Angola) and downstream operations (distributing petroleum products and operating Portugal's two refineries at Sines and Porto). They will also make EdP a major electricity and natural gas player in the Iberian peninsula. EdP currently owns a 40% stake in Spain's utility company Hidrocarb6nico and a 62% stake in Naturcorp, a natural gas distributor in Spain's Basque region, and controls much of Portugal's electricity sector<sup>6</sup>.

**Natural Gas:** Portugal lacks any viable reserves. The natural gas sector has grown within the last decade, particularly over the past few years with the Sines LNG import terminal and Maghreb-Europe pipeline that connect the Iberian Peninsula to Algerian natural gas sources. GdP is the main player because it controls the import, distribution, transmission and sales of natural gas. Since natural gas is its infancy, it is under a temporary exemption from EU requirements of liberalization<sup>7</sup>.

**Coal:** Portugal has not produced coal since its last mine closed in 1994. It does import relatively small amounts of coal for electricity generation, especially in periods of decreased hydropower<sup>8</sup>.

**Electricity:** The electricity grid in Portugal is connected to Spain's, with 44,127 miles of high/medium voltage transmission lines and 69,640 miles of low voltage transmission lines. About 10% of the power demand could be imported from and vice-versa. Within Portugal there are two electricity systems—the Public and the Independent. The Public Electricity System (PES) guarantees power supply through long term contracts between power generators and transmission grid operator. In the Independent Electricity System (IES) consumers are free to choose their suppliers. Further, generation and distribution services are not restricted<sup>9</sup>.

**Renewables:** Portugal has to meet EU requirements on electricity and has to increase renewable energy's share of total energy consumption to 12% and electricity produced from renewables to 22.1% by 2010. Currently, production of electricity from renewables in Portugal is dominated by large hydropower plants.

<sup>6</sup> EIA Country Analysis Brief, <http://www.eia.doe.gov/emeu/cabs/portugal.html>

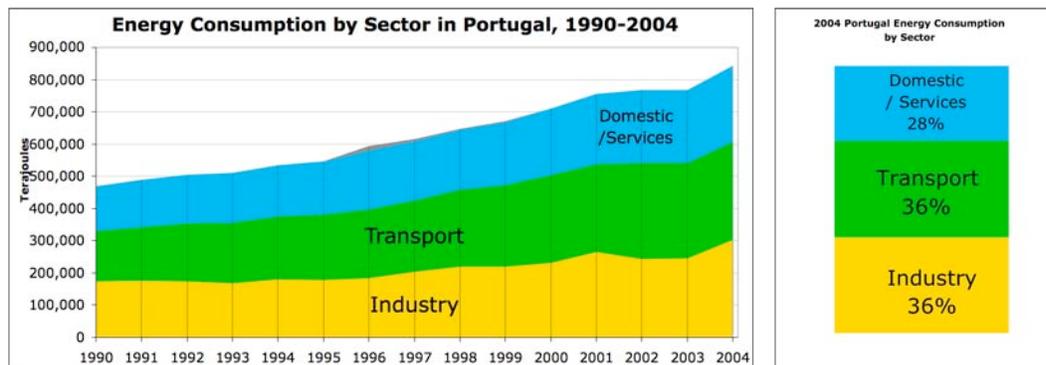
<sup>7</sup> Ibid

<sup>8</sup> Ibid

<sup>9</sup> Ibid

In 2002, hydro accounted for approximately 80% of electricity generated from renewables. The Portuguese government wants to increase renewables' share in the country's power mix, focusing its efforts away from large scale-hydro towards increasing installed generation capacity of wind (with an expected capacity of 3,750 MW by 2010) and small hydro (400 MW by 2010). To attract investment, the government has established a feed-in tariff system, which gives higher rates per kilowatt hour. As a result both domestic and foreign companies such as Iberdrola (Spain), Enersis (Chile), Gamesa (Spain), and Generg (Portugal), have invested in wind, solar and wave power projects. Portugal currently is building the world's largest solar power plant in Moura (southern Portugal), with an installed generation capacity of 64 MW. Iberdrola has under development a 75-MW wind farm and is negotiating for permits to install another 174 MW. In 2004, the company acquired an 18-MW wind farm– Catefica – from Spain's Gamesa<sup>10</sup>.

