Sustainable Development for Italy, Part I: An Integrated Model-Based Report

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Preface

On 28 December 1993, Italy's Inter-ministerial Committee for Economic Planning (CIPE) responded to the 1993 Earth Summit and growing public concerns[1,2] by approving the National Plan for Sustainable Development in Implementation of Agenda 21.[3] This was the first time that the Italian government had ever adopted a program coupling the nation's economic and development targets to environmental quality factors in pursuit of sustainable development. This plan commits Italy to:

- integrate environmental considerations in all central government structures and at all levels of government to ensure that sector policies are consistent with one another;
- set up a system of planning, inspection, and management to support this integration;
- encourage the public and the various parties concerned to participate by guaranteeing as much access to information as possible.

Since the Earth Summit, Italy has also participated in a number of international agreements concerning the environment and sustainable development (see Appendix A), as has Europe generally. One of the most important was the 1997 Kyoto Conference on global warming issues. As a result of this conference, Europe and Italy are committed to the task of reducing emissions of carbon dioxide and other greenhouse gases to meet the Kyoto targets.

The changes called for at the Earth Summit, Kyoto, and other meetings can be costly and disruptive. For example, the 1995 meeting was based in part on *Factor 10*, which calls for a x10 reduction in the consumption of resources,[4] which would be both costly and disruptive. More recently *Factor 4* has appeared with more practical recommendations for a x2 reduction of resource consumption and a x2 increase in the benefits derived from the resources used.[5]

Italy now needs a real sustainable development plan, one based on detailed, thoughtful analysis. It needs to "integrate environmental considerations" and "ensure that sector polices are consistent," as called for by the CIPE. It needs sector by sector analysis of how much environmental space can be saved.

The 1993 draft National Plan was criticized in the Congress, and CIPE is in the process of preparing a new Sustainable Development Plan for the country. To do an effective job, Italy needs the support of a tool for integrated assessment of alternative development scenarios. At present Italy lacks any means of integrating environmental issues into overall economic development plans.

The current study is a step towards a collaboration between ANPA and the Millennium Institute, using the Institute's THRESHOLD 21 national sustainable development model. It is our aim develop the capacity to integrate environmental considerations into all central government structures and to use the tool to inform policymaking at all levels, as called for by CIPE. We

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[1] For a report of the Sustainable Europe Conference, see: http://www.xs4all.nl/~foeint/confrec.html
[2] "Towards a Sustainable Europe: Italy" (Amici della Terra, 1995).
[3] Italy: Progress in the Implementation of the National Plan for Sustainable Development. 10 April 1995. 10595.htm
[4] See: Schmidt-Bleek, Freidrich in "References" section of this report.
[5] See: Lovins and Von Weizsacker in "References" section of this report.

want to be able to answer the question: What are the costs and benefits of alternative development strategies, especially strategies shifting the mix of investments among the sectors of the Italian economy.

The THRESHOLD 21 model is a flexible, transparent tool which can be used to examine the impact of a wide range of strategies on a large number of indicators of progress. It can thereby help policymakers in the choice of appropriate strategies for achieving national sustainability goals while addressing current and emerging problems.

In this report, we have applied THRESHOLD 21-Italy and used it to explore a series of 20-year scenarios of possible futures for Italy. We have focused especially on alternative actions to meet the Kyoto target for reduced greenhouse gas emissions, especially carbon dioxide (CO_2). In developing scenarios, we have drawn heavily *on The Second National Communication to the United Nations Framework Convention on Climate Change*, which proposes alternative actions. Since the Government is still considering alternatives, it is impossible to know exactly what will be done. Our goal has been to translate one set of potential measures into a realistic scenario. Other sets of measures and other scenarios need to be developed.

The Italian version of the THRESHOLD 21 model is provided on disks inside the back cover of this report. Distributing the model on which a report is based, along with the report, is a new innovation. We do this because we want readers of the report to have a deep understanding of the analysis underlying the report and because the new technology of THRESHOLD 21 makes the model exceptionally transparent and user friendly. A user's script (see Appendix E) provides installation instructions and step-by-step guidance in using the model. We would be pleased to hear your thoughts on publishing a model along with a report and your reactions to this specific model.

The CIPE wisely noted that sustainability issues need to be addressed at the local and regional levels, as these are both centers of environmental concern and sources of many environmental problems. The flow of people into Italy from other countries is causing us to look for models of development of cities generally. Many people think a city of around 100,000 population is the model for a sustainable city. Do we want to go to large numbers of such cities all over the country, or do we want a few very large cities? We will be looking in the future to see if THRESHOLD 21 can be applied on an urban and regional basis to address such questions. Policies at levels need to be consistent.

I wish to express my thanks to the Millennium Institute, especially to Dr. Gerald O. Barney, Dr. Weishuang Qu, Mr. Philip Bogdonoff, and Ms. Katherine Sucher for their innovative work on this study and on the THRESHOLD 21 model.

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Foreword and Acknowledgments

Millennium Institute has prepared this report under contract 10751 with the Agenzi**a** Nazionale per la Protezione dell' Ambiente, Italy's National Agency for the Protection of the Environment (ANPA).

The models, analyses, assumptions, conclusions, and recommendations presented in this paper are those of the authors and do not necessarily reflect the positions of ANPA or the Government of Italy.

This work is based on the best models and data available to us from our Italian collaborators and from international sources. We have made every effort to be sure the results are accurate, reasonable, and properly qualified. Nonetheless, the work still needs to be reviewed carefully by Italian experts and checked against the best data available in Italy. It is not the definitive work; no one person or group has all the necessary knowledge for such a task. The definitive work must come from an extended partnership to which many contribute. One of the most important contributions of the THRESHOLD 21 model is that it provides a framework that helps bring people together to contribute their knowledge to the whole.

The Millennium Institute gratefully acknowledges support for the Threshold 21 project provided by ANPA and ENEA, as well as earlier support for the THRESHOLD 21 model provided by Mr. John A. Harris IV, Ventana Systems (especially Dr. Robert Eberlein), the Changing Horizons Fund, Los Trigos Fund, Wallace Global Fund, Trust in Diversity Exchange, the U.S. Department of Energy, the U.S. Country Studies Management Team, the U.S. Department of Agriculture, the AES Corporation, the Tunisian Institute for Strategic Studies, the International Training Center of the International Labor Organization, the UN Fund for Population Activities, UNICEF-Bangladesh, the World Bank, and the C.S. Mott Foundation. We are especially thankful for help provided by GianCarlo Boeri, Maurizio Colagrossi, Rosanna Mascolo, Roberto Ribelli, and Fabio Musmeci towards the work of this project.

The staff members of Millennium Institute express their thanks to ANPA for the opportunity to contribute to a bright, sustainable future for Italy.

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Katherine Sucher

Executive Summary

Italy has committed itself to a series of international agreements concerning standards for sustainable development. Among these agreements are commitments to cut carbon dioxide (CO_2) emissions from the 1990 levels of approximately 460 million tonnes (Mt CO_2) to about 400 Mt CO_2 by 2017.

To achieve these commitments is a complex task. To achieve them without doing serious damage to the economy is an even more complex task involving the Italian society and economy at all levels. This report analyzes options for this task using the THRESHOLD 21 national sustainable development model.

THRESHOLD 21 brings together economic, resource, population, social, and environmental issues in an integrated framework. It answers the question: How will the growth, social development, and environment of Italy be influenced over the next twenty years if policies shift investments toward one sector or another of the economy?

Four 20-year scenarios are analyzed and evaluated using several sets of indicators, including some of the EU Sustainable Development Indicators. The Base Case Scenario (BCS) examines what could happen if the current policies in effect in Italy were to continue. A Conventional Development Scenario (CDS) explores what might happen if the goal of maximizing Gross Domestic Product were to be pursued. The Italian Sustainability Scenario (ISS) explores what could happen if Italy were to pursue "sustainability" as defined and measured selectively by ANPA from among those developed by the EU. Finally, the Greenhouse Gas Emission Reduction Scenario (Kyoto) explores the implications of efforts to meet the targets of carbon dioxide emissions agreed to at the Kyoto conference. Table 1 compares a few key variables from the four scenarios.

Table 1: Comparison of Major Scenarios

Scenario	(BCS)		CDS		ISS		Kyoto	
Year	1997	2017	1997	2017	1997	2017	1997	2017
Population in million	57.3	52.8	57.3	52.5	57.3	52.6	57.3	52.8
GDP in 10^{15} Lira87	1.158	1.445	1.158	1.693	1.158	1.168	1.158	1.443
Energy consumption in Mtoe	156.24	161.49	156.24	187.71	156.24	131.86	156.24	145.38
Energy/GDP ratio in kgoe/MLira87	134.92	111.76	134.92	110.87	134.92	112.89	134.92	100.75
CO_2 emission in MT	450.8	451.1	450.8	537.1	450.8	352.3	450.8	404.6
Net GH gas emission, $MTCO_2$ Equiv.	522.2	521.7	522.2	610.7	522.2	419.0	522.2	473.3

The first conclusion is that Italy can meet the Kyoto target for carbon dioxide emissions. In the Kyoto scenario, emissions fall to 404.6 MTCO2 by 2017. Even using less optimistic assumptions than Italy has communicated to the United Nations, it can meet the Kyoto targets with only 1.3 to 16.% of domestic investment.

It is recommended that Italy adopt the CO_2 reduction measures recommended in the *Second National Communication*, which, based on the fourth scenario in this report, seems to be the most cost-effective way to meet the Kyoto targets, based on the fourth scenario of this report.

Annual percentage GDP growth ranges from a low of 1.168 percent for the ISS scenario to a high of 1.693 for CDS. Similar variations occur for energy consumption, CO2 emission, and Greenhouse gas emission measured in CO2 equivalent. The energy-to-GDP ratio improves for all scenarios, rising from 134.92 kgoe/ML87 in 1997 to about 100 kgoe/ML87 for Kyoto and about 110 to 113 kgoe/ML87 for the three other scenarios.

Italy is dependent on energy imports, and changes in the world energy situation will have a significant influence on Italy. For the projections summarized above, it is assumed that the resource-price elasticity is -1 (which means, for example, when world oil resource declines by 10%, the real international price of oil increases by 10%) and that the price-import elasticity is -0.1 (which means, for example, when world oil price goes up 10%, Italy will import 1% less). Of course these elasticities are uncertain, and if these influences are assumed to be significantly stronger (for example, a 20% increase in price and a 5% decrease in imports), emissions are reduced in all scenarios and GDP growth is reduced but remains positive in most scenarios.

By many measures of sustainability, Italy is already doing well, and improvements are possible. Shifting investments toward energy efficient technologies and social services and away from traditional industry and services (especially transportation) generally improves measures of sustainability, especially the emissions of polluting gasses. Investments chosen to maximize GDP growth adversely affect many indicators of sustainability. This finding confirms the need for indicators of progress to supplement the GDP and other traditional indicators.

It is recommended that Italians need to participate in the international discussion of indicators and select their own indicators to supplement GDP.

In all four scenarios, Italy’s population declines by about 4.5 million from its current 57.3 million. It also ages. Italy, already the world’s oldest country, will become steadily older. As a result, young people will have more elderly relatives and friends to care for in the years ahead. The age shift also has significance for the management of education, health, retirement, and social security programs.

It is recommended that Italy study carefully the implications of its changing age structure. Failure to do so could lead to surprises and difficulties having large economic and social implications.

Finally, note that the CIPE vision of integrating environmental considerations throughout all central government structures is an extremely difficult task. There are too many interrelated factors to keep organized in one’s mind. The THRESHOLD 21 model and projections reported here provide an initial step in the desired direction. The projections are not—and cannot—be precise, but taken as a whole they provide a consistent framework to inform and guide dialog.

The THRESHOLD 21 model is provided on diskettes inside the back cover of this report. While the model needs further refinement in several areas,[6] it provides a new interactive medium for the presentation of a report like this. Its transparent, user-friendly features will stimulate new thoughts and discussion among those who open and explore it. It deals with important current issues on which Italians need consistent discussion, dialog, and decisions today.

[6] In particular, it would be important to: (a) refine the representation of the costs and benefits of resource conserving and pollution-reducing technologies, (b) represent in more detail international flows relating to trade, capital, resources, people, waste, and pollution, and (c) add the pension system, secondary, professional, and higher education, tourism, transportation, solid waste, water pollution, and the option for requiring best available technology.

Introduction

While Italy scores very well on most measures of sustainable development , it does face a number of environmental problems, including:

- water pollution from Italy's urban industrial and agricultural areas,
- a mixed situation on air quality: while SO_x emissions have declined, N_2O emissions remain high,
- potential alteration of the pH of surface waters (lakes, and rivers) and soils because of acid rain caused by air pollution,
- water demands and wastes of tourists (50 million tourists in 1990, a number close to the total population of Italy),
- dependence on energy imports of fossil fuels, with implications for balance of payments and for carbon dioxide emissions,
- an aging and declining population, which implies heavy pressures on the social security and health systems, and
- high immigration rates from several North African and Central European countries.

These are complex environmental and social considerations, and the CIPE-approved National Plan for Sustainable Development calls for them and others to be "integrated into all central government structures and at all levels of government to ensure that sector policies are consistent with one another." Such integration is a complex task and requires an integrated economic-environmental model for assessing alternative courses of action.

This report is an initial exploration of the whole sustainable development picture for Italy using the THRESHOLD 21 model. Special attention is given to questions of meeting Italy's international environmental obligations (see Appendix A),[7] especially to meeting the carbon dioxide emission targets for the Kyoto protocols.

Overview of the Model

The THRESHOLD 21 model is an *integrated assessment tool* for application to any country. Threshold 21 (a) integrates many sectoral models in a transparent fashion, (b) simulates the short- and long-term consequences of alternative policies, and (c) permits easy comparison to reference scenarios and analysis of any scenario by tracing causes of change. The model provides policymakers and other users with a general sense of the consequences to be expected from present and alternative choices, not precise predictions.

[7] The process for meeting international environmental accords involves creating incentives or requirements for technological changes to more conserving and less polluting industrial and transportation processes. To analyze such changes required detailed specifications of the technologies, their costs, their impacts, and the schedule for the implementation. The current report succeeds in doing this for technologies related to carbon dioxide emissions, but not for all of the other pollutants covered under international agreements. For example, this report does not analyze the technologies related to sulfur oxide emissions or answer the question of whether Italy's current plans will meet the obligations to cut sulfur oxide emissions.

THRESHOLD 21 includes *linkages* and feedbacks among the economic, social, resource and environmental sectors. These intersectoral connections are critical to guiding a country towards a sustainable future. For instance, water limitations may affect the production of food, which in turn will affect the health of workers and the productivity of the economy. THRESHOLD 21 provides a holistic picture of how a decision in one sector will affect other sectors, and which policies will best improve the overall health of a country.

THRESHOLD 21's features make it a very powerful and easy-to-use tool for policy exploration:

- At the core of THRESHOLD 21 is a dynamic macroeconomic model in which the resource, capital, labor, and technology inputs are connected to dynamic sector-specific models in each of these areas. With this integrated structure THRESHOLD 21 is able to address a complex set of questions -- e.g., how does the allocation of investment among the factors of production and different economic sectors affect the overall development of the country, not just economic growth.

- Many of the indicators used or proposed by UN agencies and other bodies, such as the UN Commission on Sustainable Development (UNCSD), UNEP, UNICEF, UNFPA, the World Bank, and the EU, have been implemented in THRESHOLD 21. Coupling these indicators with a model capable of making projections allows policymakers to see the future impact of policy choices on indicators of interest. The model includes UNDP's Human Development Index (HDI) and Gender-related Development Index (GDI), the World Bank's Monitoring Environmental Progress (MEP) indicators, selected indicators from UNICEF, UNCSD, and UNFPA, and unemployment. The Environment sector reports on N_2O, SO_x, CH_4, and CO_2 emissions. Part of the EU Sustainable Development Indicators of Economy, EU Social Indicators of Sustainable Development, EU Sustainable Development Indicators of the Environment, as well as the UN Common Country Assessment (CCA) indicators have been added to the THRESHOLD 21 model for Italy.

- The following sectors are included in the Italy THRESHOLD 21 model: agriculture, demographics/conceptions, economy (including production, consumption, import, export, and a supply and demand model), education, energy, environment (greenhouse gas emissions plus SO_x, solid waste[8]), forestry, goods (industrial production, including an investment allocation model), health, land, military, nutrition, social services, technology, trade, and water.

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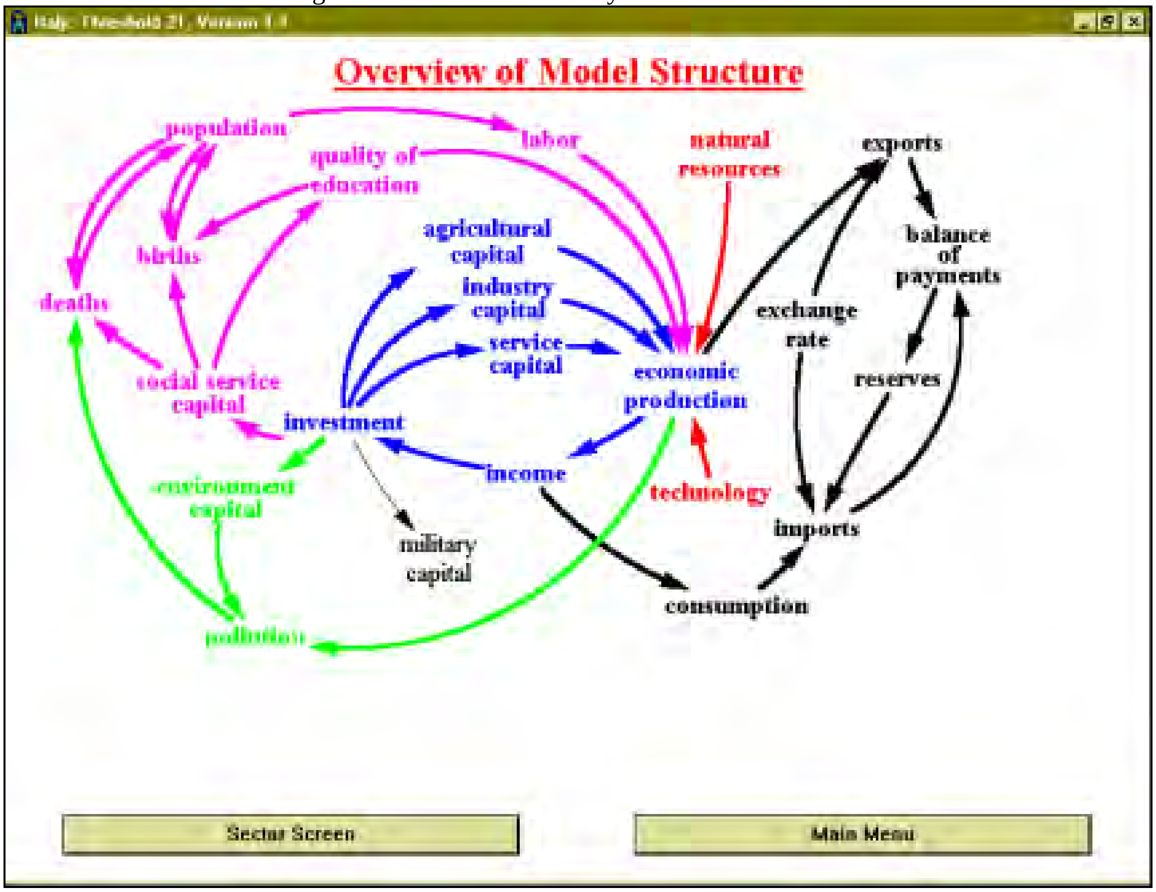
[8] THRESHOLD 21 has only a small solid waste component in the methane emissions sector. It is based on the IPCC Work Book, not on Italian information, and as a result there will be some differences with the Italian situation. For example, IPCC assumes 300 kg of solid waste per person per year, and Italian data says 450. While this appears to be a significant difference, it may not be because the definitions of "solid waste" differ widely. The IPCC number is used here because it is consistent with the many parameters and equations in the IPCC Work Book and produces consistent calculations. To develop a models that consistently project Italian solid waste production and methane emissions would require extensive additional research.

Figure 1. Overview of the Italy THRESHOLD 21 Model

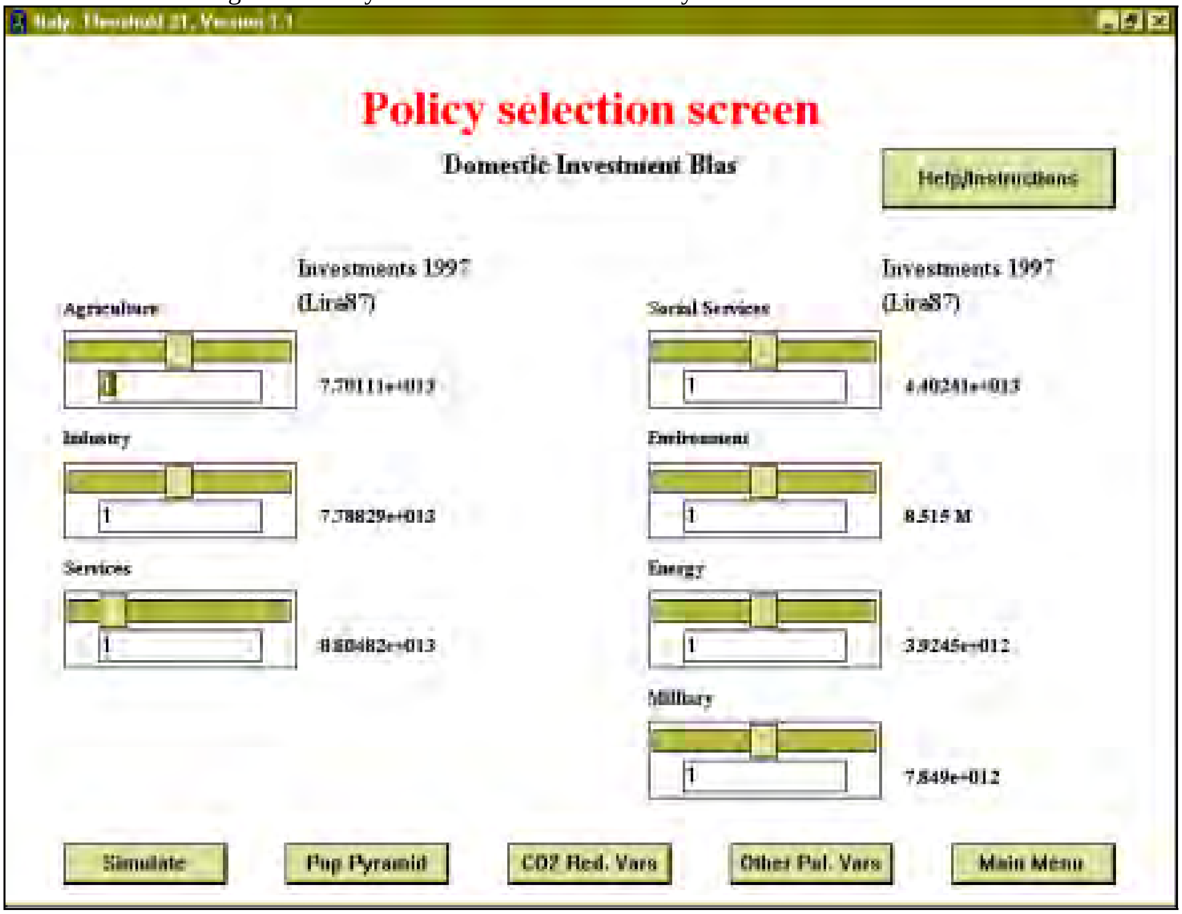


THRESHOLD 21 is continually being refined and improved to meet the needs of clients that extend the model. The development of THRESHOLD 21 is being supported by collaborative projects between the Millennium Institute and UN agencies, the World Bank, and other national agencies in a variety of countries.

