Draft – Version 7.0 – 7 June 2005

INDUSTRIAL ECOLOGY IN GENEVA

INITIAL FINDINGS AND PROSPECTS

Agenda 21 in the Canton of Geneva

Project ECOSITE

"Ecosite" Work Group, State of Geneva

Publisher: GEDEC
Editor: Suren Erkman
Design/Production:
Photography:
Printing:
Geneva, 2005

Industrial Ecology:

What is it all about?

"Industrial ecology" is a surprising expression…

In this instance, the two terms have a very precise meaning:

- "Ecology" refers to scientific ecology, which studies the various environments inhabited by living organisms.

- "Industrial" broadly refers to all the economic activities of modern technological society.

From this viewpoint, household consumption, health services, telecommunications, information technology, finance, tourism, and leisure activities among others are considered industrial activities in the same way that agriculture, the extraction of raw materials, and the manufacture of goods.

The goal of industrial ecology is to change the economic system, which is unsustainable in its current form, to make it viable long term and compatible with the normal function of natural ecosystems.

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PREFACE

By Mr. Robert Cramer, Member of the Geneva State Council

Twelve years after the Earth Summit in Rio de Janeiro, we have no choice but to recognize that the notion of sustainable development still translates very little into reality. Yet time is running out. Despite a few positive developments, the state of the planet continues to deteriorate.

How can we determine the best steps to take? What should our priorities be? In which areas would pro-environmental measures be the most effective?

It is precisely to help answer such questions that the first study of the canton's "industrial metabolism" was carried out, making it possible to assess how much of the main material resources are being used by the Genevan economy.

As the study clearly points out, the chief consumers of resources in Geneva are households and the tertiary sector. This conclusion is not a surprise given the nature of Geneva's economy. However, the findings confirm, in numbers, the importance and the relevance of efforts undertaken to encourage more careful consumption of resources by households and individual consumers and to prompt more effective use of resources by the service sector.

Studying the metabolism of economic activities provides a general framework for developing a concrete strategy for sustainable development and makes it possible to verify the relevance of efforts already underway. Using this foundation, it becomes possible to establish a pragmatic and productive dialogue between the intimately connected domains of the economy and the environment.

Following this initial phase, Project Ecosite will undertake measures to implement the principles of industrial ecology in Geneva.

Our canton is taking a pioneering step by being one of the very first communities to give a legal foundation to industrial ecology through the Law on the Public Initiative for Sustainable Development.

INTRODUCTION

Over the last two centuries, the standard of living of Geneva's population has risen significantly. As in most other regions of the world, this upheaval resulted in the extraordinary development of the industrial system.

However, the changes were accompanied by dangerous effects on human health and the environment in general. The extent of the negative impact has been such that today we need to thoroughly overhaul how industrial society operates.

An initial attempt to respond to the deterioration of the environment arose in the 1960s, particularly with the gradual implementation of pollution treatment policies. These measures made enormous progress, but it became increasingly clear that they were not enough to achieve sustainable development.

Therefore, it was agreed that a broader strategy, favoring a much better use of all resources consumed by a growing world population, should be developed and implemented.

This is the goal of industrial ecology, which aims to bring together the operation of the industrial system and that of natural ecosystems to ensure their long-term mutual survival.

Industrial ecology, a field that developed during the 1990s, reflects a particularly innovative approach to environmental issues. In 2001, the canton of Geneva was the first government body to provide a legal foundation to this pioneering approach by introducing the notion of industrial ecology in the Law on Agenda 21 in the Canton of Geneva.

In accordance with the terms of Article 12 of this law, which seeks to encourage the practice of industrial ecology in Geneva, the cantonal administration launched Project Ecosite in 2002.

The first phase of the project involved carrying out a study of the flow of resources that make up the basis of economic activities in the canton of Geneva. This preliminary phase sought to better understand how "Geneva's industrial ecosystem" operates in order to identify priority issues and determine, with full knowledge of the facts, the measures to undertake.

It must be pointed out that, in this case, the description of the flows of resources is purely quantitative. The first phase of the study of the canton's metabolism involved determining the quantities of the main resources consumed in Geneva. It was also agreed to consider qualitative aspects: one metric ton of chlorine, for example, presents a far greater potential threat to the environment and to human health than one metric ton of sand. Moreover, from an economic standpoint, one metric ton of chlorine has more potential than one metric ton of sand. Taking a qualitative approach to complement the quantitative description could be envisioned at a later time.