**Nuclear Power:** Portugal has no nuclear power plants.



Source: Eurostat [http://epp.eurostat.ec.europa.eu/portal/page?\\_pageid=0,1136239,0\\_45571444&\\_dad=portal&\\_schema=PORTAL](http://epp.eurostat.ec.europa.eu/portal/page?_pageid=0,1136239,0_45571444&_dad=portal&_schema=PORTAL)

## Environmental Overview<sup>11</sup>

Environment - current issues: soil erosion; air pollution caused by industrial and vehicle emissions; water pollution, especially in coastal areas

Environment/international agreements: *party to:* Air Pollution, Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Marine Dumping, Marine Life Conservation, Ozone Layer Protection, Ship Pollution, Tropical Timber 83, Tropical Timber 94, Wetlands  
*signed, but not ratified:* Air Pollution-Persistent Organic Pollutants, Air Pollution-Volatile Organic Compounds, Environmental Modification

- *Total Energy Consumption (2002E):* 1.1 quadrillion Btu\* (0.3% of world total energy consumption)
- *Energy-Related Carbon Dioxide Emissions (2002E):* 67 million metric tons (0.3% of world total carbon dioxide emissions)
- *Per Capita Energy Consumption (2002E):* 107.4 million Btu (vs. U.S. value of 339.1 million Btu)
- *Per Capita Carbon Dioxide Emissions (2002E):* 6.7 metric tons (vs. U.S. value of 20.0 metric tons)
- *Energy Intensity (2002E):* 6,467 Btu/\$ nominal-PPP\*\* (vs U.S. value of 9,344 Btu/\$ nominal-PPP)

<sup>10</sup> Ibid

<sup>11</sup> The total energy consumption statistic includes petroleum, dry natural gas, coal, net hydro, nuclear, geothermal, solar, wind, wood and waste electric power. The renewable energy consumption statistic includes hydropower, solar, wind, tide, geothermal, solid biomass and animal products, biomass gas and liquids, industrial and municipal wastes. Sectoral shares of energy consumption and carbon emissions are also based on IEA data

- *Carbon Dioxide Intensity (2002E)*: 0.39 metric tons of carbon/thousand \$ nominal-PPP \*\* (vs. U.S. value of 0.55 metric tons/thousand \$ nominal-PPP )
- *Fuel Share of Energy Consumption (2002E)*: Oil (66%), Coal (14%), Natural Gas (11%) Hydro (7%) Other renewable (2%)
- *Fuel Share of Carbon Dioxide Emissions (2002E)*: Oil (71%), Coal (20%), Natural Gas (9%)
- *Status in Climate Change Negotiations*: Annex I country under the United Nations Framework Convention on Climate Change (ratified December 21st, 1993). Signatory to the Kyoto Protocol (signed April 29th, 1998 and ratified May 31, 2002).



Source: Energy Policies of IEA Countries, Portugal 2004 Review  
<http://www.iea.org/textbase/nppdf/free/2004/portugal.pdf>

**Constrains on Portugal’s Energy System:** Portugal’s future energy and environment policy scenario must be explored in the context of its integration in the European Union (EU). Portugal’s policies are also subject to the various international agreements the EU and its Member States have agreed to participate in and support. Under the **2002 Lisbon Strategy**, the EU expressed interest in improving its competitiveness by increasing its energy-usage efficiency, to remain a “global leader” in low carbon technologies, and to improve its energy supply security by reducing their increasing dependence on imported sources of energy.<sup>12</sup> These sustainability, competitiveness, and security issues are likely to remain as EU’s principal future energy concerns.<sup>13</sup> Portugal and the EU ratified the **Kyoto Protocol** in May 2002. The EU agreed to decrease its Green House Gas (GHG) emissions by 8% against the base year of 1990 by 2008 – 2012. The EU has developed the “**Burden Sharing Agreement**,” through which it distributes different reduction targets among its members and uses an internal emissions trading system to achieve its 8% reduction goal. Under this agreement Portugal is to limit its net increase in GHG emissions to 27% above the 1990 levels.<sup>14</sup> The table shows that it is unlikely that Portugal will meet its Kyoto target without taking advantage of the EU Emission Trading Scheme.<sup>15</sup>