Using the Model

In every market-oriented economy, the market for capital guides investment into various sectors according to return on investment. THRESHOLD 21 is a market-oriented model in that it simulates the capital allocations function of the market. In addition, every country has a variety of policies which influence or bias the relative attractiveness of investment in the individual sectors. THRESHOLD 21 simulates this effect through a series of investment biases which are on the policy selection screen.

Figure 2: Policy Selection Screen for the Italy version of THRESHOLD 21



As shown in Figure 2, the Policy Selection Screen has domestic investment bias slide-bars for seven sectors: Agriculture, Industry, Energy, Military, Environment, Services, and Social Services. When the investment biases are set to 1.0, the general policies of the past decade or so are continued. While the investment figures should not be taken as precise or literal, the central column of the Policy Selection Screen provides investment figures for the seven sectors in 1997 in 1987 Lira.[9] When an investment bias (perhaps agriculture) is set to 1.2, the investment in that particular sector is increased by approximately 20 percent. As one or more investment biases are increased, the others are scaled back internally to fit the available capital (see Appendix G in Part II for further details).

The "Other Pol. Vars" button leads to six more policy variables: the Annual Immigration Multiplier, the Elasticity of Oil Price on World Oil Resource, the Elasticity of Oil Imports on Price, World Oil Production, Rest of World GDP Growth, and the Investment/GDP Ratio. An additional screen, reached via the "CO_2 Reduction Vars" button, allows changes in (1) the annual investment Italy makes toward the Kyoto target (Annual Kyoto Investment), and (2) the energy savings per unit of investment toward the Kyoto target (BTU Saving/Lira87 Investment Ratio).

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[9] It is also possible to see real values for the investments by sector over the course of simulation runs. The Script for using and demonstrating the model in Appendix F provides detailed instructions.

Analysis of Scenarios

Scenario definitions

The scenarios analyzed for this report are of two types. The first type assumes a general continuation of technological trends of the past decade or two in matters of energy efficiency, pollution reduction, and utilization of renewable energy sources with no governmental intervention to require shifts in technology. The second type of scenario assumes active governmental intervention to encourage or require shifts of investment toward energy efficient, pollution reduction, and renewable energy using new technologies. The scenarios are as follows:

- The Base Case Scenario (BCS) is a type 1 scenario. It continues with the investment policies of the last decade or so. These investment policies are in effect when all of the policy bias slide bars are set to 1.0, which is the investment policy setting that allows the model to reproduce Italy's historical trends of the past decade or so.
- The Conventional Development Scenario (CDS) is a type 1 scenario. It maximizes the rate of increase of Gross Domestic Product (GDP), the conventional and traditional measure of progress.
- The Italian Sustainability Scenario (ISS) is a type 1 scenario. It maximizes Italy's progress as measured with new measures of sustainable development.
- The Greenhouse Gas Emission Reduction Scenario (Kyoto) is a type 2 scenario. It explores how, through active governmental intervention to encourage or require shifts technologies, it is possible for Italy to achieve the Kyoto targets. The technologies pursue are those described in Italy's "*Excerpt from the Second National Communication to the United Nations Framework Convention on Climate Change*" (hereafter "Second National Communication", or "SNC").

The overall process of scenario analysis is first to run the Base Case. This done, the effects of increasing investments in each individual sector are surveyed to provide an overview of the direct and indirect consequences of altered investment strategies. Finally, the other scenarios (CDS, ISS, and Kyoto) are developed. Only the Kyoto scenario is a type 2 scenario in which active governmental intervention is used to prompt investment in specific technologies beyond the general trend in technological advance.

The Base Case Scenario (BCS): Continuing Previous Policies

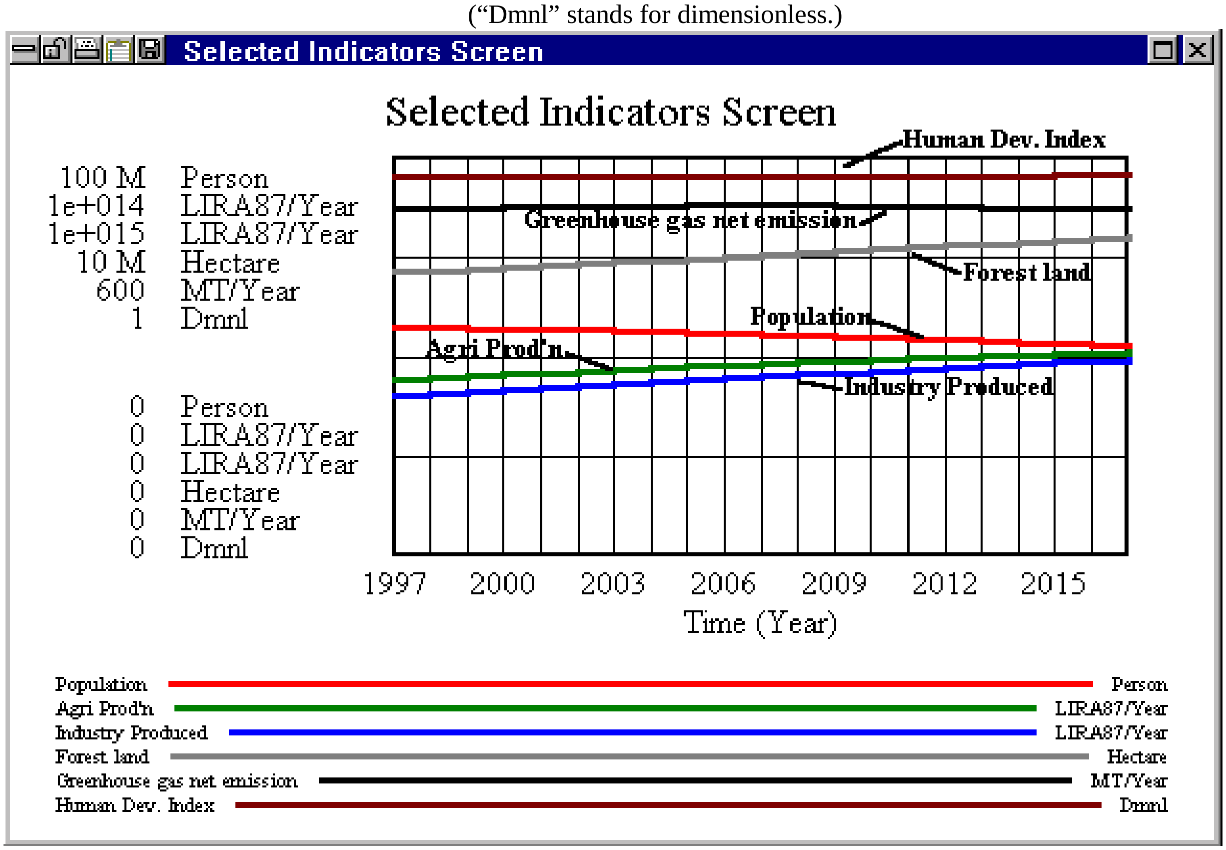
The Base Case Scenario (BCS) is established by continuing the policies that enabled the Threshold 21 model to reproduce the recent historical trends for Italy.

Figure 3 shows the overview screen for the BCS in which six important variables (population, agricultural production, industrial production, forest land, pollution intensity, and the UNDP's Human Development Index) are displayed for the period 1997 to 2017. Below the graph, the variables are identified and their units given. The scales for the various curves are listed to the left of the graph in the same order as in the key below. The upper group of numbers and units refers to the top of the graph; the lower group refers to the bottom of the graph. Labels have been applied to the curves for identification on the black-and-white graph. On the computer screen, each curve is a different color.

Graphs of about 100 more variables and indicators can be reviewed on the computer by clicking on the “View Sectors” button or on the “View Indicators” button. Using the “Do Analysis” button, all 2000+ variables can be graphed and scenarios compared (within seconds). Some screens automatically compare scenarios (e.g., see Figure 4).

Much can be learned from the overview screen. Population is declining, and with increasing rapidity. Agricultural Production and Industrial Production are increasing slightly, and at a slowing rate of increase. Forest land is increasing slightly. Pollution is also still increasing slightly. The Human Development Index (HDI), which is a composite of literacy, life expectancy, and per capita GDP, is nearly flat.

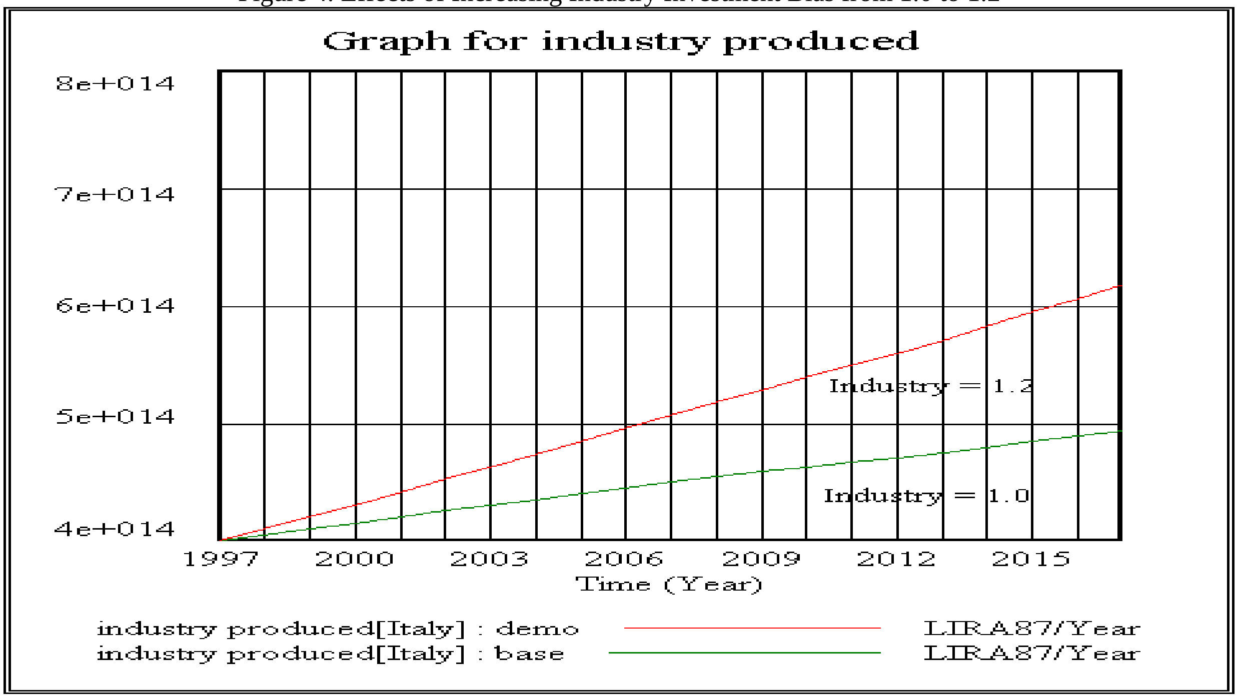
Figure 3. Selected Indicator Screen, Base Case Scenario (BCS)
(“Dmnl” stands for dimensionless.)



Altering Investment Biases in Italy: An Overview

To make a general survey of the development consequences of increased investment in each of the seven sectors, we changed the Investment slide-bars from 1 to 1.2 sector by sector, for each of the seven sectors. For example, Figure 4 shows the results of increasing the investment in the Industry sector from 1 to 1.2.

Figure 4. Effects of Increasing Industry Investment Bias from 1.0 to 1.2



The results of this survey are summarized in Table 1. It provides an overview of how increased investment in different sectors will influence development trends in Italy over the next 20 years.[10] The variables in the table columns relate to some of the sustainable development issues of concern to Italy and other industrialized countries.

Table 2. Summary of the effects of changes in the investment biases in single sectors relative to the Italy Base Case (a)

Sector	Investment	CO_2	N_2O	SO_x	GDP per capita	Energy De-mand	Re-new-able %	Ag Prod'n per capita	Total Capital
1. Agriculture	1.0 → 1.2	↓	↓	↓	↓	↓	↓	↑	↓
2. Industry	1.0 → 1.2	↑	↑	↑	↑	↑	↓	↓	↑
3. Energy	1.0 → 1.2	↓	↓	↓	-	↓	↑	-	-
4. Military	1.0 → 1.2	-	-	-	-	-	-	-	-
5. Environment	1.0 → 1.2	-	↓	↓	-	-	-	-	-
6. Services	1.0 → 1.2	↑	↑	↑	↑	↑	↓	↓	↑
7. Social Services	1.0 → 1.2	-	-	-	-	-	-	-	-
8. Oil price elas.	-1 → -2	↓	↓	↓	-↓	-↓	↑	-↓	↓
9. + Import elas. (b)	-0.1 → -1	↓↓↓	↓↓↓	↓↓↓	↓↓	↓↓	↑↑	↓↓	↓↓
10. Investment %	0.25 →0.30	↑	↑	↑	↑	↑	↑	↑	↑

a. Size and number of arrows reflects degree of range relative to the Base Case.
b. "+ Import elas." Means oil price elasticity plus import elasticity acting together.

[10] Table 2 is different for every country to which the Threshold 21 model is applied. The reason is that each country is different, and as a result investments in different sectors produce different results.

There are many complex reasons for the changes summarized in Table 2, and the changes are unique to each country to which the Threshold 21 model is applied. The following paragraphs discuss the changes for Italy line by line (i.e., sector by sector).

Line 1 (agriculture sector): Solely increasing the investment in the agriculture sector causes total and per capita agricultural production to increase modestly relative to the Base Case. GDP per capita, energy demand, the renewable percentage, and Total Capital all decline due primarily to the shift of investment resources into agriculture and away from industry, services, and energy. The reduced economic activity also results in reduced production of CO_2, N_2O, and SO_x.

Line 2 (industrial sector): Solely increasing the investment in the industrial sector (goods production) increases GDP per capita and Total Capital. It also increases energy demand and emissions of CO_2, N_2O, and SO_x. The changes are relatively large, and the primary reason is that industry output has a high capital elasticity relative to most other sectors (except services). Consequently, investment in industry generates significantly higher GDP; and higher GDP demands more energy (which is met by importing more oil and gas), resulting in more emissions. Agricultural production per capita declines due to reduced investment. The percentage of energy which is produced from renewable sources also declines for two reasons: (1) energy investment is reduced, hence investment in renewable resources is also reduced, and (2) energy imports are increased, and as a result total energy consumption is increased.

Line 3 (energy sector): Solely increasing investment in the energy sector increases the renewable percentage and improves energy efficiency. Since the energy sector in Italy is small compared to the agriculture, industry, and services sectors, it demands less investment than the other production sectors. Adding 20% investment to the energy sector produces a relatively small amount of additional energy and does not cause noticeable changes to investments in the three other production sectors; consequently there are no noticeable changes to GDP. Since investments in the energy sector increase energy efficiency, energy demand declines, and emissions of CO_2, N_2O, and SO_x are also lower.

Line 4 (military sector): Solely increasing investment in the military sector produces no significant change in the indicators of Table 1 relative to the Base Case. The reason is that the military in Italy has a very small share (about 1% to 2%) in Italy's GDP.

Line 5 (environment sector): Solely increasing investment in the environment sector produces modest declines in the production of N_2O, and SO_x, because the investment in the environment is investment in cleaning up pollution not preventing it with technological changes. The environment sector, like the energy sector, is small, and investment in environment sector is small compared to investments in the production sectors. For example, adding 20% to the environment sector is not enough to significantly reduce investments in the other sectors, and little change is seen in GDP, energy demand, renewable percentage, agriculture production, and total capital.

Line 6 (service sector): Solely increasing investment in services (transportation, communications, etc.) produces effects similar to those for Line 2 (increasing investment in industry): The result is increased GDP per capita, Total Capital, energy demand and emissions of CO_2, N_2O, and SO_x. Agricultural production per capita and the percentage of renewable energy in the overall energy mix decline. The reasons are the same as for Line 2 above.

Line 7 (social services): Solely increasing investment in social services (health care, family planning, and primary education) produces no significant change in the indicators of Table 1. The reason is that the current status in Italy's health care, family planning, and primary education are sufficiently good that investments in social services produce only marginal returns relative to investments in other sectors. This conclusion might be altered if secondary and higher education were added to the model.

Lines 8 and 9: Italy is connected to the rest of the world in several ways, and one important way is through energy imports. THRESHOLD 21 represents the energy connection to the world through two elasticities: one relating world oil resources remaining to world oil price and the other relating Italy's ability to import oil to world oil price. For lines 1-6 in Table 1, the following assumptions are made concerning these two elasticities:

- real world oil price will change with oil resource depletion with an elasticity of -1, meaning, e.g., that when world oil resource is reduced by 10%, real world oil price will increase by 10%;
- the real world oil price will affect Italy's ability to import energy with an elasticity of -0.1, meaning, e.g., that when real world oil price goes up 10%, Italy will import 1% less of what is required

These two elasticities may be changed to explore alternative assumptions on the effect of diminishing world oil resources on oil price, and the effect of increasing oil price on the amount of oil imported into Italy, and their general impact is explored in lines 8 and 9.

Line 8 (oil price elasticity): Increasing the oil price elasticity from -1 to -2 implies faster increases in real world oil prices as world oil resources are depleted. As prices rise, Italy would import less energy. As a result, Italy would burn less fossil fuels, and emit less CO_2, N_2O, and SO_x . The renewable percentage would increase. GDP per capita, Energy Demand, Agriculture Production, and Total Capital, all decline slightly due to the higher price Italy would be paying for imported energy and the reduced amount of energy Italy would import.

Line 9 (import elasticity): Increasing the oil price elasticity from -1 to -2 *plus* increasing the elasticity of price on imports from -0.1 to -1 explores the possibility of both increased cost of imported energy *and* reduced economic ability to import energy. In this case, the energy demand and the production of CO_2, N_2O, and SO_x all decline markedly as does GDP per capita, agricultural production per capita, and Total Capital. The renewable percentage increases significantly.

Line 10 (rates of investment and propensity to save): Increasing the percentage of GDP which is used for investment causes all of the indicators to rise. The increases are detrimental in some cases and beneficial in others. While this variable is easy to change in a model, it is not easy to change in a real economy. In the analyses that follows the percentage of GDP invested is left at its default value, allowing the analyses to be focused on the consequences of changing the relative proportions of investment in the various sectors.

The analysis of specific scenarios follows. The results presented in Table 1 provide general guidelines for shifting investment to different sectors according to the stated goals of each of the specific scenarios. Additional refinements are made based on the other indicators of interest in each scenario.

The Conventional Development Scenario (CDS): Pursuing GDP

The Conventional Development Scenario (CDS) focuses on maximizing GDP. It is developed by finding the mix of investment changes that will increase the future growth of GDP most rapidly. Comparisons are relative to the Base Case (BCS) described above. GDP starts in 1997 from 1.16×10^{15} Lira87/year in both the Base Case and the Conventional Development Scenario.

A variety of experiments were performed using Table 1 as a guide with the goal of making the projected growth in Italy's GDP increase as fast as possible.[11] The combination of investment biases that increase GDP most rapidly is 1.2 for Industry and 1.5 for Services. This combination increases rate of growth of GDP in 2017 from 1.45×10^{15} Lira87/year (BCS) to 1.69×10^{15} Lira87/year.

In this scenario, all the National Account indicators (Service sector GDP, Industry GDP, and Agriculture GDP) show steady increase. From the perspective of the World Bank's "MEP" (Monitoring Environmental Progress) indicators, Total Capital increases steadily due to a healthy Genuine Savings rate. The UNDP's Human Development Index and Gender-related Development Index also are very favorable: they start very high and remain so over the course of the 20-year simulation.

Hence, from the perspective of many of the traditional measures of progress, this CDS appears to perform well. However, as we expand our measures of performance to include some of the EU indicators of Sustainable Development, concerns arise over the impact on the environment.

The EU Sustainable Development Indicators are of three types: economic, social, and environmental indictors. For the CDS, the economic indicators (per capita GDP, investment percentage in GDP, industrial value added, per capita energy consumption, and percentage of renewables in energy production) are all encouraging. Although the renewable energy percentage declines initially, slightly, it recovers before 2017. The EU social indicators (population growth rate, net immigration rate, total fertility rate, infant mortality rate, unemployment rate, women per 100 men in labor force, population density, and percentage of urban population) show a more mixed picture. Italy's population annual growth rate is projected to continue to decline further from -0.21% in 1997 to -0.77% to -0.84% in 2017. Other indicators such as women per 100 men in the labor force show increases.

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[11] The Vensim programming language has a function for optimization with which it is possible to automate this experimental process, and we actually used the optimization feature to check some of our experiments. Generally, however, we prefer to experiment because through the experiments one gains insights into the operation of the Italian social-economic-resource-environment system that are lost during the optimization process.