This report summarizes the first phase of Project Ecosite. It briefly outlines the study's main findings about Geneva's "metabolism." Finally, it presents a few conclusions and recommendations based on the results. The goal of these recommendations is to pursue the pioneering approach of industrial ecology and to take it to the next level, thus helping to put Geneva on the road to sustainable development.

BACKGROUND

On 23 March 2001, the State Council of the Republic and Canton of Geneva adopted the "Law on the Public Initiative for Sustainable Development (Agenda 21)."[1]

The law, which entered into force on 19 May 2001 (revised in November 2002), provides the legal basis for carrying out Agenda 21 at the canton level. Article 12 of the law, dubbed "Ecosite," a name that was directly inspired by the notion of an industrial ecosystem, stipulates that the "State encourages considering possible synergies among economic activities with the aim of minimizing their impact on the environment."

On this basis, the cantonal administration, with the approval of the State Council launched the Ecosite work group in late 2001. It includes representatives from several canton-level administrative departments who were assigned the task of implementing Article 12 within the framework of the canton's Agenda 21 process (members of the work group are listed in Appendix 2).

Industrial Ecology

"Ecosite" Article 12 refers to a particularly innovative approach to environmental and economic development issues: industrial ecology.

In the expression "industrial ecology," the "ecology" references scientific ecology and the adjective "industrial" broadly refers to all human activities in modern technological society (production, but also consumption, tourism, health, agriculture, leisure, etc.).

The overall objective of industrial ecology is to change the industrial system as a whole to make it viable long term and compatible with the normal function of natural ecosystems.

In practice, this means using resources much more efficiently. To this end, it seems logical to draw inspiration from the biosphere (without seeking to copy it outright) since natural ecosystems represent the only known example to date of a highly evolved living system that is viable long term.

In particular, industrial ecology strives to use one group's waste as the raw material for another, just like natural ecosystems. However, it offers a much broader perspective than simply reusing waste since it seeks to strengthen the economy and make it more competitive by optimizing the use of all resources while minimizing the impact on the environment.

This assumes new interactions between the various economic players (businesses, public agencies, consumers, households). It is the idea put forth in the "Ecosite" clause when it references "possible synergies among economic activities."

The Metabolism of Economic Activities

All living organisms are endowed with a metabolism: to grow, survive, and reproduce, they consume (and then discard) resources in the form of matter and energy. Naturally, the human species is no exception to this rule.

By analogy, we can say that a business, a society, a country, and a region all have a metabolism. Consequently, we can talk about the "metabolism of economic activities" or the "industrial metabolism." If we are interested in a specific geographic area, we refer instead to a "regional metabolism" or to a "local metabolism."

[1] The text of this law is available on the State of Geneva's Web site: http://www.geneve.ch/agenda21/objectifs_2006/welcome.html

From the viewpoint of industrial ecology, if we intend to modify the operation of the current economic system wisely, we need to have a solid understanding of its metabolism.

The metabolism of a region's economic activities makes it possible to understand the operation of the material bases required for human activities: the flows of resources used for production in the primary and secondary sectors, as well as for tourism, the Internet, trade, health services, the daily life of households, etc.

In concrete terms, studying the metabolism of economic activities involves creating a physical accounting system that describes all the material resources (materials, energy) used by economic activities, including households. For additional information on the methodology used, see Appendix 1.

The physical accounting of economic activities is a fundamental tool for implementing sustainable development and serves three main purposes: diagnosis (evaluation of the current situation), decision-making (especially to guide public policy), evaluation, and follow-up.

Studies of an area's metabolism can also be considered tools for economic development and promotion on two counts:

- by giving rise to new economic opportunities (by identifying reusable resources); and
- by contributing to strengthening a region's attractiveness and competitiveness.

Like any methodology, a study of the metabolism of economic activities is not an end in itself. It is a tool among others that serves to implement sustainable development and especially relevant to a strategy based on industrial ecology.

As part of the Ecosite work group, it seemed wise to begin by conducting an overall study of the metabolism of economic activities in the Canton of Geneva. This initial evaluation will identify areas of utmost concern and then help to determine the wisest, most effective measures to take as part of Geneva's Agenda 21 process. The main findings of this preliminary study are presented in the following pages.