|                       | Kyoto Expectation   | 2005 Estimate  | Present Target                                |
|-----------------------|---|--|---|
| <b>2010 Emissions</b> | Curb net increase of GHG emissions to 27% above 1990 levels | GHG emissions will be 52% higher than 1990 levels (In 2000 emissions were already 50% higher). | Limit GHG emissions to 42% above 1990 levels. |

Portugal’s energy policies include: Liberalization of the electricity market; creation of an Iberian market through integration of Portuguese and Spanish electricity market; privatization of national energy

<sup>12</sup> Commission of the European Communities. Lisbon Action Plan Incorporating EU Lisbon Programme and Recommendations for Actions to Member States for Inclusion in their National Lisbon Programmes. Brussels, 2005

[http://ec.europa.eu/growthandjobs/pdf/SEC2005\\_192\\_en.pdf](http://ec.europa.eu/growthandjobs/pdf/SEC2005_192_en.pdf), last viewed 09/26/06

<sup>13</sup> Commission of the European Communities. Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy. Brussels, 2006 [http://ec.europa.eu/energy/green-paper-energy/doc/2006\\_03\\_08\\_gp\\_document\\_en.pdf](http://ec.europa.eu/energy/green-paper-energy/doc/2006_03_08_gp_document_en.pdf), last viewed 09/26/06

<sup>14</sup> <http://ec.europa.eu/environment/climat/kyoto.htm> last viewed 09/26/06

<sup>15</sup> <http://ec.europa.eu/environment/climat/pdf/countries/2005/portugal.pdf> last viewed 09/26/06

companies; easing the burden of increasing energy demand; addressing various environmental issues<sup>16</sup> Portugal has developed a Climate Change National Program to monitor progress towards Kyoto Protocol's emission reduction targets. Portugal has thus far used various policy tools to decrease its GHG emissions. These include: Implementation of energy efficiency regulations in the industrial and residential sectors; creation of voluntary agreements with private stakeholders; use of tax credits on renewable energy technologies in particular photovoltaic systems; improvement of the transit system.<sup>17</sup>

Through its Energy Efficiency and Endogenous Energies Program (E4 Program), Portugal has established procedures for providing financial support to improve energy efficiency, to promote co-generation and wind-power projects, and to establish energy efficient programs within the private sector.<sup>18</sup> It has not, however, taken full advantage of the Kyoto flexible mechanisms to further reduce its GHG emission levels.<sup>19</sup> Portugal's future policies will follow those of the EU, which will likely be shaped by the Lisbon Strategy. The following objectives are stated in a memorandum of the Council of the European Union:

- "Encourage a diversity of energy supply which enhances supply security"
- "Implement agreed commitments on energy market liberalization and on interconnecting infrastructure"
- "Develop policy/regulatory frameworks based on supply/demand, emissions analysis and projections that promote investment in the EU economy and provide medium and long term planning certainty"
- "Promote energy efficiency and related services. This will contribute to lower production costs and provide further job opportunities."<sup>20</sup>
- Follow the Intelligent Energy – Europe Program, which sets as goals the following:  
"Increase energy efficiency by around 1% per year; increase the use of renewable energy in consumption from 6% to 12% by 2010; increase to 22.1% by 2010 the percentage of electricity produced from renewable sources; increase the production of electricity produced from cogeneration by 2010; develop the potential of renewable sources of energy; promote Kyoto mechanisms"<sup>21</sup>