However, when we examine the EU Indicators of the Environment (emissions of CO_2, N_2O, SO_x, and CH_4, per capita domestic water consumption, per capita arable land, agriculture land, and forest land), we see that there are some significantly adverse consequences of the conventional development scenario. For example, by the year 2017:

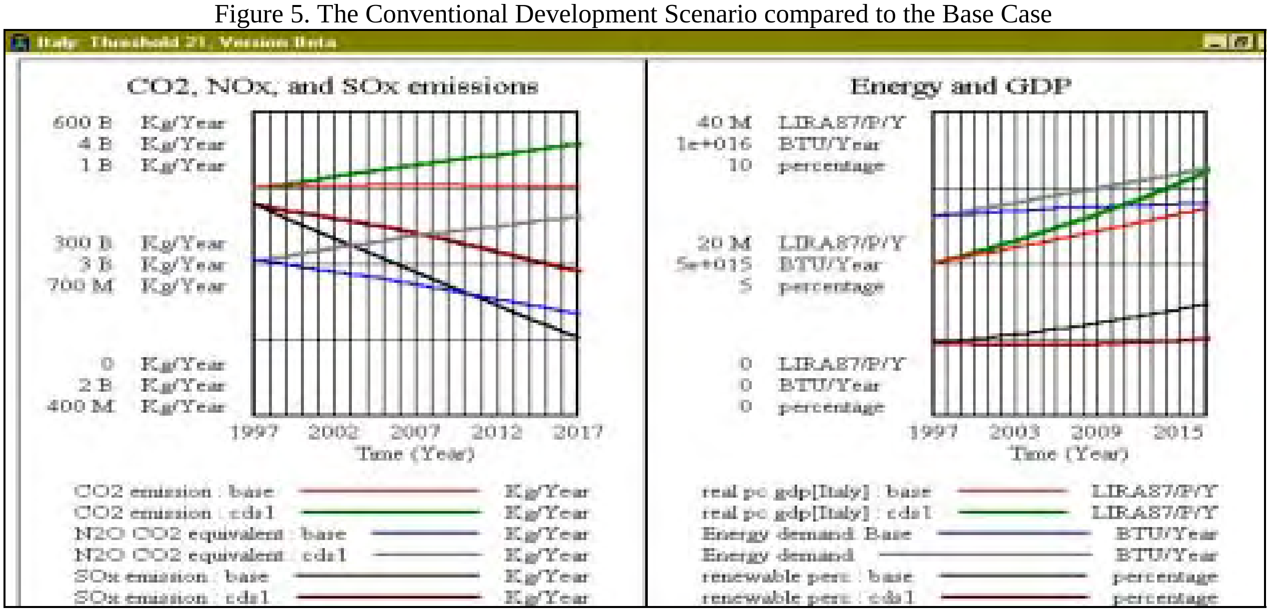
- CO_2 emissions have increased from 451 MT/yr (in the Base Case) to 537 MT/yr (starting from 451 MT/yr in 1997).
- N_2O emissions, measured in C_2O equivalent, have increased from 2.67 MT/yr in 2017 (in the Base Case) to 3.31 MT/yr in 2017 (starting from 3.03 MT/yr in 1997).
- SO_x emissions have increased from 0.555 MT/yr (in the Base Case) to 0.685 MT/yr in 2017 (starting from 0.818 MT/yr in 1997).[12]
- per capita domestic water consumption increases from 59,084 kg/yr (in the Base Case) to 63,101 kg/yr in 2017 (starting from 52,263 kg/yr in 1997).

And examining some energy indicators, we see that:

- per capita energy consumption has increased from 128 x 10^6 BTU/yr in 2017 (in the Base Case) to 150 x 10^6 BTU/yr (starting from 114 x 10^6 BTU/yr in 1997).
- while total renewable energy production has increased, the renewable percentage declines from 3.7 (in the Base Case) to 2.6 percent (starting from 2.4 percent in 1997) as investment is shifted towards industry and services, away from energy.

Figure 5 shows a set of six indicators comparing the Base Case Scenario with the Conventional Development Scenario. These indicators were chosen to show trends in some key environmental and resource areas.

Figure 5. The Conventional Development Scenario compared to the Base Case



12 Italy has obligations under the transboundary protocol concerning its future NO_x and SO_x emissions and has plans for investments in new technologies to reduce these emissions. The current version of the THRESHOLD 21-Italy model does not include these anticipated investments. To include them, it will be necessary for the responsible Italian governmental agencies to specify precisely what technologies are expected to be used, the impact they will have on efficencies, costs, and emissions, and the schedule for their implementation. Until such information is developed and included in the THRESHOLD 21 model, the projected values of No_x and SO_x emissions should be understood to be for existing technologies, not the technologies Italy will invest in to meet its obligations.

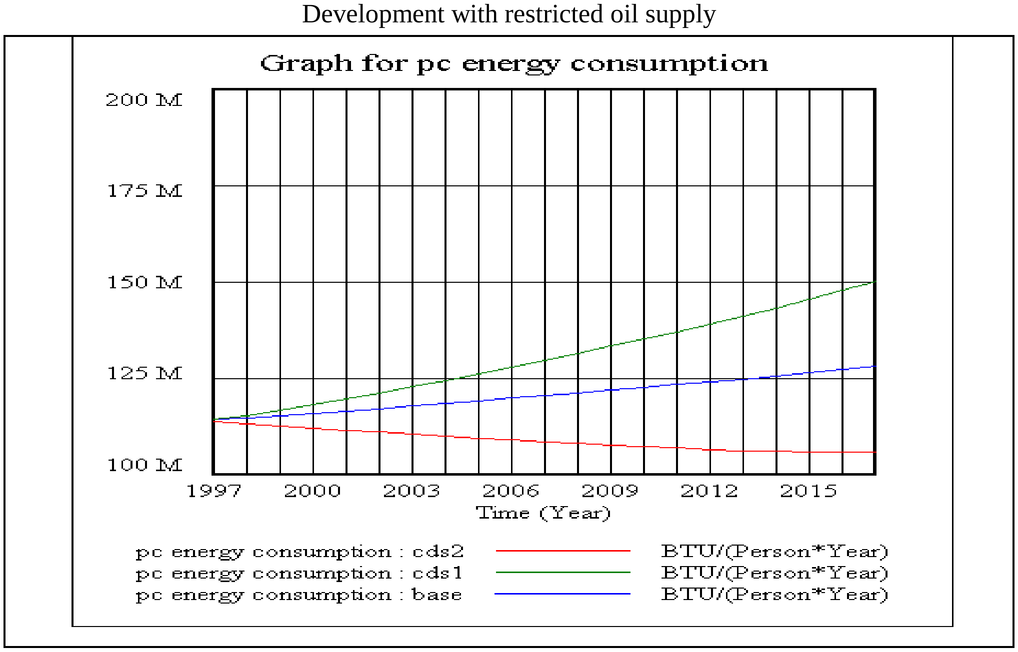
While pursuit of a Conventional Development Scenario improves many aspects of national life, it neglects some key environmental and resource issues. It also leaves the nation more vulnerable on the energy front, as we see next.

In order to simulate the effects of a diminishing world oil supply, we ran the same Conventional Development Scenario and changed the two elasticities related to oil imports. We did this in order to simulate the effects of a diminishing world oil supply. We increased the Elasticity of Oil Price on World Oil Resource from -1 to -2 (in other words, now as the world's oil resource declines, the price of oil on the world market will increase twice as quickly as in the Base Case), and we decreased the Elasticity of Oil Imports on Price from -0.1 to -0.5 (now, for example, when the price of oil goes up 10%, Italy's oil imports will go down 5%). We observed the following effects compared with the Base Case:

- per capita energy consumption *declines* to from 128 to 106 x 10^6 BTU/yr.
- the renewable percentage *declines* from 3.7 to 3.19 percent, which is the combined result of two opposite forces: less investment in energy means less investment in renewables, while higher world oil prices pushes a larger share of investment in energy to renewables.
- CO_2 emissions *decrease* from 451 (in the Base Case) to 372 MT/yr.
- N_2O emissions, measured in CO_2 equivalent, *decrease* from 2.67 to 2.25 MT/yr.
- SO_x emissions *decrease* from 0.555 to 0.467 MT/yr.
- per capita domestic water consumption increases -- but not as much -- from 59,100 kg/yr to 60,100 kg/yr.
- population growth rate still continues to decline from -0.0077 to -0.0082.

Figure 6 shows the per capita energy consumption under the three scenarios (Base Case, Conventional Development, and Conventional Development with restricted oil supply).

Figure 6. Per Capita Energy Consumption under Base Case, Conventional Development, and Conventional Development with restricted oil supply



The Italian Sustainability Scenario (ISS): Pursuing Italy's own measures of sustainability

The Italian Sustainability Scenario (ISS) is the result of experiments with the THRESHOLD 21 model with the objective of achieving long-term sustainability as measured by some of the key indicators of interest to the Italian sustainability community. These include:

- *energy demand:* this can be reduce by reducing the level of economic activity and increasing the efficiency with which energy is used.
- *percent of renewable energy*: this can be increased by increasing the investment in the energy sector; rising energy costs (e.g., for imported oil) will also shift investment to renewable sources of energy.
- *CO_2, N_2O, and SO_x production levels*: these can all be reduced by reducing the level of activity in the industrial sector, and by improving energy use efficiencies.
- *CH_4 emissions*: these emissions come primarily (1) from landfills, which, in turn, are influenced by the size of the urban population and (2) from farm animals, whose numbers are influenced by food demand, which, in turn, is a function of per capita GDP (refer to page 137 of Part II).[13]
- *water demand*: this is a function of GDP and can be reduced by reducing irrigation, industrial water demand, and household demand.
- *the amount of agricultural land*: this is affected by population pressures, which are already declining.
- *the amount of forest land*: this is affected by logging and replanting. Logging is a function of fuel supply and demand, which, in turn, is a function of economic activity and population size, again, already declining.

Experimenting with a variety of investment scenarios that aim to move these indicators in the directions mentioned above leads to the following: reduce investment in the industrial sector to 0.5, increase investment in the energy sector to 1.5, decrease investment in services to 0.9, and increase investment in social services to 1.5.

This scenario produces the following results:

- total (commercial) energy demand falls from 7.00 x 10^{15} BTU/yr (in the Base Case) to 5.70 x 10^{15} BTU/yr in 2017 (starting from 6.57 x 10^{15} BTU/yr in 1997).
- fuel imports required falls from 6.06 x 10^{15} BTU/yr (in the Base Case) to 4.69 x 10^{15} BTU/yr in 2017 (starting from 5.66 x 10^{15} BTU/yr in 1997).
- domestic energy production rises from 0.93 x 10^{15} BTU/yr to 1.01 x 10^{15} BTU/yr (starting from 0.91 x 10^{15} BTU/yr in 1997), of which renewable climbs from 0.26 x 10^{15} BTU/yr to 0.34 x 10^{15} BTU/yr (starting from 0.16 x 10^{15} BTU/yr in 1997).
- CO_2 emissions fall from 451 MT/yr (in the Base Case) to 352 MT/yr by 2017 (starting from 451 MT/yr in 1997).

[13] In 1990, a third of Italy's CH_4 emissions were from landfills, and Italy has regulations coming for landfills that will reduce both landfills and emissions from landfills. For example, by 2000 or 2001, no organic materials can be put into landfills, and this will cut CH_4 emissions. The THRESHOLD 21 projections reported in this report assume the landfill and landfill emission factors contained in the IPCC Work Book, not the detailed plans Italy has developed to reduce landfills and the emissions from landfills.

- N_2O emissions, measured in CO_2 equivalent, fall from 2.67 MT/yr (in the Base Case) to 2.04 MT/yr by 2017 (starting from 3.03 MT/yr in 1997).[14]
- Total water demand falls modestly from 1.71 x 10^{13} kg/yr (in the Base Case) to 1.67 x 10^{13} kg/yr by 2017 (starting from 1.43 x 10^{13} kg/yr in 1997) .
- Total capital declines from 19.8 x 10^{15} Lira87 (in the Base Case) to 16.0 x 10^{15} Lira87 in 2017 (starting from 17.4 x 10^{15} Lira87 in 1997).
- Per capita GDP rises from 20.2 x 10^6 Lira87 in 1997 to only 22.2 x 10^6 Lira87 in 2017 (compared to 27.4 x 10^6 Lira87 in the Base Case Scenario).

The National Account indicators (Service sector GDP, Industry GDP, and Agriculture GDP) show different trends: Agriculture GDP grows faster than the Base Case, Service GDP grows slower, and Industry GDP declines in its absolute value from 1997 to 2017. Total Capital declines slightly, in which Natural Capital grows faster than the Base Case, Produced Assets grows slower than the Base Case, and Human Resources declines (which is due to the definition by the World Bank and its implementation in Threshold 21, see page 167 of Part II). This is in marked contrast to the Conventional Development Scenario or Base Case and is due in part to the choice of investment levels by the authors that slow GDP growth to a bare minimum. The UNDP's Human Development Index and Gender-related Development Index start very high and remain very high as before.

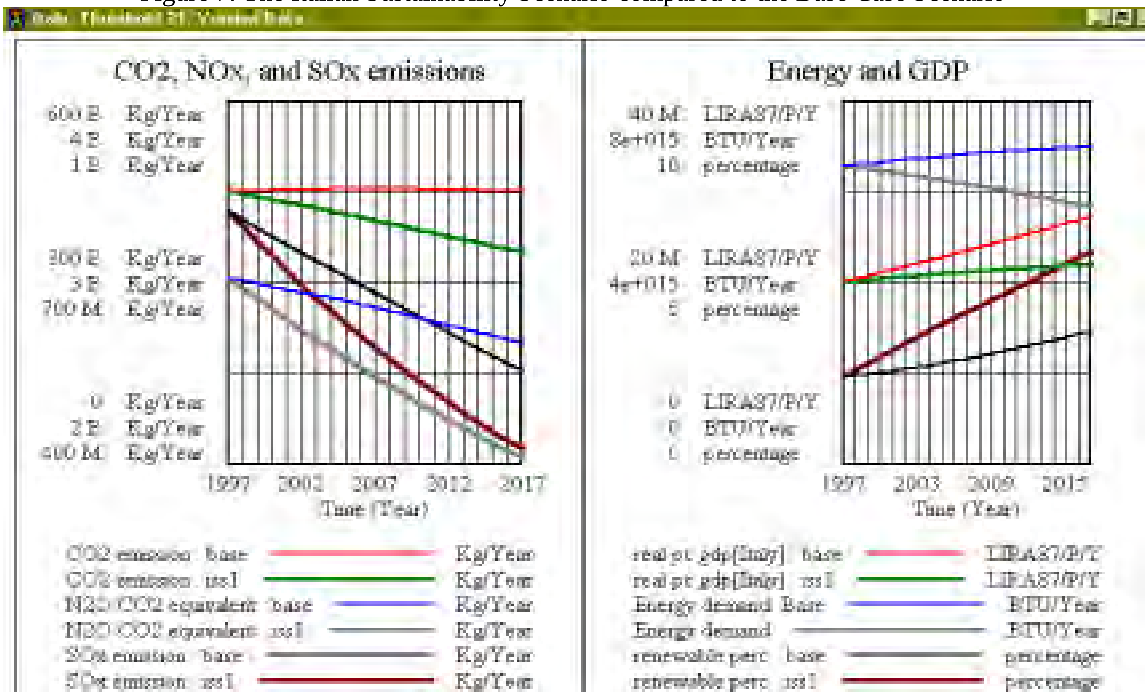
From the perspective of many of the traditional measures of progress, this Italian Sustainability Scenario performs adequately, if not well. Now, however, when we add in some of the EU indicators of Sustainable Development, the picture looks very different, especially when we examine the environmental indicators.

Of the EU Sustainable Development Indicators of Economy in the model, GDP per capita continues to rise, while the industry value added declines. However, per capita energy consumption is declining, and the renewable share rises from 2.4 to 5.9 %.. The EU Social Indicators of Development appear about the same as in the Conventional Development Scenario case. The EU Indicators of the Environment show good, declining emission levels for greenhouse gases, and while per capita domestic water consumption is slowly rising and the amount of land in agriculture is slowly declining, forests are recovering, and per capita arable land is increasing.

Hence, by slowing economic growth, some significant reductions in emissions and modest reductions in the use of other resources can be achieved without totally foregoing any economic growth. Figure 7 shows some of the trajectory of a few key indicators in this Italian Sustainability Scenario as compared to the Base Case.

[14] In its generic version, THRESHOLD 21 calculates emissions of NO_x. Because of the focus in Italy on meeting the terms of the Kyoto Protocol and because there is in the IPCC Work Book a conversion factor from N_2O emissions to CO_2 equivalent emissions (but no such conversion factor for NO_x emissions), N_2O emissions rather than NO_x emissions are calculated in the Italian version of THRESHOLD 21.

Figure 7. The Italian Sustainability Scenario compared to the Base Case Scenario

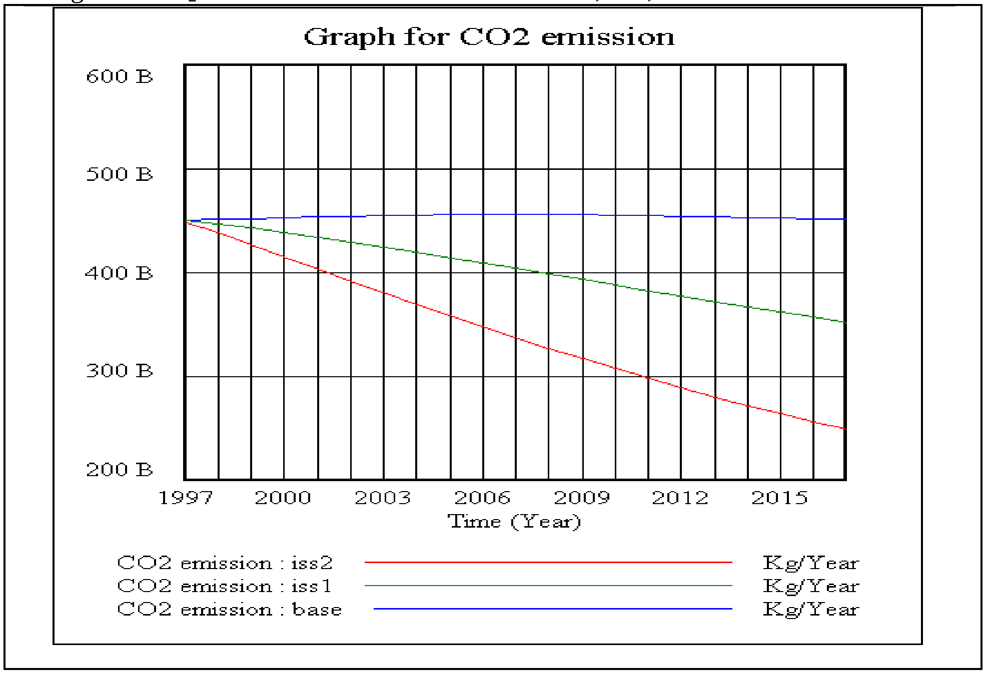


If the effects of a diminishing world oil supply are factored into the ISS scenario[15] (following the same procedure as in the CDS scenario above), we observe the following in 2017, compared with the Base Case:

- total (commercial) energy demand falls even further, from 7.00 x 10^{15} BTU/yr to 5.23 x 10^{15} BTU/yr.
- fuel imports required fall even further, from 6.06 x 10^{15} BTU/yr to 4.18 x 10^{15} BTU/yr.
- domestic energy production rises even further, from 0.93 x 10^{15} BTU/yr to 1.06 x 10^{15} BTU/yr, of which renewable climbs from 0.26 x 10^{15} BTU/yr to 0.38 x 10^{15} BTU/yr.
- CO_2 emissions fall from 451 MT/yr to 249 MT/yr.
- N_2O emissions, measured in CO_2 equivalent, fall from 2.67 MT/yr to 1.41 MT/yr.
- Total water demand falls a bit further, from 1.71 x 10^{13} kg/yr to 1.65 x 10^{13} kg/yr.
- Total capital *falls* from 19.8 x 10^{15} Lira87 to 14.6 x 10^{15} Lira87.
- Per capita GDP *does not rise at all* from 1997 to 2017 (compared to rising to 27 x 10^{6} Lira87 in the Base Case Scenario).

[15] See the discussion of lines 8 and 9 following Table 1 above and the discussion of the Conventional Development Scenario for details.

Figure 8. CO_2 Emissions in the Base Case Scenario, ISS, and ISS with restricted oil



An Aging Issue

An additional area of concern for Italian planners is the declining population size coupled with a shift in the age structure of the population. The population pyramids shown in Figures 9 and 10 graphically display this shift from 1997 to 2017. Italy is the oldest country in the world and steadily becoming older.

How well a nation takes care of its older generations can certainly be considered a measure of sustainability and, as the model confirms, providing this care may be a challenge for policymakers in the coming decades. The shift from the relatively columnar shape of the population distribution in 1997 to the inverted pyramid in 2017 implies that young people will have many more elderly relatives and friends to care for in the years ahead. It also has significance for the management of health care systems and of retirement and social security programs.

Immigration can possibly ameliorate Italy's aging issue—if the immigrants are predominately young people. But even if the immigration rate should triple from 50,000/year to 150,000/year, the resulting population pyramid in 2017 is only slightly changed (see Figure 11). The reality is that Italy is the oldest country in the world, and it is going to become older.