INITIAL FINDINGS

It would have taken too long and been too costly to study each of the resources used in an area like the canton of Geneva. Within the framework of this study, the following seven resources, considered particularly important, were selected:

- energy (electricity, automobile fuel, other types of fuel)
- building materials
- food products
- metals (iron, copper, aluminum)
- plastics
- wood (including paper and cardboard)
- water

The following paragraphs summarize the metabolism of the seven resources studied. Appendix 1 provides details about the study and offers, as an example, detailed results about the metabolism of the resource "wood."

The study, carried out by ESU-services (Uster, Zurich), was validated by several experts representing different departments within the administration of the Canton of Geneva (see

Appendix 3). Figures are from 2000, the year for which data were available at the time the study was conducted.

Geneva's Metabolism: Flows and Total Stocks

Figure 1 summarizes the flows of resources that entered and exited the Canton of Geneva in the year 2000, the chosen year of reference for this initial study.

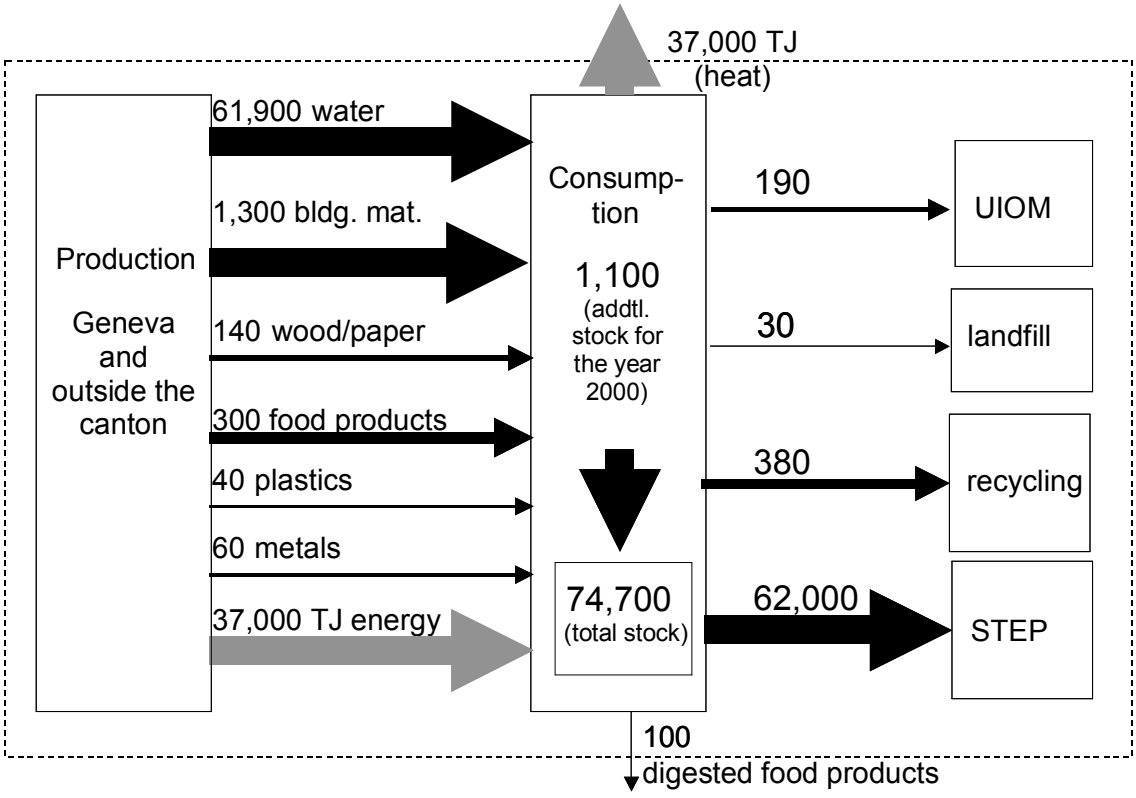

Figure 1: Total flows of resources for the Canton of Geneva for the year 2000 (UIOM = household refuse incineration plant; STEP = wastewater treatment plant). The thickness of the arrows reflects the approximate relative importance of the flows of resources.
The numbers represent thousands of metric tons for flows of matter; terajoules are used for energy (1 TJ = 1 billion joules).
(N.B.: The outflow of 100,000 metric tons, at bottom, represents the portion of digested food products eliminated as CO_2 by the human body during respiration.)