## FACTS FOR WEDGE STRATEGY

**Increased Efficiency in Coal Plants:** 43% of the electricity consumed in Portugal is generated with coal or oil<sup>22</sup>. The amount of electricity to displace is 43% of the 43Bkwh consumed annually, or 18.5Bkwh. Assuming 40% lower heating value efficiency and an emissions factor of 232 g C/kwh (as in the original Wedge Game materials), Portugal's current coal and oil generation emits 4.7 million tons C per year. Reducing the emissions factor with a 60% LHV efficiency would reduce emissions to 3.2 million tons C per year, or a savings of 1.5 million tons C per year. Cost is high. 60% efficiency does not currently exist, so this would require not only investment in expensive technologies but also decommissioning current plants before their useful life. Under this plan, Portugal will still have to import its energy requirements, though coal is more stable than gas and oil. Coal producing nations such as the US and South Africa will favor this wedge.

**Natural Gas Displacing Coal Plants:** Portugal consumed 5.9 Mmst (million short tons) of coal in 2003<sup>23</sup>. Only 4% of this is use for non-generation purposes, meaning 5.6 Mmst were used for electricity generation<sup>24</sup>. With an assumed weight fraction of carbon in coal of .71 (as assumed in the original Wedge

<sup>16</sup> International Energy Agency. Standard Reviews: Portugal. 2000  
[http://www.iea.org/textbase/nppdf/free/2000/Portugal\\_comp02.pdf#search=%22energy%20standards%20in%20portugal%22](http://www.iea.org/textbase/nppdf/free/2000/Portugal_comp02.pdf#search=%22energy%20standards%20in%20portugal%22) last viewed 09/26/06

<sup>17</sup> Ibid (see note 10)

<sup>18</sup> Ibid (see note 10)

<sup>19</sup> International Energy Agency. The Country Reports: In-Depth Review of Portugal. 2004

[http://www.iea.org/textbase/nppdf/free/2004/Portugal\\_comp04.pdf#search=%22PNAC%20Portugal%22](http://www.iea.org/textbase/nppdf/free/2004/Portugal_comp04.pdf#search=%22PNAC%20Portugal%22) last viewed 09/26/06

<sup>20</sup> Council of the European Union. Memorandum: Energy, Environment & Technology – Towards an Energy contribution to the 2005 Spring European Council. Brussels, 15 February 2005 [http://www.ceer-eu.org/portal/page/portal/CEER\\_HOME/CEER\\_PUBLICATIONS/NON\\_CEER\\_DOCUMENTS/ENERGYCONTRIB\\_SPRING\\_COUNCIL\\_05-02-15.PDF](http://www.ceer-eu.org/portal/page/portal/CEER_HOME/CEER_PUBLICATIONS/NON_CEER_DOCUMENTS/ENERGYCONTRIB_SPRING_COUNCIL_05-02-15.PDF) last viewed 09/27/06

<sup>21</sup> [http://ec.europa.eu/energy/res/intelligent\\_energy/index\\_en.htm](http://ec.europa.eu/energy/res/intelligent_energy/index_en.htm) last viewed 09/27/06

<sup>22</sup> EIA <http://www.eia.doe.gov/emeu/international/portugal.html>

<sup>23</sup> EIA Portugal <http://www.eia.doe.gov/emeu/international/portugal.html>

<sup>24</sup> Ibid (note 18)

Game materials), and assuming the coal carbon is completely combusted to CO<sub>2</sub>, we have 3.98 million tons C per year. Assuming natural gas to displace 50% of C emissions, so we have 2 million tons C per year saved by natural gas. It will require more transmission infrastructure and new plants to be built. The technologies involved are already known. However, price of natural gas is volatile and Portugal has no domestic reserves of natural gas. Due to medium cost, savings with known technologies, and Portugal's need to supplement hydropower generation this wedge is recommended.