Figure 9. Population Pyramid for Base Case Scenario, 1997

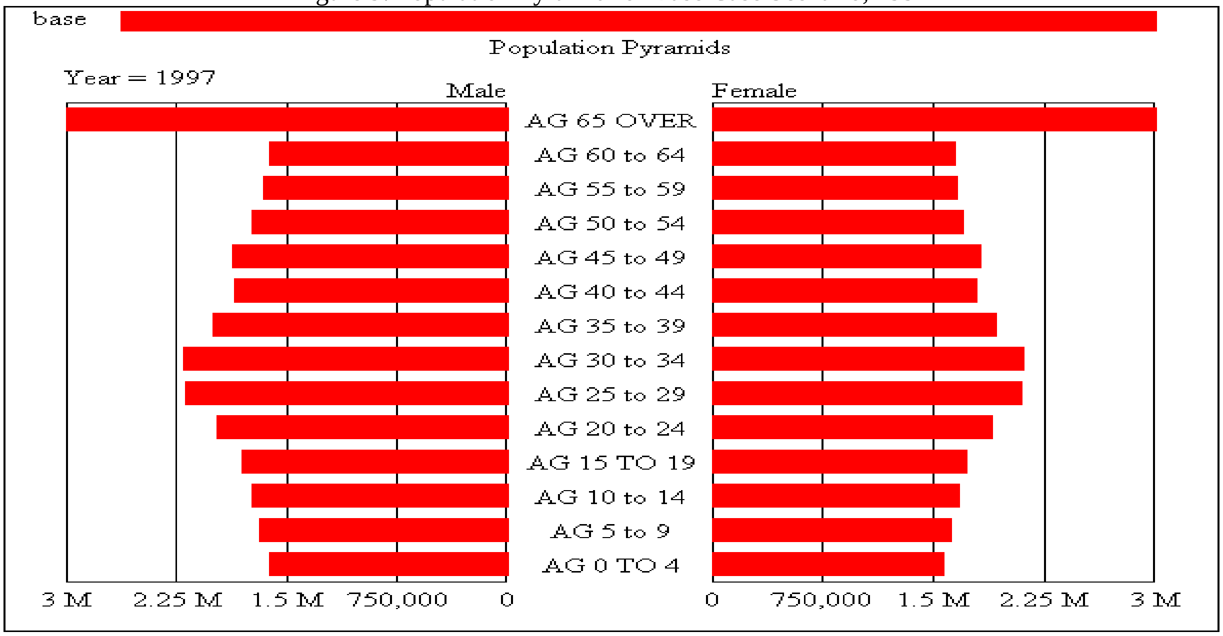


Figure 10. Population Pyramid for Base Case Scenario, 2017

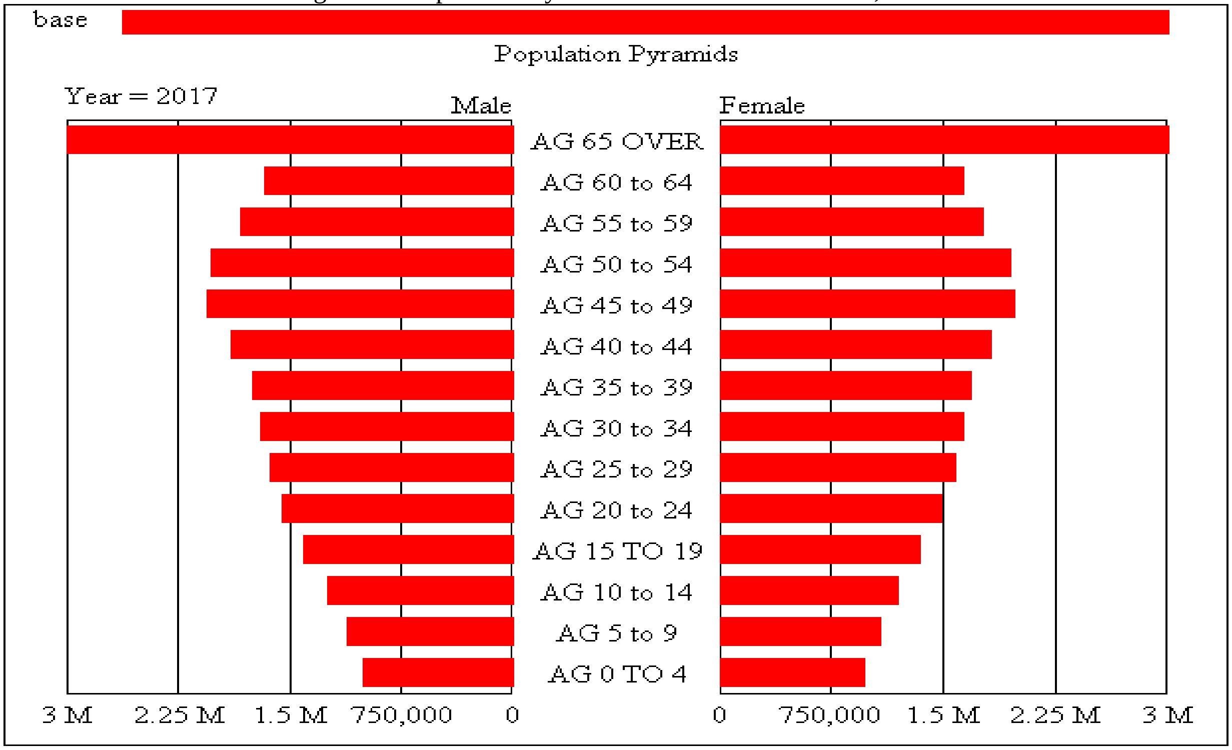
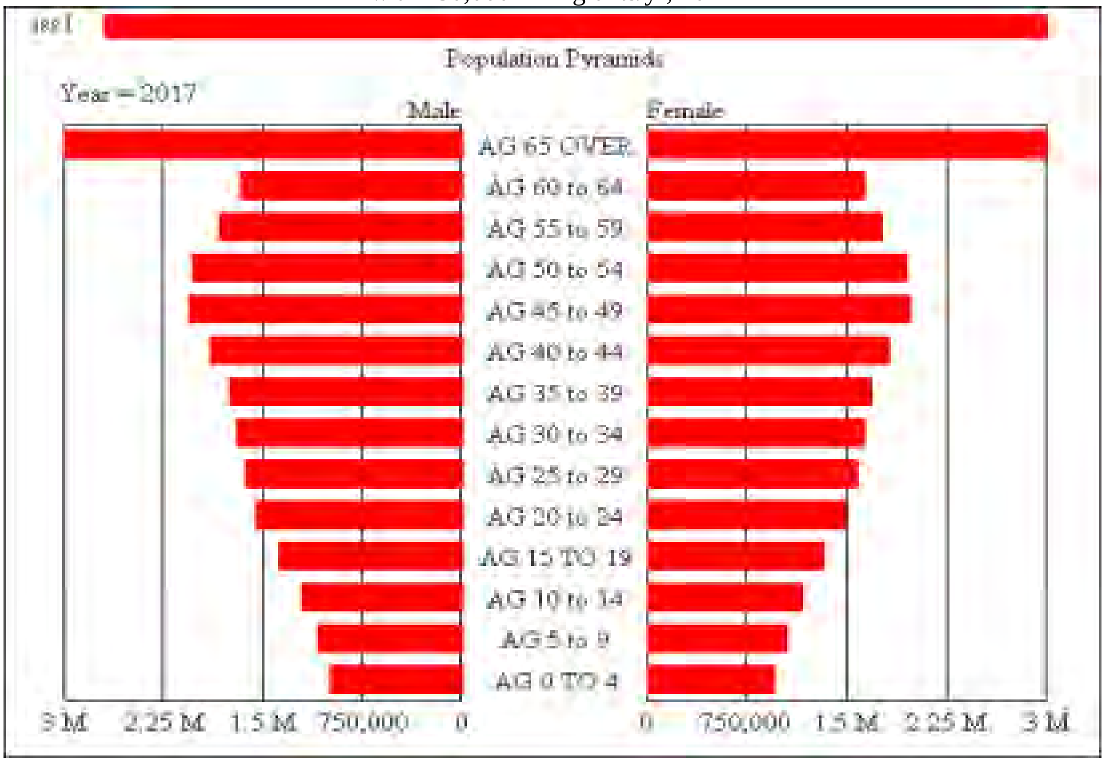


Figure 11. Population Pyramid for Italian Sustainability Scenario

with 150,000 immigrants/yr, 2017



The “dependency ratio” (the additional proportion of the total population that each worker is supporting) is another indicator of how heavily the burden of caring for the elderly is felt by young workers. The simulations show that in spite of the declining population size and age structure, the dependency ratio (defined as the ratio of non-labor force population/labor force population) improves, from 1.371 to 1.244 over the period 1997 to 2017. This unexpected result is because the total labor force as a proportion of the total population increases despite the declining population (see Figure 12). This result is highly dependent on the trend of women entering the workforce in a very significant way (see Figure 13), a trend which is assumed to continue.

Immigration, while adding more workers to the labor force, does not help the dependency ratio very much because immigrants also add to the total population.

Figure 12. Dependency Ratio for Base Scenario
and Italian Sustainability Scenario with 150,000 immigrants/yr

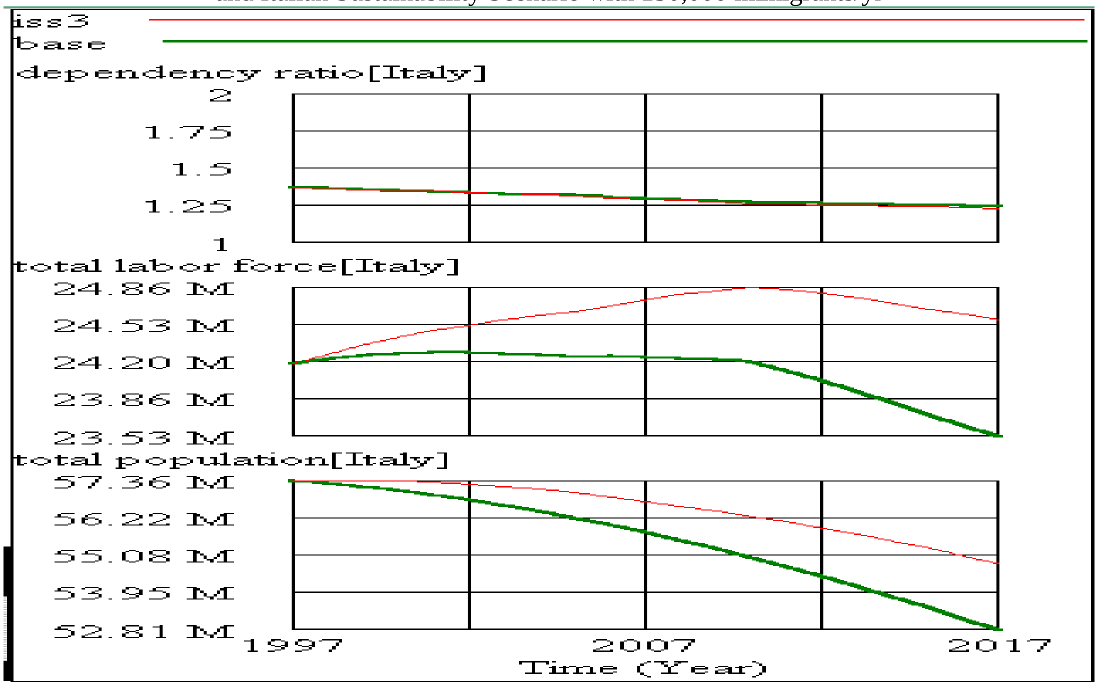
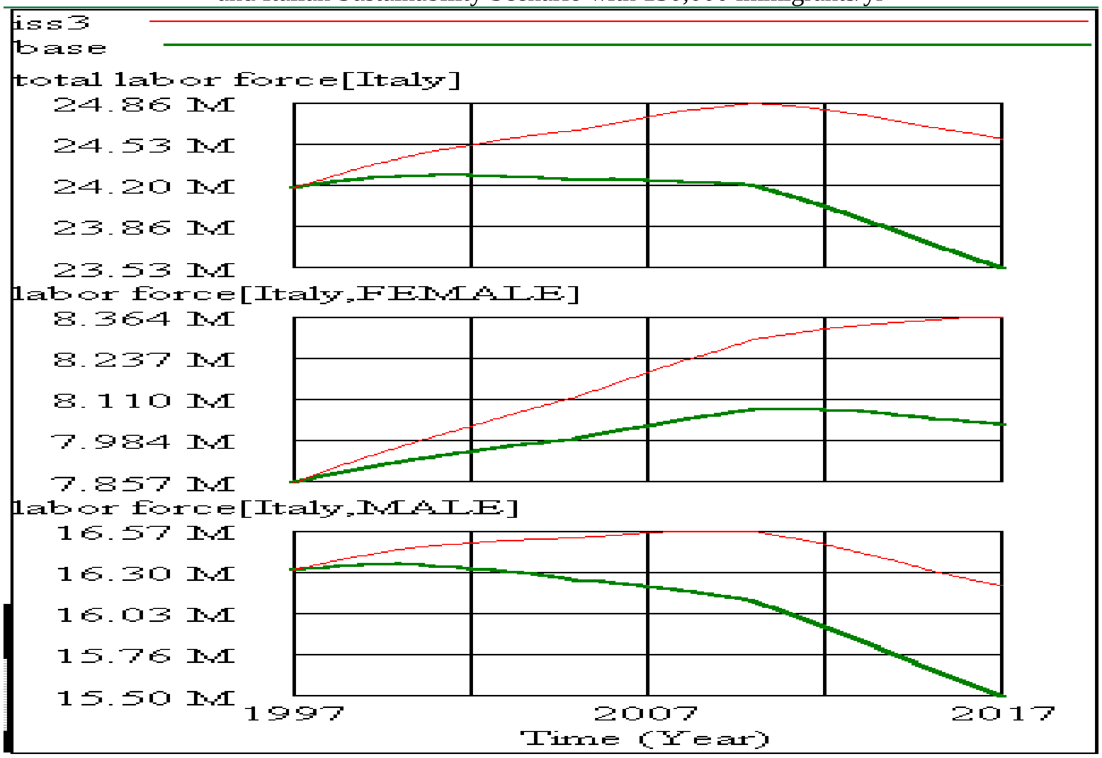


Figure 13. Total Labor Force with Female and Male Components for Base Scenario
and Italian Sustainability Scenario with 150,000 immigrants/yr

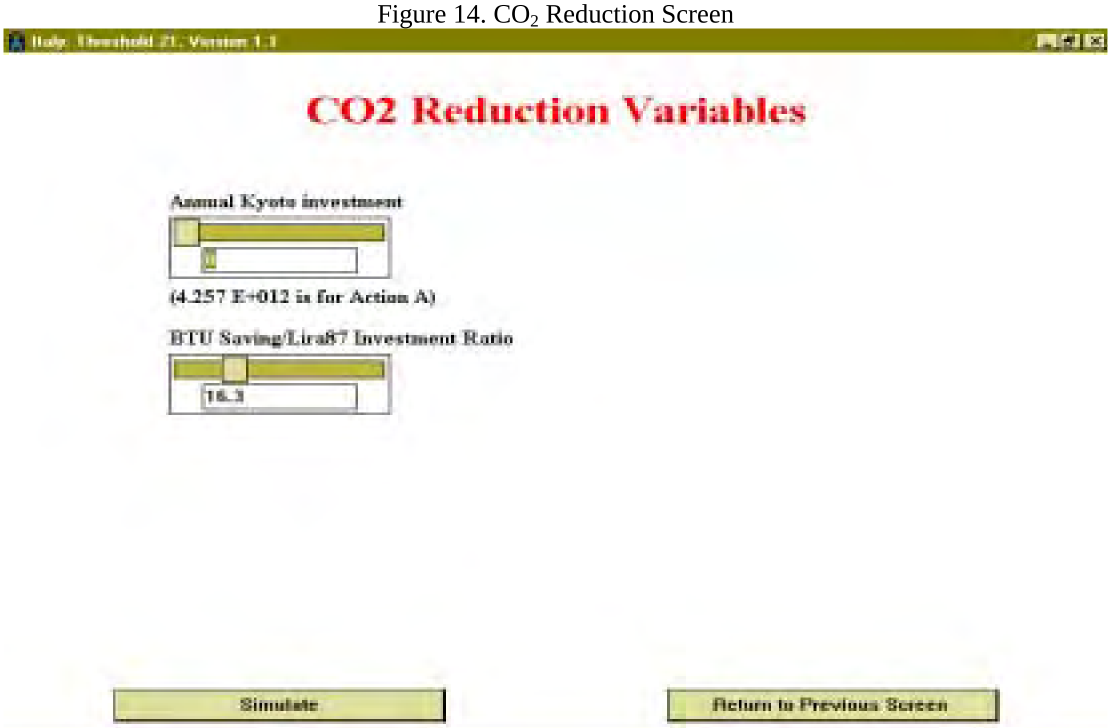


The Greenhouse Gas Emission Reduction Scenario: Meeting the Kyoto targets

This scenario is based on the data and assumptions derived from the document *Excerpt from the Second National Communication to the United Nations Framework Convention on Climate Change* (hereafter, "Second National Communication," or "SNC"). A number of technical assumptions and calculations are needed to put the data and assumptions of the SNC into the THRESHOLD 21 model, and these are presented in Appendix D.[16]

When running this scenario, all the Domestic Investment Biases on the Policy Selection Screen of THRESHOLD 21 are kept at the value of 1. Investments are made from a separate screen called *CO_2 Reduction Variables.* When investments are made to reduce emissions, the funds to cover the investments are taken all other sectors in proportion to their current investment size. The actual changes will be made on the following screen.

Figure 14. CO_2 Reduction Screen



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[16] In reviewing the numbers and assumptions in the *SNC*, a number of questions arose. A few key points follow. The THRESHOLD 21 model projects economic growth based on past performance and the mix of investments chosen; the SNC assumes economic growth rates higher than could be explained with THRESHOLD 21. The lower values of GDP were used in our analyses. The SNC assumptions of energy imports are higher than the THRESHOLD 21 results, possibly due to the differences in GNP projections. Historic data show that Italy has been reducing its energy demand per unit of real GDP; the trend is assumed to continue and Action A is in addition to the trend. The algorithms used in THRESHOLD 21 are derived from the IPPC Workbook, the international standard on such matters, and they apparently differ from those used to prepare the SNC. There are several questions about methane and net carbon dioxide emissions that cannot be answered from the information in the SNC. Reductions of emissions not related to energy consumption, such as reclamation of landfills (for CH_4 reduction) and improvements in industrial processes (for N_2O reduction), are not implemented in the current version of THRESHOLD 21, so all reductions of emissions come from reduced combustion of gas, oil, and coal. See Appendix D for further details.

The Kyoto scenarios focus on the two variables: annual Kyoto investment and BTU Saving/Lira87 Investment Ratio.

The default value of annual Kyoto investment (see Figure 14) is zero, which means Italy makes no special effort to meet the Kyoto targets. This is the value THRESHOLD 21 uses for its Base scenario. The default value for BTU Saving/Lira87 Investment Ratio (see Figure 14) is 16.3, which is based on the data from SNC[17].

If the investment to save energy (i.e., annual Kyoto investment) is set to non-zero values, it means that an annual investment of one-tenth percent of that value is made each year over the ten-year period 1998-2007; this investment is deducted proportionally from the investment in all other sectors, including industry, services, and agriculture.

The Kyoto scenarios are evaluated against emission indicators from the THRESHOLD 21 Base scenario as shown in Table 3.

Table 3. Base scenario emissions in $MtCO_2$

	1990	1995	2000	2005	2010
CO_2 energy	439	444	446	448	447
CO_2 non-energy	30.2	32.2	34.2	36.5	38.5
CH_4 energy	12.5	13.8	14.6	15.3	15.9
CH_4 non-energy	55.8	55.6	55.9	55.5	54.8
N_2O energy	3.3	3.2	3.1	3.1	3.0
N_2O non-energy	0	0	0	0	0
Absorption	26.9	28.0	29.4	30.8	32.4
Total Net	513.9	520.8	524.4	527.5	526.8
Total Gross	540.8	548.8	553.8	558.4	559.2

Note that greenhouse gas emissions comes from six sources: CO_2 energy (from fossil fuel consumption), CO_2 non-energy (from non-energy sources), CH_4 energy, CH_4 non-energy, N_2O energy, and N_2O non-energy. THRESHOLD 21-Italy follows the IPCC Workbooks[18] which do not include N_2O non-energy emission; so the values for N_2O in THRESHOLD 21-Italy are all zero. Absorption (also referred to as a “sink”) means the absorption of greenhouse gas by forest and soil due to forest area increase or forest density increase. Total Gross in Table 3 is the sum of the emissions from the six sources, and Total Net is equal to Total Gross minus Absorption.

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[17] There is uncertainty in the value of the BTU Saving/Lira 87 Investment ratio, and THRESHOLD 21 provides flexibility in this parameter. If one wishes to base the parameter on the total cost in Action A of SNC (Blit 71,000) the ratio is 16.3. If one wishes to use the net cost (Blit 27,000), the ratio is 43. See Item II.1 of Appendix D for further details. A wide range of values can be explored easily with the model.

[18] Intergovernmental Panel on Climate Change (IPCC), IPCC Guidelines for National Greenhouse Gas Inventories: Greenhouse Gas Inventory Workbook. JPCC Technical Support Unit, London. 1994.

In the THRESHOLD 21 Base scenario, Total Gross emission will increase from 540.8 Mt CO_2 in 1990 to 559.2 Mt CO_2 in 2010, an increase of 3.4%. The Italian Government has set a target for its total gross emission for 2010 of 7% below the 1990 level, which is 502.9 Mt CO_2. Thus the Base scenario results in emissions that are 56.3 MtCO_2 are in excess of the target. This is not serious, however, as shown below for the Kyoto scenarios.

For the Kyoto1 we change the annual Kyoto investment in Figure 14 from zero to Blit 4.257e+012/year for 10 years beginning in 1998. The following table presents the greenhouse gas emissions from the Kyoto1 Scenario measured in million ton CO_2 equivalent.

Table 4. Kyoto1 Scenario Emissions in Mt CO_2. Kyoto investment of 4.257e+12/year for 10 years.

	1997	**2000**	**2005**	**2010**
Kyoto1 CO_2 energy	444.7	436.4	414.9	400.5
Kyoto1 CO_2 non-energy	32.9	34.2	36.5	38.5
Kyoto1 CH_4 energy	14.2	14.3	14.4	14.5
Kyoto1 CH_4 non-energy	55.8	55.6	55.1	54.4
Kyoto1 N_2O energy	3.2	3.1	2.8	2.7
Kyoto1 Absorption	28.5	29.3	30.8	32.4
Kyoto1 Total Net	522.2	514.3	492.9	478.2
Kyoto1 Total Gross	550.8	543.7	523.6	510.5

Note: Table 3 does not list emission values for 1990 and 1995, as Kyoto1 Scenario (and all other scenarios) start from 1997, and all pre-1997 values are the same as the Base Scenario. Investments for the Kyoto scenarios start in 1998.

Comparing Table 4 with Table 3, we see that total gross emission has been considerably reduced for 2010, from 559.2 to 510.5. While this figure is still higher (1.5%) than the Italian government's target of 502.9 Mt CO_2, it is very close. Italy can obviously meet the Kyoto target if the assumptions in the *Second National Communication* are correct (see Appendix D).

Does the Kyoto1 Scenario seriously affect economic development? Let us look at the following table which compares three variables between the Base and the Kyoto1 Scenarios: GDP, energy demand, and percentage of renewable energy.

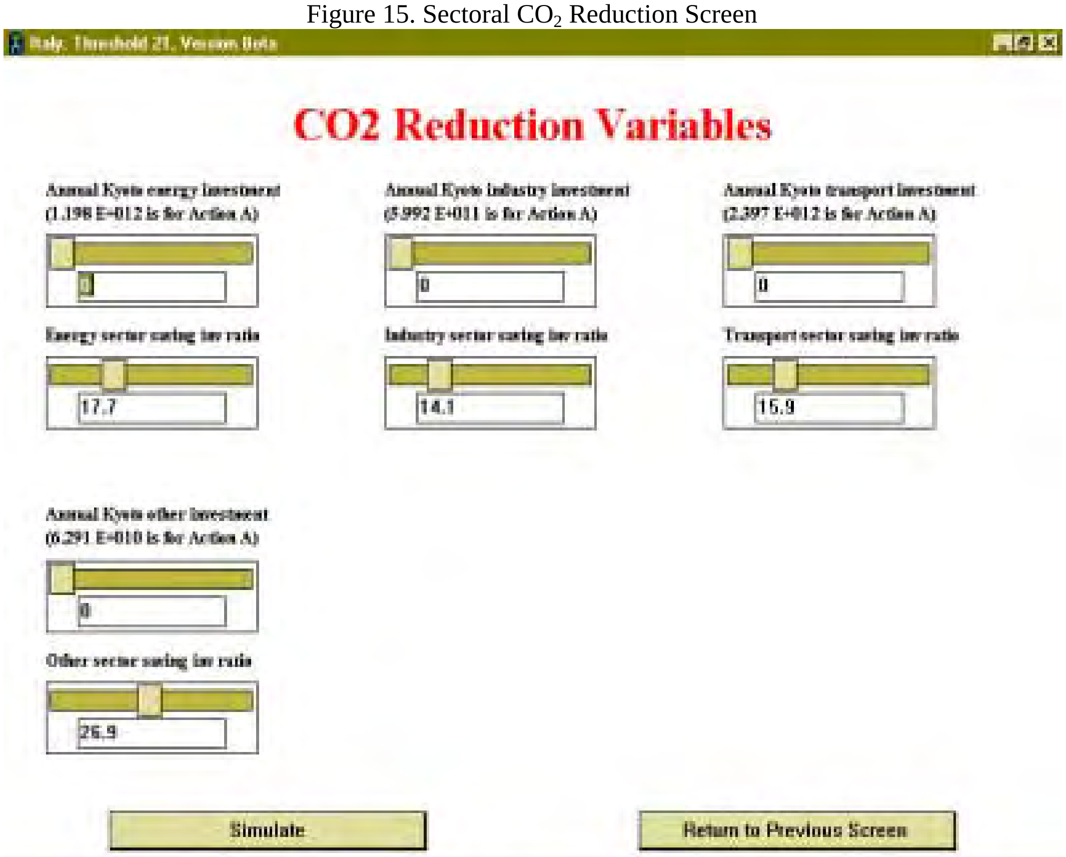
Table 5. Comparison Between Base and Kyoto1 Scenarios

Time (Year)	1997	2000	2005	2010
Base Real GDP Lit87	1.1578E15	1.2041E15	1.2838E15	1.3552E15
Kyoto1 Real GDP Lit87	1.1578E15	1.2032E15	1.28210E15	1.3518E15
Base Energy Demand BTU	6.57E15	6.65E15	6.79E15	6.89E15
Kyoto1 Energy Demand BTU	6.57E15	6.51E15	6.30E15	6.19E15
Base Renewable %	2.43	2.54	2.80	3.12
Kyoto1 Renewable %	2.43	2.60	3.01	3.46

Table 5 shows a 10% reduction in energy demand in 2010, from 6.89 E15 BTU to 6.19 E15 BTU, but the GDP is essentially unaffected. In 2010, the GDP reduction is less than 0.3%. The reason for the small impact on GDP relates to data and assumptions in both the *Second National Communication* and THRESHOLD 21. The SNC assumes a small percentage (less than 2%) of total domestic investment generates big (about 10%) energy savings, and THRESHOLD 21 assumes that a 2% or less reduction in total domestic savings has little influence on GDP. As a result GDP is reduced only slightly.[19]

At ANPA's request, a separate user interface was developed so that the investments for the Kyoto1 scenario can be made on a sectoral basis (refer to Item IV.4 of Appendix D). This interface— the CO_2 Reduction screen—includes four sectors: energy, industry, transport, and other (civil and agriculture), as Figure 15 shows.