**Conservation Tillage:** Portugal currently has 25,000 hectares (ha), or .8% of its total cultivated land, under no-till practices<sup>25</sup>. This implies a total Portuguese cultivated land area of 3.1 million ha, and also shows that we can essentially ignore current no-till in Portugal. Assuming savings estimates of 0.3-0.6 tons/ha/yr we would have total savings of 0.93 – 1.87 million tons C per year by converting Portuguese agricultural land to conservation tillage. According to the Food and Agriculture Organization of the United Nations (FAO), implementation of conservation tillage generally results in a reduction of costs and input labor. The FAO states, though, that higher costs and management will be required in the first few years of implementation (due to new machinery required and the learning/oversight of new techniques). These characterizations imply a low- to zero-cost of implementation over a longer time horizon, but an upfront cost which may be higher than some farmers (esp. in developing nations) can afford, requiring subsidies. Resistance should be expected from the older Portuguese farmers to change and the current structure of EU farm subsidies.

**More Fuel-Efficient Automobiles:** Portugal does not have any auto manufacturers, so there would be little added R&D cost to develop more efficient autos. Plus, at the rate that Portuguese citizens are buying cars, they could easily increase the % of fuel-efficient cars in their national stock (should those cars be made available). There is also the social benefit of paying less for gasoline.

**Drive 50% Less (light-duty vehicles):** The Portuguese have been rapidly expanding their stock of light-duty autos. There would be social opposition if Portuguese citizens were told they cannot drive their new cars. While the country has a high amount of daily travel (26 daily km/person), their overall travel is relatively low (~100bn km/yr).

**Biomass Fuel:** Costly for Portugal! With mostly mountainous terrain, there would be little potential for creating fuel from biomass. Should the country be required to use biofuels, they would likely purchase them from elsewhere, creating a dependence on foreign energy. Also, there is potential for using biomass as 'atmosphere scrubber' (that would be a 'second period' application for 2050-2100).

**Increased Efficiency in Buildings:** The residential sector in Portugal has shown 16% improvement in energy efficiency between 1990 and 2004. The industrial sector has undergone a 4% improvement compared to the European Union industry's 10% improvement.<sup>26</sup> It is estimated that in 2054, there will be 50 billion light fixtures compared to today's 10 billion. We calculate that approximately 0.2% of the world's light fixtures belong to Portugal. This indicates that Portugal's overall contribution to international efforts to institute this building efficiency wedge in the industrial and residential sector would be small. Can be considered expensive because energy efficiency depends largely on how buildings are constructed; some remodeling will be needed. Sub-categories such as electricity efficiency are cheaper and can have a significant impact in reducing GHG emission. It is also expected that most of the contribution in this wedge will come from the residential and industry sectors in the developing world. By utilizing the Kyoto Mechanisms, Portugal can take advantage of this and earn Carbon credits by investing in Energy Efficiency at a lower cost than it would at home. Based on the size of Portugal's lighting sector, we can say that the contribution of Portugal will be small, and hence Portugal would bear little of the total cost of the two wedges (one from residential, the other from industrial sector). There might be opposition to stricter regulations due to the cost.

**Solar Power:** Portugal is the third largest potential for solar energy amongst the EU countries. The average number of hours of sunshine per year range between 1,800 and 3,100 from the North and South respectively. The average annual solar radiation value ranges between 5.9 GJ m<sup>-2</sup> and 7.1 GJ m<sup>-2</sup><sup>27</sup>.

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<sup>25</sup> European Conservation Agriculture Federation <http://www.ecaf.org/>

<sup>26</sup> <http://www.odyssee-indicators.org/Publication/country%20profiles%20PDF/prt.pdf#search=%22portugal%20building%20efficiency%22>

<sup>27</sup> International Energy Conversion Engineering Conference [http://pdf.aiaa.org/preview/CDReadyMIECEC04\\_858/PV2004\\_5544.pdf#search=%22portugal%20potential%20](http://pdf.aiaa.org/preview/CDReadyMIECEC04_858/PV2004_5544.pdf#search=%22portugal%20potential%20)

Portugal is building the world's largest solar plant which will save 30,000 tonnes of CO<sub>2</sub> emissions per year equaling to about 0.083 percent reduction in Portugal's CO<sub>2</sub> emissions based on 2005 levels<sup>28</sup>. Therefore, Portugal must go beyond increase its solar power output capacity by a factor of 23 (2000GW/88GW). The solar plant will have an installed capacity of 49.6 MW, produce 88 GW of electricity a year, have 350,000 solar panels over 114 hectares, provide electricity to about 8000 homes<sup>29</sup>.