Figure 15. Sectoral CO_2 Reduction Screen



[19] The *Second National Communication* reports that for a net annual investment of 4.257 E12 Lira87 for ten years, substantial energy savings (1.64 Mtoe or 69.4 E12 BTU) will be achieved in next year and in all following years (refer to Item II.1 of Appendix D). In the Base Case, the total domestic investment for 1998 is 2.70 E14 Lira87, and for 2007 it is 3.28 E14 Lira 87, we can see that the investment required to meet the SNC (4.257 E12 Lira87) is only 1.3% to 1.6% of total domestic investment. In THRESHOLD 21 we assume that GDP is a function of investment, labor, technology, and resources. Labor, technology, and resources are essentially unchanged and total investment changes only slightly.

If the investment slide bars for all the four sectors are moved to the indicated values (1.198E12 for energy, 5.992E11 for industry, 2.397E12 for transport, and 6.291E10 for other), the same scenario results are generated as the Kyoto1 scenario.

Scenario Kyoto 2 explores what would happen if the international oil supply were to tighten. The method used is described above following Table 2, lines 8 and 9. As in the previous cases, the oil resource elasticity on price was changed from -1 to -2, and the elasticity of oil price on imports was changed from -0.1 to -0.5. These changes represent the possibility that, relative to the Base Case, world oil prices would increase faster, and Italy's ability to import all the oil it needs would be lower. Selected results are presented in Table 6.

Table 6: Major results of Kyoto2 Scenario

Time (Year)	1997	2000	2005	2010
Energy Demand in BTU	6.57E15	6.41E15	6.01E15	5.73E15
Real GDP Lira87	1.1578E15	1.1823E15	1.2235E15	1.2554E15
Net GH gas emission in $MTCO_2$	522.2	489.7	431.8	385.7

Compared with the Kyoto1 scenario, Kyoto2 has 7.4% lower energy demand, produces 7.1% lower GDP, and emits 19.1% less greenhouse gases by 2010.

There are a number of aspects of the *Second National Communication* that appear to be overly optimistic (see Appendix D), and to test the robustness of the SNC we prepared the Kyoto 3 scenario in which we reduced by a factor of two the impact of investments to reduce energy consumption and CO_2 emissions. Meeting the Kyoto targets will still have relative little impact on the Italian economy. This findings confirm that Italy is able to meet its Kyoto commitments to CO_2 reductions with very little impact on its economy.

Conclusions

Italy's Sustainability

The Base Case Scenario. This scenario demonstrates that Italy has already achieved several critical aspects of a sustainable industrial future as measured by many different indicators of sustainable development. Italy's stable (actually declining) population, opportunities for women, and high education levels are particularly important determinants of sustainability that have proven difficult to achieve in many countries. Italy's weaknesses are primarily in its dependence on foreign sources of energy, its emissions of gaseous pollutants, and its immigration rates. Development of renewable energy resources and energy conservation can reduce dependence on imports. Abatement and conservation technologies can reduce emissions.

Aging and declining population. As populations stabilize, the age distribution shifts toward more elderly and fewer young, and Italy is experiencing this phenomena. Under all scenarios investigated, Italy's population continues to decline and age. The changing age structure can create difficulties for the management of education, health care, retirement programs, and social security systems. Immigration (especially of young workers) and women entering the workforce help to ease the transition to a mature, stable age distribution. Nonetheless, the shifting age structure of Italy's population needs careful study, especially its impacts on education, health care, retirement, and social security programs.

The Greenhouse Gas Emission Reduction (Kyoto) Scenario. By investing in the energy saving technologies identified in the SNC, Italy can meet its commitments to CO_2 reduction under Kyoto protocol with very little economic impact. Even after compensating for some optimistic assumptions in the SNC, the economic impact is likely to be only 1% reduction in real GDP.

Single-Sector Investment Scenarios. Scenarios in which investments are shifted into individual sectors provide several insights.

- Heavy investment in agriculture increases agricultural production per capita and reduces pollutants and energy demand. It also reduces GDP and total capital.
- While investment in the Environment sector reduces N_2O and SO_x, investments in energy conserving technologies are required to reduce CO_2 emissions.
- Modest investment in the military will have little effect, either positive or negative, on sustainability indicators because Italy invests only a small percentage of GDP in the military.

The Conventional Development Scenario. Pursuing a policy of maximizing GDP also maximizes the rates of natural resource depletion and of waste generation; water and energy resources are most severely affected. Greenhouse gas emissions are also increased. This scenario assumes a continuation of trends of improved energy efficiency and pollution reduction, but no wholesale changes or upgrades of technology.

The Italian Sustainability Scenario. Shifting investment from the Industrial and/or the Services sectors maximizes progress toward sustainable development as measured by several indicators chosen by ANPA from among those developed by the EU (especially transportation). The shifts also help Italy meet its obligations under the Kyoto protocols.

Scenarios in which assumptions about the rest of the world are changed. Tests of alternative assumptions about the world outside Italy show that:

- In all scenarios, immigration from the rest of the world is large. Since immigration is not entirely in Italy's control, it will be important for Italy to have constructive relations with the source countries and to assist them in creating conditions that allow effective management of immigration flows.
- As world petroleum resources decline, world oil prices can be expected to rise, thus reducing the amount of oil Italy can afford to import. In some cases, the economic consequences could be quite serious. A policy of investment in energy conservation and renewable energy can reduce this national vulnerability.
- Higher world energy prices lead Italy to burn less fossil fuel overall, which leads to less emissions of greenhouses gasses and SO_x.

Indicators of Sustainability

Sustainability involves meeting the needs of the current generation in ways that do not make more difficult the task of future generations to meet their own needs. Since meeting a generation's needs requires both renewable and non-renewable natural resources, indicators of sustainability must measure the flows of natural resources from their sources into the economy and back out again into waste disposal spaces or "sinks."[20]

- The Base Case scenario illustrates the inadequacy of GDP as an indicator of sustainability or even "progress;" it measures the rate of economic activity but tells us nothing about the flows from resource sources to waste sinks.
- The Italian indicators of sustainability are strong in drawing attention to flows into waste, but they are too numerous to provide a convenient single overall measure of sustainability.
- The "ecological footprint" and the "environmental space" indicators would be useful additions because they provide an overall measure of the resource flows within the country and also draw attention to environmental impacts a country produces outside its borders through trade[21].

Usefulness of THRESHOLD 21

The analysis presented in this paper demonstrates a new technological tool—the THRESHOLD 21 national sustainable development model—that allows the integration of environmental considerations into the full range of factors considered throughout an entire national government. The technology provides a common language through which objectives of different parts of the government (e.g., maximizing GDP, or minimizing CO_2 emissions) can be discussed thoughtfully and productively. The tool is relatively transparent and easy to understand which allows it to foster public involvement and consensus in the decision-making process. Conflicts can be addressed constructively, and collective actions explored that achieve the best part of many different objectives.

While this work is an important first step toward the kind of integrative analytic tool called for by CIPE, further improvements in THRESHOLD 21 are needed to achieve the CIPE vision. In particular, it would be useful to have:

- the representation of the costs and benefits of resource conserving and waste-reducing technologies refined and strengthened,
- trade, financial exchanges, resource flows, migration, and waste flows represented in more detail, and
- the pension system, tourism solid waste, water pollution, transportation, and technology sectors added or expanded.

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[20] There can be reuse and recycling flows back into the economy. Such flows are not recognized now in some measures of sustainability. Without consideration of this possibility, definition of sustainability is too restricted.

[21] There are typically two phases to the development of indicators. In the first phase, many indicators are suggested and a national list is developed that is often too long. In the second phase, a higher level (aggregate) indicator is developed to support decision makers working at a high level of aggregation. Currently in Italy there is no agreement on a high level indicator.

Appendices

Appendix A: The Main International Environmental Conventions Italy has Joined

The following preliminary draft summary of the main international environmental conventions which Italy has joined was prepared by ANPA staff.

I. Transboundary Air Pollution
   A. Geneva Convention:
      1. Date of adoption: 1979
      2. Place of adoption: Geneva
      3. Date of entry into force: 16 March 1983
   B. Sofia Protocol:
      1. Date of adoption: signed in 1988
      2. Place of adoption: ratified in 1992
      3. Date of entry into force:
      4. Date of entry into force in Italy:
      5. Object:
         a) Within 31/12/1994, NO_x stabilization of 1987 limits.
         b) Within 1/1/1998, 30% NO_x emissions reduction of 1987 value (1986=1473000 tons).
   C. Oslo Protocol:
      1. Date of adoption: 1994
      2. Place of adoption:
      3. Date of entry into force:
      4. Date of entry into force in Italy:
      5. Object: SO2 reduction within 2000 and of 73% SO2 reduction within 2005 with reference to 1980 (3196000 tons).

II. Biological Diversity
   A. "Convention relative to the preservation of fauna and flora in their natural state"
      1. Date of adoption: 8 November 1933
      2. Place of adoption: London
      3. Date of entry into force: 14 January 1936
      4. Date of entry into force in Italy: 27 September 1939
      5. Object: To preserve the natural fauna and flora in some parts of the world, particularly in Africa, by means of national parks and reserves, and by regulation of hunting and of collection of species.
   B. "International Convention for the Regulation of Whaling" (ICRW)
      1. Date of adoption: 2 December 1946
      2. Place of adoption: Washington
      3. Date of entry into force: 10 November 1948
      4. Date of entry into force in Italy: 3 February 1979
      5. Object: To establish regulations for purposes of conservation and utilization of whale resources, and to serve as an agency for the collection, analysis, and publication of scientific information related to whales and whaling.

C. "International Convention for the protection of birds"
   1. Date of adoption: 18 October 1950
   2. Place of adoption: Paris
   3. Date of entry into force: 17 January 1963
   4. Date of entry into force in Italy: 8 June 1979
   5. Object: The protection of bird species in the wild, considering their interest for the protection of nature in general and for the economy of each nation, and their particular interest for science.

D. "International Convention on plant protection "
   1. Date of adoption: 6 December 1951
   2. Place of adoption: Rome
   3. Date of entry into force: 3 April 1952
   4. Date of entry into force in Italy: 3 August 1955
   5. Object: To maintain and increase international co-operation in controlling pests and diseases of plants and their products, and in preventing their introduction and spread across national boundaries.

E. "Union pour la protection des oprention vegetables" (UPOV)
   1. Date of adoption: 2 December 1961
   2. Place of adoption: Geneva
   3. Amended in Geneva, Switzerland, on:
      a) 10 November 1972
      b) 23 October 1978
      c) 19 March 1991 ("International Convention on the Protection of the New Plant Varieties")
   4. Date of entry into force in Italy: 28 May 1986
   5. Object: to define and control the property rights of the creator of the new plant species and institute the "Union pour la protection des operation vegetables" in Geneva.

F. "Convention on Wetlands of International Importance" (The Ramsar Convention).
   1. Date of adoption: 2 February 1971
   2. Place of adoption: Ramsar
   3. Date of entry into force: 21 December 1975
   4. Date of entry into force in Italy: 14 April 1977
   5. Object: to provide the framework for international cooperation for the conservation and wise use of wetlands and their resources. The Convention was amended with a Protocol approved in Paris, 3 December1982.

G. "Convention Concerning the Protection of the World Cultural and Natural Heritage"
   1. Date of adoption: 23 November 1972
   2. Place of adoption: Paris
   3. Date of entry into force: 17 December 1975
   4. Date of entry into force in Italy: 23 November 1978
   5. Object: To establish an effective system of international protection of cultural and natural heritage of outstanding universal value, organized on a permanent basis, in accordance with modern scientific methods.

H. "Convention on International Trade in Endangered Species of Wild Fauna and Flora" (CITES)
   1. Date of adoption: 3 March 1973
   2. Place of adoption: Washington
   3. Date of entry into force: 1 July 1975
   4. Date of entry into force in Italy: 10 October 1979
   5. Object: to establish worldwide controls on the international trade in threatened species of animals and plants. It requires that this trade be subject to authorization by government-issued permits or certificates. In the case of species threatened with extinction, CITES prohibits all commercial trade in wild specimens. This Convention was amended in Bonn, Germany, on 22 June 1979.

I. "Convention on the Conservation of Migratory Species of Wild Animals" (CMS) (The Bonn Convention)
   1. Date of adoption: 23 June 1979
   2. Place of adoption: Bonn
   3. Date of entry into force: 1 November 1983
   4. Date of entry into force in Italy: 1 November 1983
   5. Object: to conserve terrestrial, marine and avian migratory species throughout their range. Italy have also signed, but not ratified, the agreement on the Conservation of Small Cetaceans of the Baltic and North Seas.

J. "Convention on Biological Diversity" (CBD)
   1. Date of adoption: 22 May 1992
   2. Place of adoption: Nairobi
   3. Date of entry into force: 29 December 1993
   4. Date of entry into force in Italy: 14 February 1994
   5. Object: The objectives of this Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding.

III. Desertification

A. "United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa" (CCD)
   1. Date of adoption: 17 June, 1994
   2. Place of adoption: Paris
   3. Date of entry into force: 26 December, 1996
   4. Date of entry into force in Italy: 21 September, 1997
   5. Object: to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas.

IV. Protection of the Atmosphere
   A. Transboundary Cooperation
      1. Date of adoption: 1980
      2. Place of adoption: Madrid
      3. Date of entry into force: 22 December, 1981
   B. Vienna Convention for the Protection of the Ozone Layer
      1. Date of adoption:1985
      2. Place of adoption: Vienna
      3. Date of entry into force: 1 January, 1989
      4. Object: Outlines state's responsibilities for protecting human health and the environment against the adverse effects of ozone depletion.
   C. "Montreal Protocol" on substances that deplete the Ozone Layer
      The Montreal Protocol on Substances That Deplete the Ozone Layer is a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere—chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform—are to be phased out by 2000 (2005 for methyl chloroform).
      1. Date signed in Italy: 1988
      2. London Amendment (1990) signed in 1993
      3. Copenhagen Amendment (1992) signed in 1993

CFC (1986)	**Stabilization**	**% Reduction**	**Elimination**
Montreal Protocol (1987)	1.7.1991	20% within 1993 50% within 1999	
London Amendment (1990)		20% within 1993 50% within 1995 85% within 1997	2000
Amendment Copenhagen (1992)		75% within 1994	1996
Regolamento UE n°3093/94		85% within 1994	1.1.1995

Halons (1986)			
Montreal Protocol (1987)	1.7.1992		
London Amendment (1990)		50% within 1995	2000
Amendment Copenhagen (1992)			1995
Regolamento UE n°3093/94			1.1.1994

Carbon Tetrachloride (1989)			
London Amendment (1990)		85% within 1995	2000
Amendment Copenhagen (1992)		75% within 1994	1996

Regolamento UE n°3093/94		85% within 1994	1.1.1994

Methyl Bromide (1991)			
Amendment Copenhagen (1992	1991		
Vienna Meeting (1995)		25% within 2001 50% within 2005	2010
Regolamento UE n°3093/94		25% within 1998	
L. 549/93		25% within 1998 50% within 2005	1.1.2000
D.L. 315/96			1.1..2009

Hydro-bromofluorocarbons (HBFC)			
Regolamento UE n°3093/94			1.1. 1996

Hydrochlorofluorocarbons (HCFC)			
Amendment Copenhagen 1992	1.1.1995	35% within 2004 65% within 2010 90% within 2015 95% within 2020	1.1.2030
Regolamento UE n°3093/94		35% within 2004 60% within 2007 80% within 2010 95% within 2013	1.1.2015

A. "Convention on Climate Change" (CCC)

1. Date of adoption: 9 May 1992
2. Place of adoption: New York
3. Date of entry into force: 21 March 1994
4. Date of entry into force in Italy: July 14 1994
5. Object: to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. 7% CO_2 reduction within 2000 with reference to 1990 (400-421 Mtons)

1. Protection of the sea
   - Barcellona Convention on Mediterranean Sea Protection

     Date of adoption: 1976
     Place of adoption: Barcellona
     Date of entry into force: 12 February 1978
     Date of entry into force in Italy:1995
   - "United Nations Convention on the law of the sea" (UNCLOS)

     Date of adoption: 10 December 1982
     Place of adoption: Montego Bay
     Amended in: 28 July 1994
     Date of entry into force: 16 November 1994
     Date of entry into force in Italy: 13 January 1995
     Object: All aspects of the use of the oceans, from the edge of the coast to the bottom of the deepest sea are addressed in this convention. The article 194 § 5 of this Convention establish the obligation to preserve the marine ecosystems, particularly those related to the habitats of endangered species.

2. Deforestation
   - Convention on the Alps on mountain forests

     Date of adoption: 1991
     Place of adoption: Salisburgo
     Date in which Italy signed the protocol to activate the Convention: 27 February 1996
     Object: The objectives of this Protocol are the conservation of alpine land and the sustainable use of its components.

3. Hazardous wastes
   - Base l Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

     Date of adoption: 1989
     Date of entry into force: 1992
     Date of entry into force in Italy: 1994
     Object: This global environmental treaty strictly regulates the transboundary movements of hazardous wastes and provides obligations to its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner.

Appendix B: The THRESHOLD 21 Model

Introduction

This appendix provides a brief overview of THRESHOLD 21, its major assumptions, and a description of how the model is used. Further information is available in the THRESHOLD 21 documentation (Part II of this report) and in the help screens of the model itself.

The Model: An Overview

The name THRESHOLD 21® was chosen with the intention of conveying a sense of opportunity and possibility for the future at the passage from the 20th century to the 21st.

THRESHOLD 21 is an integrated national sustainable development model. It answers the question: *How will the economic growth, social development, and environmental condition of the country change if incentives shift the balance of investment funds among the sectors of the economy.*

The model is "transparent" in that it is easily understood and can be helpful in increasing understanding, communication, and cooperation. The model creates a 'forum' in which policy-makers think and speak with each other in a common language, where their 'mental models' are graphically displayed and available for discussion, improvement, and cooperation.

THRESHOLD 21 is a continuous time model based on the stock-and-flow methodology used in economic, demographic, resource, environment, and social models. Advanced software technology allows the model to usefully encompass a very wide range of variables and yet to be relatively easy to calibrate from available data sources.

The design of THRESHOLD 21 was inspired by the World Bank's Revised Minimum Standard Model-Extended (RMSM-X), which analyzes the flows of funds among the current and capital accounts of the government, private, monetary, and foreign sectors. Its growth dynamics are driven by a single-input (capital) production function.

THRESHOLD 21 retains the national accounts, major aspects of the flow of funds structure, and the aggregate national and government debt aspects of RMSM-X, and has replaced the single-input production function with four input (resources, labor, capital, and technology) production functions for industry, agriculture, services, and energy. Through these inputs, connections are made to additional sector models: demography, education, environment, agriculture, water, forestry, land, nutrition, health care, energy, goods, economy, trade, service, and sometimes military. As a result, THRESHOLD 21 is able to address a wider range of questions than the World Bank's model.

THRESHOLD 21 incorporates many new sustainable development indicators as well as the traditional national accounts. As a result, the future implications of current policy alternatives can be evaluated with the new indicators as well as with GDP.

THRESHOLD 21 is based on more than twenty years' experience with hundreds of national and sector-specific models and is constantly improving. In addition to Italy, the model has been applied to the United States, Bangladesh, Benin, Cambodia, Malawi, Tunisia, and China. As the individual national models are refined and extended, the improvements are shared with other users for incorporation into other versions.

THRESHOLD 21 has been constructed with Vensim®, a 4th-generation modeling language. Vensim's diagrammatic interface allows sectoral models to be programmed accurately and rapidly, and then explained clearly and simply. Vensim's "Causal Tracing™" feature enables a user to trace the behavioral determinants of any variable or indicator with ease.

THRESHOLD 21 is quick. A twenty year simulation of the more than one thousand variables runs in just seconds on a 100 MHz Pentium personal computer. These results are not simple projections, but rather the consequences of the dynamic interactions among all of the variables in all of the sectors of the model.

The Millennium Institute's long-term goal is to have a version of THRESHOLD 21 in use in every country of the world and to link the country-specific versions together in a Global THRESHOLD 21. The global version would provide national research teams with information on the combined global consequences of the plans of 186 individual countries. It would also provide a tool for exploring scenarios under which the whole planet might move toward sustainability.

Assumptions and Structure

The assumptions and structure of the THRESHOLD 21 model and the sector specific models are described in considerable detail in a volume of documentation (see Part II of this report). The following material provides an overview of the assumptions and structure in the generic model. Appendix C provides specifics for the Italy version of THRESHOLD 21.

1. Dynamics
    - The dynamics of the model are controlled by several thousand feedback loops among the more than 1,000 variables. The major driving force of growth in the model is positive feedback. Two important positive feedback loops are (a) production provides income, some of which is invested and results in increased production; and (b) population produces births, and births produce more population.
    - Many negative feedback loops related to policy, markets, resources, and environment regulate growth from the positive feedback loops. Two important negative feedback loops are (a) population naturally has deaths and deaths mean less population; (b) capital depreciates and as a result there is less capital.