**CCS at coal-fired plants:** Portugal has 2 coal fired power plants and Portugal does not rely much on coal as a source of energy. Also, since there are not coal gasification plants, this would be expensive. Not recommended.

**Wind power:** This is in line with Portugal's current goals. "With joblessness at nearly an 18-year high, the Socialist government's auction also aims to create 1,600 jobs by mandating 900 million euros in spending on wind turbine equipment plants." 25 percent of the total new capacity in Europe was added in Portugal. It is seasonal and intermittent. Given Portugal's initiative in wind, we recommend this wedge.

**Wind to Hydrogen for Cars:** This is not feasible unless there is a hydrogen economy. It makes up for the intermittency of wind –and can store energy during excess capacity. Still, this wedge is not feasible right now.

**CCS Coal to Syngas:** In 2002, coal accounted for 14 percent of energy consumption and 20 percent of the carbon dioxide emissions<sup>30</sup>. CCS technology will be new to Portugal and result in increased cost of electricity generation. Also, the gains from CCS technology will exhaust quickly because coal is not a large source of energy in Portugal. It is resorted to in times of hydroelectric power generation fluctuations which Portugal is trying to meet with solar power plants. Portugal contributes to 0.3 percent of world's CO<sub>2</sub> emissions and Portugal's coal contributed to about 0.06 percent of world's CO<sub>2</sub> emissions. *This wedge is not recommended* because given Portugal's economy and budget deficit Portugal would best contribute to global CO<sub>2</sub> emissions reductions through the other wedges proposed.

**CCS for Coal to Hydrogen to Vehicles:** In 2002, coal accounted for 20 percent and natural gas amounted for 10 percent of Portugal's carbon dioxide emissions<sup>31</sup>. Portugal does not produce coal or natural gas. Natural gas is transported to Portugal through Spain. Coal is usually imported in Portugal during times of low hydroelectric power generation. Therefore, to take advantage of this wedge Portugal will have to significantly increase the coal and natural gas share in its energy mix. The cost is high in terms of hydrogen safety and the need for infrastructure. The shift to renewable sources of energy such as solar, hydroelectric, wind and the possibility of nuclear energy will make the opportunity cost of investment in CCS technology high. *Wedge not recommended.*

**Nuclear Power Substituting Coal Power:** Portugal currently has no nuclear energy capabilities. Because nuclear power generation does not emit GHG this wedge represents potential savings of 4.7 million tons of Carbon per year. The government will need to streamline licensing and certification procedures, and provide subsidies for construction cost.<sup>32</sup> Questions of proper nuclear waste disposal, uranium acquisition, not-in-my-backyard (NIMBY) issues, and safety hazards exist. *Not recommended.*

**Reduced Deforestation, Plus Reforestation, Afforestation, New Plantations:** Portugal has almost 4 million hectares of forest area (41% of the country), out of which 1.45% is primary forest. Average annual reforestation rate during 1990 – 2000 was of 1.56%, and 1.2% during 2000 - 2005. Nonetheless, Portugal lost 5.5% of its forest and woodland habitat through habitat conversion during 1990 – 2005.<sup>33</sup> The potential for Portugal rests on the Kyoto Mechanisms through which it can invest in deforestation-related projects in developing countries and cheaply gain GHG/Carbon credits. Carbon mitigation cost through forestry in developing countries is estimated to be US\$0.1 – US\$20/tC, and US\$20 – US\$100/tC in developed countries. This is low compared to other emission reduction options.<sup>34</sup> Carbon reservoirs saturate eventually. The carbon sequestration rate and the pool of carbon cannot both be maximized.

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<sup>28</sup> BBC News <http://news.bbc.co.uk/2/hi/europe/5056012.stm>

<sup>29</sup> Ibid (note 28)

<sup>30</sup> CIA World Factbook 2005, <https://www.cia.gov/cia/publications/factbook/geos/po.html>

<sup>31</sup> Ibid (note 30)

<sup>32</sup> <http://www.rmi.org/sitepages/pid305.php>

<sup>33</sup> <http://rainforests.mongabay.com/deforestation/2000/Portugal.htm>

<sup>34</sup> [http://www.grida.no/climate/ipcc\\_tar/wg3/156.htm](http://www.grida.no/climate/ipcc_tar/wg3/156.htm)

## WEDGE STRATEGY

| Wedge Type  | Portugal Potential  | Cost   | Issues  | Recommendation   |
|---|---|--|---|--|
| Increased Efficiency in Buildings   | 1990-2004: Residential sector has shown 16% improvement in energy efficiency. Industrial sector has shown a 4% improvement compared to the EU's 10% improvement. We estimate about 0.2% of world's light fixtures belong to Portugal.   | \$\$ Expensive because energy efficiency depends largely on how buildings are constructed. But some areas of improvement, such as lighting, are relatively cheap.  | Possible opposition to stricter regulations due to the cost. In the long run increases competitiveness and reduces overall costs. | 2 wedges (one from residential sector, the other from the industrial sector)   |
| 50% Greater Fuel Efficiency in Autos (Light Duty)                             | High potential for gain at little cost as Portugal does not have any auto manufacturers. Given Portuguese rate of acquiring cars they can easily increase the % of fuel efficient cars in their stock.  | Little R&D cost to develop more efficient autos. Social benefit of paying less for gasoline.   | Possible opposition from countries with auto-makers and older, less efficient fleets of car.                                      | 1 wedge  |
| Natural Gas Displacing Coal Plants  | 2 million tons C per year saved by natural gas. (see wedge rationale section for calculations)  | \$ Medium because technologies and technical know how already exists.  | Exposes Portugal to the volatility in natural gas prices. Coal makers will oppose this.   | 1 wedge since cost is medium. Will supplement Portugal's intermittent generation (hydropower) with generation that can be more easily switched on and off. |
| Solar/Wind replacing coal   | After Spain and Greece, Portugal has the third largest potential for solar energy amongst the EU countries. 25 percent of the total wind power added in Europe was through Portugal   | Medium; Portugal is already building the world's largest solar plant. Efforts to enhance wind power already under way.   | Both sources are seasonal   | 1/2 wedge solar, 1/2 wedge wind  |
| Reduced Deforestation, Plus Reforestation, Afforestation, and New Plantations | 41 percent of the country is forest area. Deforestation is not an issue in Portugal. Portugal lost 5.5% of its forest and woodland habitat through habitat conversion during 1990 and 2005. The potential for Portugal rests on the Kyoto Mechanisms through which it can invest in deforestation-related projects in developing countries and cheaply gain GHG / Carbon credits. | The costs of carbon mitigation through forestry in developing countries are estimated to be US\$0.1 – US\$20 / tC, while in developed countries the cost is estimated to be US\$20 – US\$100 / tC. Low compared to other emission reduction options. | Portugal will be investing in foreign rather than national projects. Also, carbon reservoirs are eventually maximized.            | 1 wedge. It is relatively cheap, flexible and effective option for controlling GHG emissions   |
| Conservation Tillage  | Using the savings estimates presented in the Wedge Game materials (.3-.6 tons/ha/yr) we would have total savings of .93 – 1.87 million tons C per year by converting Portuguese agricultural land to conservation tillage   | Low- to zero-cost of implementation over long term. Upfront cost which may be higher than some farmers (esp. in developing nations) can afford, requiring subsidies  | Resistance of older Portuguese farmers to change and the current structure of EU farm subsidies                                   | 1 wedge. Low cost, easy to implement   |