2. Economy
    - The economic sector includes the National Accounts, savings-investment balance, investment by sector, foreign debt, foreign exchange reserves, and balance of trade. Market and policy decisions combine to shift investments among the seven sectors: agriculture, goods (industry), services, energy, environment, social services, and military.

- Capital in each sector increase with investments and decrease with depreciation.
- The trade sector simulates the imports and exports of goods, energy, and food.
- The model calculates both government debt and national debt. National debt is owed to foreign creditors. Government debt is to both foreign and domestic creditors.

3. Population
   - Population change is related to births and deaths. Births are determined by conceptions. Deaths for each male and female age cohort are based on the analysis of the United Nation’s Population Database.
   - Conceptions are directly influenced by two variables: the size of the sexually active female cohorts, and their total fertility rates. Total fertility rates are influenced by many variables, including capital in social services, per capita GNP, female literacy rate, and family planning effectiveness.

4. Agriculture
   - Agricultural productivity is the product of agriculture land and land productivity.
   - Agricultural land increases with deforestation, and decreases due to land degradation, urban expansion, and population increase.
   - Land productivity is related to water availability, energy availability, soil quality , capital in agriculture, and agricultural technology.

5. Industry and services
   - Goods (industrial) production and service production are the product of labor in these sectors and employee productivity.
   - Per capita productivity of labor in goods and services is influenced by: capital in the sector, energy availability, quality of education, and technology.

6. Energy
   - Energy is classified into three categories: fossil fuel, nuclear, and renewable. Fossil fuel is further classified into oil, gas, and coal.
   - Investment in energy is allocated to fossil fuel, nuclear, and renewable. Production of nuclear energy and renewable energy are related to capital in these two energy sub-sectors. Production of fossil fuel energy depends on both capital and proven reserves. Oil, gas, and coal are modeled individually with interactions.
   - Commercial energy demand depends on real GDP and energy technology. The difference between energy demand and energy production is energy exports or imports. The model assumes that needed imports of energy are partially met (depending on the country’s economic ability) from the rest of the world.

7. Environment
    - The environment (pollution) sector simulates the generation of air pollution of CO_2, CH_4, N_2O, and SO_x from energy consumption, and non-energy industrial and agricultural activities. With an increased investment in environmental capital, the emissions of CH_4, N_2O, and SO_x, (but not of CO_2) decline after a delay. Carbon dioxide dissipation depends on the difference between national CO_2 pollution intensity and the global average CO_2 pollution intensity. The bigger the difference, the faster the dissipation.

8. Social Sector
    - The social service sector has its own capital and investment rate. Capital in Social Services influences education, health care, and family planning.
    - The education sector simulates the primary school system, including students, teachers, and classrooms. Quality of education depends on: dropout rate, student-teacher ratio, student-classroom ratio, and female enrollment ratio.
    - The health care sector simulates the numbers of doctors, nurses, and hospital beds, and from them the quality of health care indicator is derived.
    - The food and nutrition sector computes the per capita intake of calories and protein. It computes the quality of nutrition against international standards. This sector includes separately both crop food and animal food. Animal food includes beef, mutton, pork, poultry, eggs, milk, and fish.

9. Technology
    - The technology sector simulates the technological advances in agriculture, industry, services, energy, and environment. The rate of technological advance is related to the characteristics of the sector and the investment rate for the sector.

10. Rest of World
    - The Rest of World sector simulates the world oil resource and global carbon in atmosphere. When oil resource is further depleted, the real price of world oil will increase, affecting the ability of the country to meet its energy import demand. The global carbon concentration will affect the air pollution dissipation of the country.

11. Other sectors in THRESHOLD 21
    - Water, forest, land use, greenhouse gas emission, government, and HIV/AIDS

12. Indicators in THRESHOLD 21
    - The National Accounts as calculated in the World Bank's Revised Minimum Standard Model-Extended.
    - The UN Human Development Index (HDI) and Gender-related Development Index (GDI) as computed in UNDP's Human Development Report.
    - The World Bank's Monitoring Environmental Progress (MEP) indicators

- EU Sustainable Development Indicators of Economy (per capita GDP, investment percentage in GDP, industrial value added, per capita energy consumption, and percentage of renewable in energy production)
- EU Social Indicators of Development (population growth rate, net immigration rate, total fertility rate, infant mortality rate, unemployment rate, women per 100 men in labor force, population density, and percentage of urban population)
- EU Indicators of the Environment (emissions of CO_2, N_2O, SO_x, and CH_4, per capita domestic water consumption, per capita arable land, agriculture land, and forest land)
- Selected indicators from UNICEF, UNCSD, UNFPA, and UN Common Country Assessment (CCA)

Using THRESHOLD 21

Validation: Simulating the Past Before Simulating the Future

A two-step process is used in applying THRESHOLD 21. First, the model is best validated by simulating the past, typically from 1965 to 1997. Second, when the past has been satisfactorily simulated, projections are made for 20 to 50 years based alternative scenarios specified with the Policy Selection Screen of the model.

In the first step of an application, the model results are compared with historic data from various sources, such as the World Bank's World Data 1995, UN databases, and national statistics. The model is not used for future projections until it is able to reproduce history.

The main "control panel" for the THRESHOLD 21 model is the "Policy Selection Screen" (see Figure 2). From the Policy Selection Screen users can set a number of parameters which define a scenario for a future projection or simulation. Most of the parameters affect the levels of investment, either redirecting investment within the country, or setting levels of international borrowing or assistance.

The following sections provide an overview of the Domestic Investment Biases, the Investment Fraction, international assistance, and other means to enter policy decisions into THRESHOLD 21 An in-depth description of the operation of the Domestic Investment Biases is provided in the detailed model documentation (see Part II of this report).

Overview of the Domestic Investment Biases

The Domestic Investment Biases are all set to 1 during the fitting of the model to historic data. As a result, making a projection with the Domestic Investment Biases all set to 1 continues into the future. Increasing the bias for a particular sector represents a change of tax, subsidy, and other policies that result in making investments in that sector more attractive than under current policies. Decreasing the bias has the opposite result.

The specific effects of the Domestic Investment Bias for each sector are as follows. In all cases, the effects are phased in over a five-year implementation period.

- Increasing the Agricultural Investment Bias increases the market attractiveness of investment in agricultural capital, agricultural technology, and irrigation.
- Increasing the Industry Investment Bias increases the market attractiveness of investment in goods manufacturing capital and industrial technology.
- Increasing the Energy Investment Bias increases the market attractiveness of investment in energy production capital (in fossil fuel, nuclear, and renewable) and energy production technology.
- Increasing the Military Investment Bias increases the flow of funds through government consumption into military capital.
- Increasing the Environment Investment Bias increases the market attractiveness of investment in environmental protection capital and into environmental technology.
- Increasing the Social Services Investment Bias increases the market attractiveness of investment in education (classrooms and teachers), health care (doctors, hospitals, nurses), and family planning programs.
- Increasing the Services Investment Bias increases the market attractiveness of investment in service capital and service technology, and as a result increases the quantity and quality of transportation, communication, banking, and social services

An increase of an investment bias for a sector from 1.0 to 1.2 increases the investment flowing into that sector by approximately 20 percent. The word "approximately" applies for two reasons:

1. Internal to the model, there is a fixed total to invest at any time. The investment biases simply shift the attractiveness of investment—not actual investment—from one sector to another. To keep the total investment fixed at whatever is available, any increase in the actual investment for one sector results in a proportional reduction of actual investment in all the other sectors.
2. The investment bias is superimposed on the operation of the capital market. After the first iteration of the model (typically one eighth of a year), the market situation has changed in the model (as it would in the real world) and the market mechanism alters the mix of investments automatically. The market works something like the thermostat in an apartment. Changing the investment bias is somewhat analogous to changing the temperature on the thermostat, but because of the complexities of the market, the effects of the change are altered by the market itself and are not exactly equal to the value of the investment bias.

A detailed technical explanation of the effects of moving the Investment Bias slide-bars is provided in the THRESHOLD 21 documentation (see Appendix G of Part II of this report).

Investment Fraction

At the top right of the Policy Selection Screen is a graph for the "Investment/GDP Ratio". Clicking on this graph allows the user to set exogenously the portion of the country's GDP that will be invested[22] . For some countries, this factor is extremely important.

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[22] In a later version of THRESHOLD 21, we hope to make Investment Fraction an endogenous variable. This will be difficult, however, because the determinants of the variable are to some degree psychological and cultural in origin.

Appendix C: THRESHOLD 21-Italy

The Italian Model: Overview

THRESHOLD 21 is constantly being updated and refined, and THRESHOLD 21-Italy is the most advanced version now available. In particular it is strong on energy and the modeling of greenhouse gas emissions.

The water supply sector is well developed, but water quality issues (water pollutants and water treatment) are not included.

Fertilizer and pesticide components are integrated into the agriculture sector and energy use, not treated separately as they were in earlier versions.

The "Rest of World" sector includes two new components: global carbon in the atmosphere and world oil reserve in billion barrels. The value of the first component, global carbon in atmosphere, is based on the DICE model (see "Rest of the World" in Part II of this report) and is used in THRESHOLD 21 to calculate CO_2 concentration in a country's atmosphere. The second component computes world oil depletion with extraction, and its effect on real oil prices. Real exchange rates for the future are assumed to stay at the 1997 level. Beyond 1997, change of real oil prices affects Italy's ability to import the energy it needs.

Major Assumptions for the Italian Model

The major assumptions for the Italy version of THRESHOLD 21-Italy are essentially the same as for generic versions of the model (see Appendix B for specifics).

Country-Specific Custom Features

The THRESHOLD 21 policy selection screen can be customized to the needs of modelers or policy analysts, and the country-specific versions of THRESHOLD 21 have various custom policy inputs. The Italy version of THRESHOLD 21 has the following additions:

- Annual Immigration Multiplier: This slide-bar can be moved to change the annual immigration rate multiplier.
- Elasticity of Oil Price on World Oil Resource: This elasticity (and the next) may be changed to reflect how the world oil price will change as the world oil resource decreases.
- Elasticity of Oil Imports on Oil Price: This elasticity may be changed to reflect how Italy's oil imports will be affected by the price of oil.
- Annual Kyoto Investment: This is the annual investment in energy saving technologies to reduce greenhouse gas emission toward the target agreed to in Kyoto.
- BTU Saving/Lira87 Investment Ratio: This ratio is the assumed energy saving (measured in BTU) achieved with each Lira87 invested. Its default value 43 was derived from the document "*Excerpt from the Second National Communication to the United Nations*

Framework Convention on Climate Change". The value can be changed to reflect new estimates.

- Rest of World: The "Rest of World" sector can be modified to affect how a country, Italy in this case, interacts with the "rest of the world." Clicking on the CO_2 Reduction Variables button reveals two exogenous variables that can be set: "World oil production" and "Rest of World GDP Growth".

Indicators in THRESHOLD 21-Italy

In addition to the extensive general set of indicators in THRESHOLD 21, some special indicators were developed for THRESHOLD 21-Italy.

ANPA developed an extensive series of indicators for this report. (The full list is available from ANPA.) The ANPA indicators were chosen from among those suggested in reports on sustainable development indicators published by the UN, the World Bank, the Wuppertal Institute, the World Resources Institute, EUROSTAT, and others.

The ANPA list, while very complete, is too long to use for the evaluation of scenarios.[23] Furthermore, some of the proposed indicators are conceptually elegant but lack any practical data on which to base them. Many of the ANPA indicators can be added to THRESHOLD 21 when data is available and their causal relationship with other variables are quantitatively defined. Other indicators will require the creation of additional sub-models or sectors. For this report, a subset of the ANPA indicators was chosen. The subset chosen is as follows:

Sustainable Development Indicators of Economy

- GDP per capita
- Investment in the GDP
- Value added by industry
- Annual consumption of energy per capita
- Consumption of renewable energies

Social Indicators of Sustainable Development

- Population growth rate
- Net annual migration rate
- Female fertility rate
- Infant mortality rate
- Life expectancy at birth
- Unemployment rate
- Women per hundred men in the labor force (%)
- Population density
- Rate of growth of urban population

[23] This is not a criticism of ANPA or the ANPA list. Choosing a short list of sustainable development indicators is a difficult task. The UN Commission on Sustainable Development, for example, has produced a list that is even longer. The UN indicators of Basic Social Services for All is even longer.

Sustainable Development Indicators of the Environment

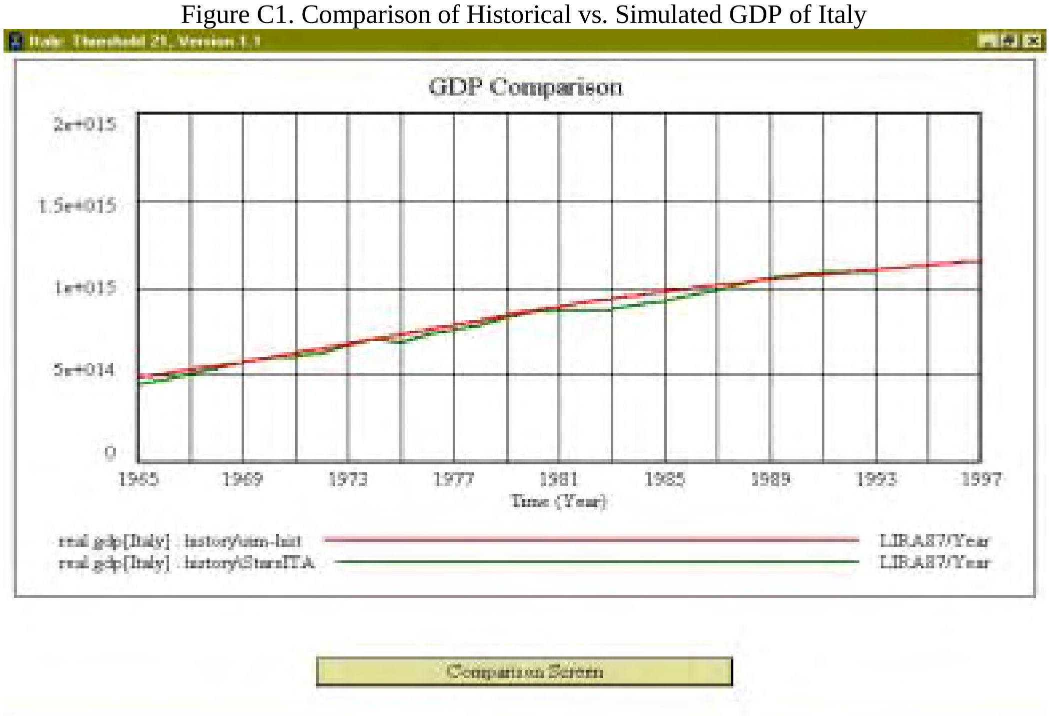
- Emissions of greenhouse gases
- Emissions of sulfur oxides
- Agricultural land per capita
- Land use change
- Forest area change

Using the Italian Model

To begin the application of THRESHOLD 21 to Italy, the model is used to simulate the historic period 1965 to 1997 with the investment slide bars set at 1. The results are compared to the actual data for the period, and adjustments are made as needed to achieve a reasonable fit.

Figure C1 shows a comparison between the historical data and the simulation for Italy's GDP.

Figure C1. Comparison of Historical vs. Simulated GDP of Italy



Once the model is satisfactorily calibrated, the Base Case Scenario is run. The Base Case is a simulation of the 1997-2017 period with the investment biases all set at 1, which means continuation of the historical policies. The Base Case provides the reference scenario against which the other scenarios are compared.

Alternative scenarios are made using the Policy Selection Screen as described above in Appendix B.

Appendix D: Kyoto Scenario Technical Notes

This Appendix presents technical notes on assumptions and data. IT contains two attachments which present specific data and information provided by ANPA.

<u>I. CO_2 Reduction Scenario</u>

To reduce Greenhouse Gas emissions, Italy needs to consume less energy. To maintain GDP growth with less energy Italy needs to invest in energy saving technologies and improving its energy efficiency.

Italy's plans to invest in energy saving technology are specified in *the Second National Communication to the United Nations Framework Convention on Climate Change*. Three levels of action (A, B, and C) are discussed. The analysis here focuses on action level A.

To model Italy's proposed action, two questions arise:

1. For each unit investment in energy saving technologies and improving energy efficiency, how much energy will be saved? The answer to this question varies with the technologies chosen. For a particular scenario, the answer to this question is the energy savings/investment ratios.
2. How much should Italy invest in energy savings to reduce Greenhouse Gas emission? Or in other words, how much emission reduction does Italy want to achieve? The answer to this question is a statement of Italian policy.

The energy savings/investment ratio, measured in BTU/Lira87, has a default value 16.3 BTU/Lira87 in THRESHOLD 21-Italy. This default value, which is derived from Action A (see item II.1 below) of *the Second National Communication to the United Nations Framework Convention on Climate Change*).

The necessary annual investment for achieving Action A goals is about 4.257 E12 Lira 87 (see item II.1 below).

Both these values can be altered in THRESHOLD 21 to test different estimates on these variables.

<u>II. Major assumptions</u>

1. Energy savings/investment ratio is based on Action A. The calculations are:

- From page 15, net savings measured in the net present value (NPV) of 1997 Lira is the difference of cost (71,000 BLit) and benefit (44,000 Blit)
  71,000 BLit - 44,000 BLit = 27,000 Blit97
- However, in the e-mail of August 6, 1998 from dott. Maurizio Colagrossi and dott. Rosanna Mascolo (M&R), they wanted to use 71,000, not 27,000, as the cost.

- As THRESHOLD 21 uses Lira87 as its currency unit, 71,000 BLit97 is converted to 32,870 Blit87 (GDP deflator for 1997 was 2.16 using 1987 as the base year)
- This investment will be made evenly over 10 years from 1999 to 2008, so annual investment at real interest rate of 5% is:
  PMT(0.05, 10, 32870,0,0) = 4257 BLit87/year (4.257 E12 Lira87)
  (PMT is a function in Microsoft Excel)
- Net savings in annual energy consumption: 16.4 Mtoe/y (see Attachment A to Appendix), which converts to 694 e12 BTU, based on the following information
  1 toe = 7.3 barrels
  1 barrel of crude oil = 5.8 M BTU
  (or 1 toe = 42.34 M BTU)
- As investment is spread out in 10 years, this energy savings of 694 e12 BTU will also be achieved in 10 years with a delay of one year, starting from 2000. Annual energy saving is 69.4 e12 BTU
- And the saving/investment ratio is
  69.4 e12 BTU/4257 BLit87 = 16.3 BTU/Lira87
- This ratio implies a linear relationship between investment and energy savings, i.e., when investment is doubled, energy savings will also be doubled. This relationship is assumed true within a certain range of investment

2. According to the *Second National Communication*, Italy has highly efficient ways to invest to reduce energy demand:

- The cost and benefit numbers (both cost and benefit are in net present values of BLit) for Actions A, B, and C are provided in Table D1:

Table D1: Costs and Benefits of Activities A, B, and C

	Cost	Benefit	Net Investment
Action A	71,000	44,000	27,000
Action B	20,000	32,000	-12,000
Action C	27,000	32,000	-5,000

Note: Actions B and C have negative net investment, or positive returns (benefits exceeding costs).

- Even for Action A, the net investment cost of 27,000 BLit is very small considering its CO_2 reduction effect of almost 11% (509.7 Mt CO_2 to 453.5 Mt CO_2, Table 9, page 19). If the net investment of 27,000 BLit is made evenly in 10 years, annual investment is less than 1% of total domestic investment.
- Based on requirements from M&R's Aug 6 e-mail, the total cost of 71,000 BLit will be used for Action A
- According to Table 4 on page 12 of the *Second National Communication*, real GDP for 1996 was 1399 TL'90. World Bank data shows Italian investment has averaged between 20% and 25%. If 20% of it was invested, domestic investment (private and public) for 1996 would be 280 TL'90.

- From page 15, net investment for Action A is
  71,000 BLit

- GDP deflators for 1990 and 1997 are 1.219 and 2.16 (from World Bank's database), using 1987 as the base year, so the net investment in BLit'90 is:
  71,000 * 1.219/2.16 = 40,069 BLit'90

- This investment will be made evenly over 10 years from 1999 to 2008, so annual investment at real interest rate of 5% is:
  PMT(0.05, 10, 40069, 0, 0) = 5188 BLit'90/year = 5.188 TL'90
  (PMT is a function in Microsoft Excel)

- This net investment of 5.188 TL'90 is less than 2% (1.85% to be exact) of 1996 domestic investment (280 TL'90):
  5.188/280 = 1.85%

- The assumption is that by spending about 2% of total domestic investment for ten years, Italy can reduce its CO_2 energy emission by about 10%. Energy demand will also be reduced by about 10% (energy saving of Action A is 16.4 Mtoe, and energy demand for 1990 was 163.5 Mtoe).

3. In THRESHOLD 21-Italy, the investment made to reduce CO_2 emission is taken proportionally from all sectors, including industry, services, and agriculture.

4. Reductions of emissions not related to energy consumption, such as reclamation of landfills (for CH_4 reduction) and improvements in industrial processes (for N_2O reduction), are not implemented in the current version of THRESHOLD 21, so all reductions of emissions come from reduced combustion of gas, oil, and coal.

5. Fossil fuel imports ratios for oil, gas, and coal:

- From the UN Energy database, Italy's fossil fuel imports measured in Tj (terajoules, or E12 joules) for 1990 and 1995 were:

Table D2: Gas, Oil, and Coal Imports, 1990 and 1995

	1990	1995
Gas Imports Tj	1,178.158	1,328,676
Oil Imports Tj	3,138.450	3,087,966
Coal Imports Tj	511,125	462,125

- The percentages of imports were:

Table D3: Gas, Oil, and Coal Imports, 1990 and 1995, Percents of Total Energy Imports

	1990	1995
Gas Imports Tj	24.4%	27.2%
Oil Imports Tj	65.0%	63.3%
Coal Imports Tj	10.6%	9.5%

- The percentages of imports used in THRESHOLD 21 are:

Table D4: Gas, Oil, and Coal Imports, 1965, 1990, 1995, and 2020; Percentages Used in THRESHOLD 21.

	1965	1990	1995	2020
Gas	15%	24.4%	27.2%	35%
Oil	70%	60.1%	63.3%	60%
Coal	15%	10.5%	9.5%	5%

6. Italy does a good job in forest management. We assume there is a 0.8% annual growth rate of forest land (or forest density) at least until 2017.

7. There are data conflicts (or multiple values for the same data item) in the *Second National Communication.* The values which are estimated latest are adopted for use in THRESHOLD 21-Italy. For example, in Table 4 the last two columns have estimates for the same year of 2000. The values in the last column were used because they were estimated in 9/1997, while the second last column was estimated in 1/1997.

III. Base Scenario Comparison between THRESHOLD 21 and SNC Data

1. GDP comparison

- The following table compares the real GDP (in TL90) from the base projections by THRESHOLD 21 with those in the *Second National Communication (SNC)* (Table 4 on page 12):

Table D5: Comparisons of Real GDP in THRESHOLD 21 Base Projections and the SNC

	1990	1996	2000	2017
THRESHOLD 21	1294	1395	1468	1762
SNC	1311	1399	1531	N/A

The differences are all less than 2%. For further comparisons, look under the button "Model Compared With Historic Data" on the Main Menu of the THRESHOLD 21 model.

- From the above table we can calculate average real GDP growth rates:

Table D6: Average Real GDP Growth Rates

	1990 to 1996	1996-2000	2000-2017
THRESHOLD 21	1.25%	1.28%	1.1%
SNC	1.1%	2.28%	N/A

The THRESHOLD 21 model projects economic growth based on past performance and the mix of investments chosen. The SNC assumes economic growth rates higher than can be explained with THRESHOLD 21, and the lower values of GDP were used in this analysis.

2. Population comparison

- The following table compares the THRESHOLD 21 and SNC population figures in millions. While the figures are close (the maximum difference less than 0.8%), there is some discrepancy. One of the possible sources for discrepancies is SNC immigration and emigration assumptions, which were not available.

Table D7: Population Figures (in millions)

	1990	1995	2000
THRESHOLD 21	57.40	57.46	57.06
SNC	56.95	57.33	57.50

3. Energy demand comparison

- The following table shows energy demand in Mtoe (1 Mtoe = 42 M BTU). (See Attachment B for data).

Table D8: Energy Demand (in Mtoe)

	1990	1995	2000	2010
THRESHOLD 21	152	155.4	158.4	164.1
SNC	163.5	172.6	193	196

- This table shows that SNC projects a faster energy demand growth, which is probably related to the faster GDP growth projected in the *Second National Communication* and which is discussed earlier.

- The base scenario of THRESHOLD 21 is a continuation of history in Italy. Historical data shows that Italy has successfully reduced its ratio of "energy demand/unit real GDP" in the past years. The following table illustrates the trend.

Table D9: Historical Trends in Italian unit GDP Energy Demand measured in kgoe/MLira

Time (Year)	1965	1970	1975	1980	1985	1990	1995
THRESHOLD 21	236.6	217.5172	200.7501	186.9439	176.0521	167.7419	160.8386
World Bank	N/A	213.2615	209.3097	185.7866	169.8101	165.4202	N/A

The THRESHOLD 21 base scenario assumes that this trend will continue into the future and that Actions A, B, and C are supplemental to the historic trend.

4. Emission comparison and a few notes

- SNC data in the following table are derived from Tables 4, 9, and 13 of the *Second National Communication.* Units are all in Mt CO_2 equivalent.

Table D10: Comparison of Energy Emissions

	1990	1995	2000	2005	2010
SNC CO_2 energy	402	411.8	421.3	445.8	471
T21 CO_2 energy	439	444	446	448	447
SNC CO_2 non-energy	40.5	37.4	37.7	37	38.7
T21 CO_2 non-energy	30.2	32.2	34.2	36.5	38.5

SNC CH_4 energy	11.6	N/A	N/A	8.3	7.8
T21 CH_4 energy	12.5	13.8	14.6	15.3	15.9
SNC CH_4 non-energy	40.4	N/A	N/A	43.9	48
T21 CH_4 non-energy	55.8	55.6	55.9	55.5	54.8
SNC N_2O energy	16.6	N/A	N/A	14.7	16.6
T21 N_2O energy	3.3	3.2	3.1	3.1	3
SNC N_2O non-energy	37.3	N/A	N/A	38.1	36.5
T21 N_2O non-energy*	0	0	0	0	0
SNC absorption	35.9	N/A	N/A	36.2	36.2
T21 Absorption total	26.9	28	29.4	30.8	32.4
SNC Total Net	512.5			551.6	582.4
SNC Total Gross	548.4			587.8	618.6
T21 Total Net	513.9	520.8	524.4	527.6	526.8
T21 Total Gross	540.8	548.8	553.8	558.4	559.2

N/A = not available

*Non-energy N_20 emissions are not included in the THRESHOLD 21 model currently.

- The algorithms used in THRESHOLD 21 and in the *Second National Communication* for computing emissions must be somewhat different. The emission algorithms of THRESHOLD 21 are presented in the Greenhouse Gas Emission Sector of THRESHOLD 21 Documentation, which is Part II of this report, and above in Paragraph IV. 1 of this appendix. The algorithms used in the *Second National Communication* are not known.

- The *Second National Communication* projects a growing CO_2 energy emission, but a decreasing CH_4 emission from energy sources. It also projects a growing percentage of gas consumption (see Table 4 on page 12). According to the IPCC workbook, gas emits much more CH_4 than oil and coal, so a higher percentage of gas use and higher overall energy consumption should generate more CH_4 emission. It is unclear why CH_4 emission is projected to decrease in the *Second National Communication.*

- SNC's data for energy consumption of 1990 was 163.5 Mtoe (above, paragraph III.3). In Table D10, the CO_2 emission from energy for 1990 is only 402 Mt CO_2. Renewable energy used was less than 1% for 1990. Given these facts, it is unclear how the CO_2 emission was calculated for the *Second National Communication*.

- SNC's figures for CO_2 energy emissions increased from 402 Mtoe to 421.3 Mtoe during 1990 to 2000, a 4.8% increase. But during 2000 to 2010, it increases from 421.3 to 471, a 11.8% increase. It is unclear why CO_2 energy emissions increase so much faster in the first decade of the 21st century than in the last decade of the 20th century.

- THRESHOLD 21 does not have non-energy and non-forest N_2O emission. The reason is that algorithms for these N_20 emissions are not included in the IPCC workbook (approved in September 1994 and adopted November 1994)

5. CO_2 energy emission/GDP ratio comparison

- Data for the CO_2 energy emission/GDP ratio is provided in Table 4 on page 12 of the *Second National Communication. The units are* Kg CO_2/Klit'90. T21 data is derived from T21 base results. The comparison is provided in Table D11.

Table D11: Comparison of CO_2 Energy Emission/GDP Ratio

	1990	1995	2000	2005	2010
THRESHOLD 21	0.339	0.322	0.304	0.286	0.271
SNC	0.307	0.296	0.275	N/A	N/A

- From 1990 to 2000, THRESHOLD 21 and SNC data (see Table D11) show similar energy efficiency increase of about 10.4% (0.275/0.307 = 0.896, 0.304/0.339 = 0.897)

IV. THRESHOLD 21 Changes

Changes were made in six parts of the model:

- greenhouse gas emission sector
- energy sector
- forest sector
- investment algorithm
- annual Kyoto energy savings
- four sector emission reduction scenarios: power generation, transportation, industry, and other

The following paragraphs describe only the changes made. Please refer to THRESHOLD 21 Documentation in Part II of the report for original sector description.

1. Changes made to the greenhouse gas emission sector

- The earlier version of THRESHOLD 21 Italy calculates NO_x emission, but the version developed for Italy calculates energy and forest N_2O emissions. There are two reasons for this change: 1) ANPA wants the change, and 2) N_2O can be converted to CO_2 equivalent with a parameter of 310, while for NO_x in general, no such general parameter can be found.

- N_2O emission is defined as coming from two sources:

  N_2O emission = forest N_2O emission+N_2O fuel emission

- *forest N_2O emission* is defined as

  forest N_2O emission =
  net forest carbon release*(N in N_2O to C weight ratio)*(N to N_2O weight ratio)

  in which *net forest carbon release* is defined in documentation of the forest sector. *N in N_2O to C weight ratio* is the weight ratio of N in N_2O over C, whose default value is 0.00007 given in IPCC workbook 2 in pages I-12 and I-13. *N to N_2O weight ratio* can be calculated based on the atomic weight of N (14) and O (16). For each kilogram of N, 44/28 or 1.57, kilograms of N_2O will be obtained.

- *N_2O fuel emission* is defined as

  N_2O fuel emission =
  energy C emission*(N in N_2O to C ratio)*
  (N to N_2O weight/technology[environment])

  in which *energy C emission* was defined in THRESHOLD 21 Documentation (see Part II of this report). *N in N_2O to C ratio* and *N to N_2O weight* are treated the same as in *forest N_2O emission*, as they were not treated differently in IPCC Workbooks. It is also assumed that N_2O emission will decrease with technology development in environment protection, so it was divided by *technology[environment]*, which has a numeric value greater than or equal to 1.

- *GHGas net emission* (greenhouse gas net emission) was added and is defined as

  GHGas net emission =
  CO_2 emission+CH_4 emission*CH_4 to CO_2+N_2O emission*N_2O to CO_2

  in which *CH_4 to CO_2* is equal to 21, and *N_2O to CO_2* is equal to 310. Both values were provided by SNC in their documentation. Net emission is different from gross emission in that it includes sinks, which for Italy are forest and soil absorption of greenhouse gases.

2. Changes made to the energy sector

- In earlier versions of THRESHOLD 21 the only energy import was oil. In THRESHOLD 21- Italy, all three forms of fossil fuels—oil, gas, and coal—are imported. The UN energy database provides the following data measured in Tj (terajoules, or E12 joules):

Table D12: UN Energy Database Imports for Italy

	1990	Percent	1995	Percent
Gas imports Tj	1,178,158	24.40%	1,328,676	27.23%
Oil imports Tj	3,138,450	65.01%	3,087,966	63.30%
Coal imports Tj	511,125	10.59%	462,125	9.47%
Totals	4,827,733	100%	4,878,767	100%

This information was used to calculate percentages of imports for oil, gas, and coal, as shown. Percentage of coal imports is assumed steadily going down from 1965 to 2017, while the gas percentage was assumed to be going up.

- Total energy imports is represented by the variable *fuel imports affordable*
- The following variables were added: *oil imports, oil imports share, gas imports, gas imports share, coal imports, coal imports share.*
- In *energy C emission factor[fossil fuel]*, the parameter for gas was changed from 17.2 to 15.2. The reason is that page I-6 of IPCC workbook 2 says 17.2 in TonC/Tj, but page I-13 in the more detailed workbook 3 says 15.2.

- The commercial energy demand calculated by THRESHOLD 21was initially too high compared to World Bank data for Italy. To correct this, we changed the *tech advance parameter[energy]* from 0.15 to 0.2, and the fit is now quite good.

3. Changes made to the forest sector

- *Net forest carbon release* in earlier versions of THRESHOLD 21 was assumed to be always positive, which means forest land and/or forest density can only shrink. For Italy it is not true. So this variable was reformulated so that it can take either a positive or a negative value. When it is negative, it indicates carbon absorption as a sink. Its actual equation is:

  net forest carbon release =
  -forest land change*dry matter density*carbon fraction

4. Changes made to the investment algorithm

- *total domestic investment* is updated to subtract *Kyoto investment* and *Kyoto sector investment* as the following equation shows:

  total domestic investment =
  total inv ratio*real gdp[Italy] - Kyoto investment - Kyoto sector investment

- *Kyoto investment* and *Kyoto sector investment* can not be both non zero. To prevent mistakes by users, two interface (VCD) files were created: one allows the users to alter the *Kyoto investment,* and the other *Kyoto sector investment*

- *Kyoto investment* and *Kyoto sector investment* are added to the model for CO_2 emission reduction. Their actual equations are:

  Kyoto investment =
  IF THEN ELSE((Time>=1998):AND:(Time<2008),annual Kyoto investment,0)

  Kyoto sector investment =
  IF THEN ELSE((Time>=1998):AND:(Time<2008),
  annual Kyoto sector investment,0)

which shows that the investment to meet the Kyoto target only happens between 1998 and 2007.

- *annual Kyoto investment* is calculated above in paragraph II.1 as 4257 BLit87/year. In THRESHOLD 21 Italy, this constant is allowed to be changed by users to test different assumptions.

- *annual Kyoto sector investment* is calculated below. In THRESHOLD 21 Italy, these constants are allowed to be changed by users to test different assumptions.

  annual Kyoto sector investment =
  annual Kyoto energy investment+
  annual Kyoto industry investment+
  annual Kyoto transport investment+
  annual Kyoto other investment

- The work of Maurizio and Rosanna produced the summary table: (see mail980812.doc)

	Cost in BL	Saving in Mtoe/yr
energy	24250	4.48
industry	1050	2.6
transport	45750	8.3
other	0	1.6
total	71050	16.98

Since the data of two sectors, industry and other, do not make sense, I adjusted the table to:

	Cost in BL	Saving in Mtoe/yr
energy	20000	5
industry	10000	2
transport	40000	9
other	1050	0.4
total	71050	16.4

Notice that the total energy saving is adjusted to 16.4, which was the number in the original table developed by Rosanna

5. Addition of *annual Kyoto energy savings* and *Kyoto energy savings*

- *Kyoto energy savings* is defined as:
  Kyoto energy savings =
  INTEG(annual Kyoto investment, initial Kyoto energy savings)
- *annual Kyoto energy savings* is defined as
  annual Kyoto energy savings =
  Kyoto investment*action A saving inv ratio
- *action A saving inv ratio* is a constant and is calculated above in Paragraph II.1 as 16.3 BTU/Lira87. In THRESHOLD 21 Italy, this constant is allowed to be changed by users to test different assumptions of the ratio.

6. Addition of *annual sector energy savings* and *sector energy savings*

- *sector energy savings* is defined as:
  sector energy savings =
  INTEG(annual sector energy savings, initial sector energy savings)
- *annual sector energy savings* is defined as
  annual sector energy savings =
  annual energy sector energy savings +
  annual industry sector energy savings +
  annual transport sector energy savings +
  annual other sector energy savings

The right-hand-side variables of the above equations are defined as follows to guarantee that the energy savings do not continue when investment ends in 2008:

annual energy sector energy savings =
IF THEN ELSE((Time>=1998):AND:(Time<2008),
annual Kyoto energy investment*energy sector saving inv ratio,0)
annual industry sector energy savings =
IF THEN ELSE((Time>=1998):AND:(Time<2008),
annual Kyoto industry investment*industry sector saving inv ratio,0)
annual transport sector energy savings =
IF THEN ELSE((Time>=1998):AND:(Time<2008),
annual Kyoto transport investment*transport sector saving inv ratio,0)
annual other sector energy savings =
IF THEN ELSE((Time>=1998):AND:(Time<2008),
annual Kyoto other investment*other sector saving inv ratio,0)

annual Kyoto energy investment*energy sector saving inv ratio+
annual Kyoto industry investment*industry sector saving inv ratio +
annual Kyoto transport investment*transport sector saving inv ratio +
annual Kyoto other investment*other sector saving inv ratio

- The four *sector saving inv ratios* are constants and were calculated in the following table similar to the calculations in Item II.1 (refer to sectorEmission.XLS). In THRESHOLD 21 Italy, these constants are allowed to be changed by users to test different assumptions of the ratios.

Sectors	Cost	Savings	inv/yr Lira87	saving/yr BTU	sav/inv ratio
energy	20000	5	1.198E+12	2.116E+13	17.657
industry	10000	2	5.992E+11	8.463E+12	14.126
transport	40000	9	2.397E+12	3.809E+13	15.891
other	1050	0.4	6.291E+10	1.693E+12	26.906
total	71050	6.4	4.26E+12	6.94E+13	16.303

7. Notes to the addition of four sectors:

- It is based on the work of Maurizio and Rosanna summarized in sector Emission.XLS
- Running cost was not quantified in their work and so was not implemented in the current version of THRESHOLD 21

Attachment A to Appendix D: Net Savings in Annual Energy Consumption

While much information is provided in Table 6, Page 17 of the *Second National Communication* about Action Program A, additional details were needed to include Action A in the THRESHOLD 21 model.

The following table is the unaltered Table 6 from the *Second National Communication*. The next table is supplemental information provided by ANPA staff. Note that lines in the second table are keyed to the original Table 6 from the *Second National Communication*.

Table 6: Programme to Reduce Greenhouse Gas Emissions by the Year 2010: Modernization Interventions (A)

1. REDUCTION OF EMISSIONS FROM THE ENERGY SECTOR (Millions tons of CO_2/annual equivalent)	CO_2 Mt/a	CH_4 (a)	N_2O (b)
1.1 Gasification of emulsions and residual products, very high-efficiency combined cycles (2700 MW)	3	-----	-----
1.2 Further cogenerations (1200 MW)	1.3		
1.3 Six per cent reduction of leaks in the electricity grid	0.7		
1.4 Further gasification of emulsion and residual products. CH_4 combined cycles	5.1		
1.5 Further combined cycles, dismissal of plants in existence (3000 MW)	3.5		
1.6 Electric power production from wind turbines (1500 MW) (c)	1.9		
1.7 Further biomass systems + solid wastes (1300 MW (c)	2.1		
1.8 Reduction of leaks and emissions from methane systems		0.7	
1.9 Measures for city public transport	2.1		
1.10 Replacement of 12 million circulating cars with 12 million low-emission cars (145g CO_2/km)	12		
1.11 Realization of new underground tram, local railway systems, modernization/increase of speed of 1100 Km	4		
1.12 Transfer of freight from road to railway and to coastal navigation for about 40 Bton*Km for the year 2010	5.5		
1.13 Promotion of biofuels and biodiesel (d)	1.5		
1.14 Increase in the use of natural gas in industry	3		
1.15 Further use of methane in housing and in the tertiary sector	2		
1.16 Voluntary agreements and energy diagnosis in industries with medium-low energy consumption, new technologies	4.5		
1.17 Standards and voluntary agreements for high-efficiency equipment in industry	1.5		
1.18 More efficient equipment for reducing electricity consumption in housing and in the tertiary sector, new technologies	2.5		
TOTAL	56.2	0.7	

2. REDUCTION OF EMISSIONS FROM THE ENERGY SECTOR	CO_2	CH_4	N_2O
2.1 Energy-saving measures (recycling of solid wastes), reclamation of landfills, incineration of industrial sludge		16	
2.2 Reduction N_2O emissions in industrial processes (nitric acid and fatty acid)			4/5
TOTAL: MODERNIZATION PROGRAMME/ENVIRONMENT SAFEGUARD	56.2	16.7	4.5

a) the decrease of methane emissions (CH_4) is expressed in millions tons of CO_2 equivalent; in order to calculate the right values in millions tons of CH_4, one has to divide by 21, which is the coefficient of CH_4 global warming potential;

b) the decrease of nitrogen protoxide emissions (N_2O) is expressed in millions tons of CO_2 equivalent: in order to calculate the right values in millions tons of N_2O, one has to divide by 310, which is the coefficient of N_2O global warming potential;

c) the production of electric power from renewable sources is additional to the 2600 MW forecast by CIP 6-92;

d) the financial contribution which is necessary to make biodiesels competitive is liable to the EC approval: in propitious circumstances the intervention may be extended to 3Mtoe/a;

e) the process of recycling half the paper used in Italy allows to replace a higher cut of imported pulp in the national production cycles and to reduce, by overseas pulp produces, the energy consumption of circa 0.2 Mtoe/a and the emission of circa 0/6 Mt CO_2/a if the pulp is produced thanks to processes which use the by-products as fuels;

f) if the investment cost falls below Lit/Wp 5000; in the opposite case, the objective has to be redefined.

Table 6 Plus: A. Programme of emissions reductions -Table 6 page. 17

1	Cost Billion Lira	Mtoe/y	Van
1.1	3600	0.5	1724
1.2	1800	0.5	1724
1.3	running cost	0.24	810
1.4	6600	1.2	4138
1.5	4000	0.7	2414
1.6	3000	0.5	1270
1.7	5200	0.8	2439
1.8	50	0.04	168
1.9	150	0.7	1322
1.10	3600	4	7556
1.11	34000	1.4	6253
1.12	8000	1.7	7137
1.13	running c	0.5	115
1.14	running c	1	0
1.15	running c	0.7	0
1.16	250	1.1	3354
1.17	600	0.5	2000
1.18	running c	0.9	1700
Total	70859	16.4	44124

2	Cost Billion Lira	Mtoe/y	
2.1			0
2.2	200		
Total	71050		44124

Attachment B to Appendix D: Data for Energy Demand

The following data were compiled and provided by dott. Maurizio Colagrossi, dott. Rosanna Mascolo, and dott. Roberto Ribelli on the dates indicated:

Excerpt from letter from dott. Rosanna Mascolo, ANPA, Rome, July 13, 1998:

Here you have the official Italian report about the emission gases inventory set in the framework of the Convention on Climate Change. In the document are also described the policies and measures to be undertaken by our country to comply with the pre-Kyoto commitments (stabilization of CO_2 equivalent emissions at 1990 levels).

Nevertheless in 6.3.2 paragraph of the report there are the provisions (A plus B interventions) sufficient to satisfy also the -8% Kyoto commitments for European Union (that is for Italy a -7% reduction in the 2008-2012 period): our suggestion is to utilize this scenario with A and with B interventions (C interventions are overcoming the objectives), with the data available, technology by technology, as specified in tab. 6 and 7 (pages 17 and 18) and summarized in tab. 9 (page 19) with savings of greenhouse emissions.

The Italian official Communication presents also an intermediate evaluation at 2005, that can be useful for checking the results of your calculation with Threshold 21.

Please check also the consistency of your data in the model on GDP and on population with those assumed in the report evaluations (tab. 4, page 12).

Regarding the "unit GDP commercial energy" you have mentioned in your e-mail of April 28, 1998 fixed at the value of 8.5 BTU/Lira '87; please check this value with the value of 171 koe/millions lira '85 we have found as basis for the calculations of the official Italian communication to FCCC. It is worthy to note that in tab. 4 you should have enough data to calculate the trend (decreasing?) of this parameter by 1990 to 2000 (the energy consumption should range between 163 Mtoe of 1990 and the forecast of 196 Mtoe of 2010: please check the consistency of such data with the data already sent and used in the calculation). Please let us know how you will calculate this value and its projections over time.

Excerpt from letter from dott. Rose Anna Mascolo, AMPA, Rome, Jule13, 1998

Conventional conversion factors

	TJ	Gcal	Mtoe	MBTU	GWh
TJ	1	238.8	2/388 x 10e-5	947.8	0.2778
Gcal	4.1868 x 10e-3	1	10e-7	3.968	1.163 x 10e-3
Mtoe	4.1868 x 10e-3	10e-7	1	3.968 x 10e7	11630
Mbtu	1.0551 x 10e-3	0.252	2.52 x 10e-8	1	2.93 x 10e-4
GWh	3.6	860	8.6 x 10e-5	3412	1

1 Mtoe = 1 Million of tons of oil equivalent

Coal
1 Mtoe = 1.3 Mtons of metallurgic coal
1 Mtoe = 1.6 Mt of steam coal
1 Mtoe = 4 Mt of lignite

Methane
1 Mtoe = 1/21 billions of cubic meter
1 billion of cubic meter =0.825 Mtoe

Electric energy
1kWh =2200 kcal   1TWh =0.222 Mtoe

Fossil Fuel
1Mtoe =1.02 Mt

Gas oil
1 Mtoe =1.02 Mt

Gasoline
1Mtoe =0.95 Mt

Oil
1 Mtoe = 1Mt
1 Mtoe = 7.3 million of barrel

Methane consumptions for 1980-2010 in billion of cubic meter (you can do conversions, now)

1980	1990	1995	1996	1997	1998	1999	2000	2005	2010
27.4	47.2	54.5	55.9	60.2	63.8	66.9	69.8	78.8	84.2

12) Energy production (%)

	1980	1990	1995	1996	1997	1998	1999	2000	2005
coal	8.5	9.7		7.7	7.6	7.4	7.4	7.3	7.1
methane	15.5	23.9		26.9	28.4	29.5	30.4	31.1	33.6
oil	67.3	56.6		54.5	53.7	52.9	51.1	49.8	47.9
renewables		0.2		0.2	0.2	0.2	0.7	0.8	1.1
idro-geo	7.5	5		6.2	5.9	5.9	5.9	6.5	6.3
nuclear	0.3								
Total	100	100	100	100	100	100	100	100	100

In 1990 total energy production has been =163.5 Mtoe and then you can calculate these results:

	1990
coal	15.8 Mtoe
methane	39.1 Mtoe
oil	92.5 Mtoe

In 1995 total energy production has been =172.6 Mtoe and in 2000 will be probably, 193 Mtoe. At this moment I don't have other information. I will send you when I'll found them

13) I have found the known domestic fossil fuel reserves for 1994-1996

	gas (million of cubic meter)	oil (Mtons)
1994	297.538	99.860
1995	296813	101.708
1996	277670	100.024

14) About forest land change, I don't have exact data but I have found total forest area burnt:

1990 =96.157ha
1991 = 24.630ha
1992 =40.549ha

Appendix E: Summary of Technical Work Done

In July and August 1998, the followings were done:

1. Check data consistency between THRESHOLD 21 Italy, the SNC document (*Excerpt from the Second National Communication to the United Nations Framework Convention on Climate Change*), and IPCC Workbooks

2. Update the THRESHOLD 21 Italy model. Changes were made in six parts:

- greenhouse gas emission sector
- energy sector
- forest sector
- investment algorithm
- annual Kyoto energy savings
- four sector emission reduction scenarios: energy, industry, transport, and other

(Please refer to Section IV. THRESHOLD 21 Changes, in Appendix D for details)

3. Update and re-write the Report

During the period October - December 1997, the followings were done:

I. THRESHOLD 21 was applied to Italy

II. The following sectors were improved

1. Agriculture sector: production function substantially improved to reflect latest modeling methodologies in the field

2. Nutrition sector: meat demand, meat imports, grain demand, and grain imports are added. Animal stock is calculated based on meat demand and meat imports.

3. Industry sector: production function re-designed to facilitate

- communication with economists, and
- ease for fitting the model to real data

1. Service sector: similar to industry in production function

2. Pollution sector: captures greenhouse gas (CO_2, NO_x, CH_4) emission and SO_x emission. Pollution dissipation is improved in that it happens only when domestic CO_2 concentration is higher than the world average level of concentration.

6. MEP Indicators updated based on The World Bank, *Expanding the measure of wealth: indicators of environmentally sustainable development*, The World Bank, June 1997

III. Two new sectors were added to THRESHOLD 21 Italy

1. Government sector: This sector includes government revenue, government expenditure, and government borrowing. Government expenditure is further divided into education, health care, social security, defense, and others.

2. Rest of the World sector: This sector includes global oil reserve and annual production, real world oil price which changes with reserve depletion, and global carbon dioxide in atmosphere (based on DICE model)

IV. Documentation

1. Final Report (by Gerald O. Barney, Weishuang Qu, and Philip Bogdonoff)

2. THRESHOLD 21 Documentation

Appendix F: Script to Use Threshold 21 for Italy

This section is a guide for installing and running the run-only version of the THRESHOLD 21 model. The run-only version usually comes on two disks. To install the model on your computer, insert disk 1 into drive a:, get into Windows Explorer (Windows 95) or File Manager (Windows 3.1), double click the *setup.exe* file on disk 1, then follow instructions on the screen. After installation, double click the THRESHOLD 21 model icon, and the model starts running.

1. Opening screen

Models built in Vensim can be used in at least two ways. The first is a flexible, interactive mode in which you ask the model to do a variety of things by simply clicking the mouse or by pressing a few keys, but this interactive mode requires you to spend some time to get familiar with the model and with the Vensim modeling language.

With the second mode the user interface is largely pre-defined, and you use an application program (VenApp) to manipulate the model and present its output. Users of VenApp program do not have to have any knowledge of the model or of Vensim or VenApp. Now we are using the second mode for this demo of the THRESHOLD 21® Italy Model, Version 1.0.

The current version 1.0 is a more detailed and more integrated version than all previous THRESHOLD 21 models. Linkages between sectors are well defined, and each sector can be separated and independently developed or modified and then be reintegrated. Version 1.0 also includes new sectors, such as the government and the rest of the world sectors.

After installing and starting the model, click anywhere on the screen with your mouse or press any key to advance to the next screen of Notice. Click once more to advance to the screen of the Main Menu.

2. Screen of Main Menu

There are seven buttons on this screen. The first five offer options for using the model. The last two buttons are for help and exiting the model.

Position the mouse over the "Sponsors and Major Features" button and press the left mouse key (you will use the left mouse key exclusively for this demonstration). This brings up a screen detailing the sponsors; press any key for a summary of the model's major features. THRESHOLD 21® is a decision support tool for development investments. The model analyzes the social, economic, ecological, and security impacts of alternative uses of available investment funds. It is particularly useful for participatory processes and consensus building. Its projections are not precise predictions. Now press any key to return to the main menu.

Before we move on to the second button it is necessary to explain that this model is designed to run simulations over two different periods of time. The first period is the historic period from 1965 - 1997 (using T21ITA10.VMF), and the results can be related to historic data (from the Stars database of the World Bank and the Population Age and Gender distribution of the UN and other sources) to verify that the model generates reasonably reliable results for the historic period. The second period is a 20-year future period from 1997 to 2017. To simulate and view future trends click on the Simulate: Long Term button in the Policy Selection Screen, which will be described later.)

The second button presents the structure of the model and its various sectors. The third leads us into historical comparison between the simulation results and the existing data, while the fourth and the fifth buttons are for running and analyzing simulations for the period 1997 - 2017.

We will examine the model in that sequence.

3. The Model Structure Screen

Use the mouse to click on the second button of the main menu marked "Model Structure". A screen will appear that has eight buttons. The top five buttons represent five groups of sectors.

Click on the National Accounts/Financial System button and you will see five sectors on the screen: National Accounts, Foreign Reserves, Balance of Trade, Savings/investment Balance, and Government. Then click on one of them, such as Government, and you will see the structure of the Government Sector. Click on the Threshold 21 Sectors button in the middle of the bottom row to return to the sector screen.

Similarly you can click on each of the other four upper buttons to find out the major sectors in THRESHOLD 21.

Each sector structure is based on the best theoretical model currently available, and we can view the structure of each sector by clicking the corresponding button following the sector group button on the screen. A more detailed description of some sector structures starts from Section 9 of this script.

Clicking on the Overall System Structure button in the bottom-left corner reveals an overview with economic production as a focal point, with inputs from labor, capital, technology, quality of education, and natural resources (land and energy). Out of production comes, exports, income, and pollution. Income is divided between consumption and investment, and investment is further divided into different sectors much like a pie being cut into different portions. The investment sectors include energy, industry, agriculture, military, environment, and social services which covers education, family planning, and health care. Consequences of these investments feed back to production either directly or indirectly.

On the right hand side of this screen is the balance of payment sector that ties in imports, exports, and foreign reserves.

Now, click on the button marked Sector Screen. After familiarizing yourself with some or all of the sectors, click the "Main Menu" button at the base of the screen.

4. Screen of Model Compared with Historical Data

Click the third button on the main menu and you can view simulation results for the period 1965 - 1997. The top twelve buttons of the screen provide accesses to screens comparing selected data items from the simulation of the Italy THRESHOLD 21® with historic data from the Stars data base of the World Bank and from the Age and Gender Distribution of Population of the United Nations.

As an example, press the Population button. It shows two lines: the red line is from THRESHOLD 21 simulation, and the green is historical data from UN. Click the Population Cohorts button at the lower-left corner, and it leads to a series of screens, each showing the comparison for a certain age group, such as Age 0 to 4, Age 5 to 9, and so on. In each screen, there are four lines: the red and the blue lines are for female and male from the simulation, and the green and the gray lines are from historical data. Due to conditions like immigration or war, there could be differences between these lines.

Also click on the GDP button, and compare the red line, which is the simulation result, with the green line, which is from historical data. You can repeat this operation on any of the buttons.

For using the lower half of the screen, Historical Model Analysis, please refer to Section 18: Overall Analysis.

Click the "Exit back to the main menu" button to return to the main menu.

5. Scenario Setup Menu

Now click the fourth button of the main menu, "Start and run a scenario", which allows you to simulate from 1997 to 2017 and build your own scenarios (or what-if analyses). You will see the Scenario Setup Menu.

There are two ways to start a scenario. In a demonstration, the second option— "Modify and Rerun an Existing Scenario"—is preferable. Click on this button.

To learn more about the options, click on the Help/Instructions button.

6. Select Scenario Screen

This opens a Vensim dialog box entitled "Select the Scenario to Work With". In the top-left corner is a box that contains scenario files. Among the files are "base.vdf." and "demo.vdf." The base file has been built for you as a base scenario in which no policy changes were made, indicating that it will be a continuation of existing policy into the future. The base.vdf file should be left alone and not touched by the user. The demo.vdf file is provided to users for manipulating the investments and other variables and then simulating the future results. The result of the simulation will be compared to the base.vdf scenario to see the impact of those changes. Click on "demo.vdf"; that name will be highlighted, and will also appear above in the file name box. Now click on "Open" and the next screen will appear.

7. Policy Selection Screen

The Policy Selection Screen is the principle screen for establishing scenarios. This screen permits the user to alter the distribution of investments by introducing "investment biases" in sectors. The bias represents a combination of government policies affecting the relative attractiveness of the sectors to private sector and government investments. (See Appendix B above for an introduction to the operation of the investment bias).

To change the investment bias of a sector, place the mouse over the small square box corresponding to the sector you wish to adjust. Depress the mouse key and hold it down. Now drag the square box on the slide bar to the desired level and release the mouse key. For our demonstration, drag the industry square to the right until the corresponding number reaches 1.2. This suggests that we have increased investment in the industrial sector. The built-in algorithm of THRESHOLD 21 will adjust investments in other sectors so that total investment equals to what is available.

At the bottom are five options: (1) Simulating the long-term results of the policy choice, (2) Simulate the Population Pyramid, (3) CO_2 Reduction Variables (which allows for making investment to reduce CO_2 emission), (4) Other Policy Variables, and (5) Return to Main Menu.

Click on the fourth button, Other Pol. Vars, and you will see six policy variables. On the left side are options which allow you to adjust the annual immigration multiplier as well as the elasticity of oil price based on available oil resources, and the elasticity of oil imports based on oil prices. For the sake of simplicity, we will leave these unchanged.

On the right side of the screen there are three variables: World Oil Production, Rest of World GDP Growth, and Investment/GDP Ratio. Let's begin changing the investment/GDP ratio by clicking on the graph at the lower-right of the screen. A new screen will appear, showing the investment/GDP ratio as a time-series variable. This ratio can be adjusted in two ways. The graph at the right depicts investment/GDP ratios over time. To change these ratios, select the point on the line directly above the year in which you wish the ratio to be different. Using the same technique as above, drag the point to the desired level. Similarly, years and ratios can be input by hand. Near the bottom left of the active screen appears the word "New" with a pair of empty text boxes below. To input a new investment/GDP ratio, click on the left box and type the year for which the new ratio applies. Then you use either the tab key or the mouse to access the second box, and type in the ratio for that year. Pressing enter will apply the new ratio, which will appear as a new point on the graph. For the sake of our example, do not alter the investment/GDP ratio. Click "Cancel" to erase any changes you've made and return to the other policy variables screen.

Click on the "Simulate" button.

8. Screen for the Long Term Simulation Graph

Once you click the Simulate Long Term button in the previous screen, the simulation starts off, and a few of the many variables are plotted here against simulated time. These variables are population, agricultural production, industry produced, forest land, greenhouse gases net emission, and human development index (HDI).

Remember you selected the demo.vdf scenario, and all the simulation results are stored in that file. Unless otherwise specified, all the following discussions are oriented toward this file.

At the bottom of the screen are five buttons: “View Sectors”, “View Indicators”, “Do Analysis”, “Modify and Rerun”, and “Rescale”. If you want to know more about simulation results, select “View Sectors”, which displays selected variables from each sector. “View Indicators” displays a variety of development indicators including economic and social indicators, information on the environment, etc. If you want to investigate one or more variables and compare them to the base scenario, select “Do Analysis”. If you want to start a new simulation with a different set of policy choices, click the “Modify and Rerun” button. If some of the variables go beyond the screen, select “Rescale” to view them.

Let’s choose the “View Sectors” button first.

9. Screen of Scenario Results by Sectors

This opens a screen entitled “Scenario Results by Sector”. Here we see five larger buttons representing five groups of sectors, and five smaller buttons at the bottom which allow the users to switch to other screens.

By first clicking on one of the five larger buttons, followed by clicking the individual sector buttons we can find further simulation results specific to each sector. At the bottom of the screen, the “View Indicators” and “Do Analysis” buttons become available once again. Three more buttons lead us back to the original simulation, to a new simulation with policy changes, or to the main menu.

10. Overall analysis

Return to the “Scenario Results by Sector” screen and click on the “Do Analysis” button. This opens a new screen entitled “Analysis Control.”

To use this screen, it is necessary to first choose a variable from which to start the analysis. To do this, notice the heading “Causal Tracing”, and click the first button below it labeled “Select a variable as a starting point for further analysis”.

A box opens that lists all of the variables in the model alphabetically. To illustrate the number of variables, click on the down arrow key to the right of the list and scroll through the variables. As an example, choose the variable “real gdp” by either clicking on it or typing the phrase, clicking on the variable in the menu, and clicking the okay button.

The second button under “Causal Tracing”, the button entitled “Comparison of loaded scenarios”, compares the chosen variable across loaded scenarios. By default it will always compare variable results in the demo and the base scenarios.

Now click on the third button: “Trace underlying causes using trees”. A tree diagram will appear showing that our “real gdp” variable is comprised of production in the agriculture, industrial, and service sectors.

Note the graph at the bottom right corner of the screen. The red line illustrates real gdp in the current demo scenario; in other words, real gdp after boosting investment in the industrial sector, which we did previously on the Policy Selection Screen. The green line illustrates the base scenario. It displays real gdp assuming that no changes were made to any sector. Unsurprisingly, the scenario in which industrial investment has increased illustrates a rise in real gdp.

It is often important to know where a particular variable is used in the model, and this can be determined easily by clicking on one of the buttons at the left of the screen, namely, “Uses of current variable”. Click on this button and a new tree will appear with the chosen variable, real gdp, at the left side of the screen. The branches of the tree indicate all of the places where the real gdp variable is used.

It is often convenient to switch quickly from one variable to another, and this can be done by double clicking on a new variable name. For example, choose the variable “real pc gdp” (which is the eighth variable down in the tree) by pointing the cursor at “real pc gdp” and double clicking. This produces a new tree indicating that real pc gdp is used in the calculation of domestic and municipal water demand, adjusted income, grain demand elasticity, etc.

To trace the sources of this variable, “real pc gdp”, press the top button marked “Causes of current variable”. This yields a tree showing that real pc gdp is derived from real gdp and the total population. In the bottom right corner, real pc gdp has been graphed. Again, the red line illustrates the demo scenario which includes boosted industrial investment. As expected, the green line is the base scenario which takes no changes into account.

It would also be useful to see the input variables plotted, and this can be arranged by clicking on the top button on the left, “graph based”. This produces three graphs on the right side. The top graph is a reproduction of real pc gdp in both the demo and base scenarios. The other two graphs represent the inputs used in the calculation of real pc gdp: real gdp and total population. The second graph shows the former. The red line is above the green, showing that upping industrial investment improves real gdp. The third graph illustrates total population, and the red line lies slightly above the green. Population has increased by a very small amount.

Before explaining the usefulness of these graphs, you will note that the equation for the chosen variable is plotted in the upper left-hand corner. Not restricted to abbreviations, the equation is easy to understand: real pc gdp is calculated by dividing real gdp by the total population. (Immediately below the equation is a line called units. Vensim requests units of measure following the entry of every equation. It then checks to see if units are used correctly. This in turn helps to identify and solve problems in formulating the model).

These graphs, coupled with the equation for our variable, makes analysis simple. Consider the second and third graphs: the second graph shows that real gdp increased with the boosted investment in industry. The third graph shows that the change in investment also increased population, though only by a tiny amount. Thus, if the equation for real pc gdp is "real gdp/total population," and real gdp has increased a lot while total population has increased only slightly, then real pc gdp must be rising. The first graph, real pc gdp, illustrates this.

To carry the analysis one step further you can examine the inputs of the inputs. To clarify, bear in mind that real gdp and total population are inputs for real pc gdp. Similarly, each of these two variables, real gdp and total population, is derived from another set of inputs. To see these, simply double-click (press the mouse key twice in rapid succession) on the title of the graph whose inputs you wish to examine. For example, double-click on "real gdp [Italy]" and a new series of graphs will appear. The top graph is the one you selected: real gdp [Italy]. The next three illustrate the inputs used in deriving real gdp: agricultural, industrial, and service production. Each graph contains both the base and the demo models.

Through similar operations (double-clicking), you can trace further down the road to find what caused the difference between demo and base. As we know, the reason is we moved more investment to industry, and other sectors are getting less.

Similarly, you can view and compare investments in each sector between the base and the demo scenarios. The names of these investment variables in Threshold 21 are:

- investment agri (for agriculture)
- investment industry
- investment energy
- investment env (for environment)
- investment military
- investment service
- investment ss (for social services)

Now press the "Exit - return to analysis" button. This brings us back to the Analysis Control screen, which offers us access to the Main Menu. Press the "Main Menu" button.

With the above explanations, you should be able to build your own scenarios and do your own what-if analysis, by altering the values of the variables in the Policy Select Screen and CO_2 Reduction and Other Policy Variables screen.

Many people at this stage would like to understand how each sector of the model works. For viewing the sector structure, click on the second button of the Main Menu: Model structure.

11. Population Sector

To view the structure (diagram) of the Population Sector, click the button labeled "Social System", followed by clicking the Population button. This opens a screen with a diagram of the population model. Note that this is a highly aggregated description of the population sector because there is only a single population box or variable. In truth, 65 one-year age cohorts for each gender are included in the model. This means that a full representation of the population sector would require 130 separate stock variable boxes.

The valve-shaped symbols together with the double arrows going into and out of the population stock (box) variable represent the flows, or rate of change, of the stock variables.

Click the "Threshold 21 Sectors" button at the bottom of the screen to return to the sector screen.

12. Agriculture Sector

To view the structure of the Agriculture Sector, click the button labeled "Production System", followed by clicking the Agriculture button. You will see the structure of the agricultural sector. The stock of agricultural land is influenced by a flow going in and out which in turn is influenced by urbanization, land degradation, and land reclamation. Capital for agriculture (tractors, irrigation equipment, transportation, etc.) is also important, and is increased by investment and reduced by depreciation.

Agricultural production is harvested area times yield.

13. Industry Production Sector

Return to the "Production System" screen, and choose "Industry".

Here again we see the general structure of the industry production sector.

The industry produced variable is shown to be influenced by the number of workers employed in the sector, labor productivity of each worker, and the availability of energy.

14. Energy Sector

Return to the "Production System" screen, and choose "Energy Supply and Demand".

The energy sector simulates both energy demand and energy production, using the difference between the two to calculate energy exports or imports. It includes fossil fuels (oil, gas, and coal), nuclear power (set to zero for Italy), and renewable power (e.g., hydro power). The total demand for energy is related to four variables: real GDP, technology, the unit gdp commercial energy requirement (defined as the number of units of energy required to produce one unit of gdp for the year when the simulation starts), and the country energy demand parameter (which adjusts the amount of energy demanded based upon a country's mode of production and consumption). Technology is assumed to improve steadily, but with no technological breakthroughs, as it is not possible to predict when such a change will happen. Demand for energy is met primarily by fossil fuels, either through production or imports. With alternative development policies, fossil fuels are depleted at different speeds: the results can be seen by looking at variables such as:

fossil fuel production[oil]
fossil fuel production[gas]
fossil fuel production[coal]
renewable production

15. Air Pollution Sector
Return to the "Threshold 21 Sectors" screen. Choose "Environment and Resource System", followed by "Air Pollution".

The current version of THRESHOLD 21 covers only air pollution, in particular the four pollutants CO_2, CH_4, SO_x, and N_2O. In this sketch, you see a stock variable called Pollution. This stock is affected by two flows: (1) pollution dissipation, and (2) pollution generation. Pollution generation is further split between CH_4, SO_x, N_2O, and CO_2 emissions.

16. Education Sector Screen
Return to the "Threshold 21 Sectors" screen. Choose "Social System", followed by "Education".

The current education sector model takes into account primary school education for children. Gender difference is included. Inputs to this sector from other sectors include age 6 population and social service investment. Outputs to other sectors are adult literacy rates and primary graduates.

Quality of education is measured by three factors: student-classroom ratio, student-teacher ratio, and net enrollment ratio.

17. Screen of Health Care Sector
Return to the "Social System", followed by "Health Care".

Here again, the structure of the Health Sector is shown.

The level of basic health care access is measured by three factors: population per doctor, population per nurse, and population per hospital bed. The model consists of three parts for each of these three factors.

Inputs from other sectors to this sector include population and social service investment. Outputs from this sector are access to basic health care, population per doctor, population per nurse, and population per hospital bed.

For some countries, there is need for a detailed health sector that includes disease-specific components to simulate the consequences of diseases spreading and disease prevention, and we plan to add this detail to a later version of THRESHOLD 21.

18. Food and Nutrition Screen
Return to the "Social System", followed by "Food and Nutrition" to see the structure of the Food and Nutrition Sector.

This sector first computes the *pc grain demand* for direct human consumption, and *pc meat demand*. *Pc meat demand* is then converted to *grain for animal feed*, after deducting *meat imports*. The sum of *grain for animal feed* and *total grain demand* (for direct human consumption) is the demand on grain.

The supply of grain is production plus imports. It is assumed that the country will be able to import as much grain and meat as it needs.

Pc consumptions of grain and meat are total demands (or supplies) over total population. They are then converted to calories and protein measurements. Quality of nutrition is determined by comparing nutrition levels with the standards established by the World Health Organization (WHO).

Animal stock is calculated based on demand for domestic meat production (which is total meat demand minus meat imports), *ton per head ratio* (how much meat each head of animal can produce on average), and *animal growing time*.

With similar operations you can view all the other sectors in Threshold 21.

This concludes our demonstration. Ask for questions and start a discussion.

Appendix G: References

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