Inflows

As seen in Figure 1, the largest inflows of matter in terms of tons come from water and building materials. In third place are food products.

More precisely:

- Water is the largest mass consumed in Geneva with 62 million metric tons (or 62 million m^3). This amount represents drinking water pumped from Lake Geneva (80%) and the Arve aquifer (20%). Households are the number one consumers (24 million m^3), followed by the tertiary (15 million m^3) and secondary (14 million m^3) sectors.
- Second place goes to building materials, which account for the principal flow of solid matter: 1.3 million metric tons (or nearly 70% of the materials consumed).
- Food products fall in third place with 300,000 metric tons (16%).

- Finally, wood and paper (140,000 metric tons), metals (60,000 metric tons), and plastics (40,000 metric tons).

The total consumption of primary energy equaled 37,000 TJ (terajoules) in the year 2000.

It is difficult to directly compare energy with flows of matter. Energy is not expressed in metric tons, but in joules (here in terajoules where 1 terajoule = 1 billion joules).

Nevertheless, to facilitate the comparison, we can express energy in metric tons of oil equivalents. Thus, the 37,000 TJ of primary energy consumed in Geneva represent 870,000 metric tons of oil equivalents, or slightly less than building materials (1.3 million metric tons), but nearly three times food consumption (300,000 metric tons).

Outflows

Of a total 600,000 metric tons of waste products, approximately 350,000 metric tons (63%) are recycled, and 160,000 metric tons are incinerated at the Cheneviers household refuse incineration plant (UIOM).

We also have to account for digested food products. A portion is funneled into the wastewater system (outflow toward the wastewater treatment plant, or STEP). The remainder (outflow of 100,000 metric tons at the bottom of Figure 1) is emitted as CO_2 by the human body during respiration.

Stocks

All in all, the stocks of materials in Geneva increased 1.1 million metric tons in 2000. The rise reflects the growth in the number of buildings and the automobile population. The total stock of resources in 2000 was 74.7 million metric tons. This represents mainly the materials that make up buildings and roads.

Balance Sheet for Mass and Energy

According to the law of conservation of mass and energy, mass is balanced: total inflows (63.74 million metric tons) equal total outflows (62.64 million metric tons) plus additional stock (1.1 million metric tons). The same is true for energy: the outflow of 37,000 TJ, dispersed as heat, equals the 37,000 TJ of raw energy consumed.

CO_2 Equivalence of Flows

Mass is not the only way to measure flows of resources. We can also indirectly evaluate them by examining the greenhouse gas emissions resulting from the production and use of resources.

Among the various greenhouse gases emitted into the atmosphere as a result of human activities, the most significant is carbon dioxide (CO_2). However, there are others: methane, certain nitrogen oxides, chlorofluorocarbons (CFCs), etc. For convenience sake, all greenhouse gases are expressed as a single unit: CO_2 equivalents.

The four categories of greenhouse gas emissions are:

a) **emissions related to manufacturing** goods. For example, the processes used to manufacture computers, household appliances, food products, plastics, cars, etc. produce greenhouse gas emissions. Other examples include the extraction and refining of resources such as petroleum.

b) **emissions produced by the use** of these goods in the canton. For example, the consumption of fuel oil (for heating buildings) and gas (for transportation purposes) generates CO_2 emissions in Geneva during combustion.

c) **emissions tied to transporting** these goods from their manufacturing site to their place of consumption in Geneva.

d) **emissions connected to eliminating** goods at the end of their life cycle, resulting for the most part in the incineration of waste.

Emissions related to the elimination of goods are not accounted for here since they can be considered marginal compared to the others.

Transportation-related emissions are not insignificant, but due to the lack of available data, it was not possible to evaluate them precisely within the framework of a preliminary study. However, in the case of certain resources, emissions resulting from the transport of goods from their production (or extraction) sites to Geneva are included in part under the category "manufacturing." They represent emissions due to the transportation of products into Switzerland to a regional distribution center. Moreover, emissions due to the distribution of goods within Switzerland are partially included in emissions related to the resource "energy" (which includes the use of automobile fuel in Geneva).

Figure 2 illustrates greenhouse gas emissions (expressed in CO_2 equivalents) resulting from the consumption of resources in the Canton of Geneva in the year 2000.

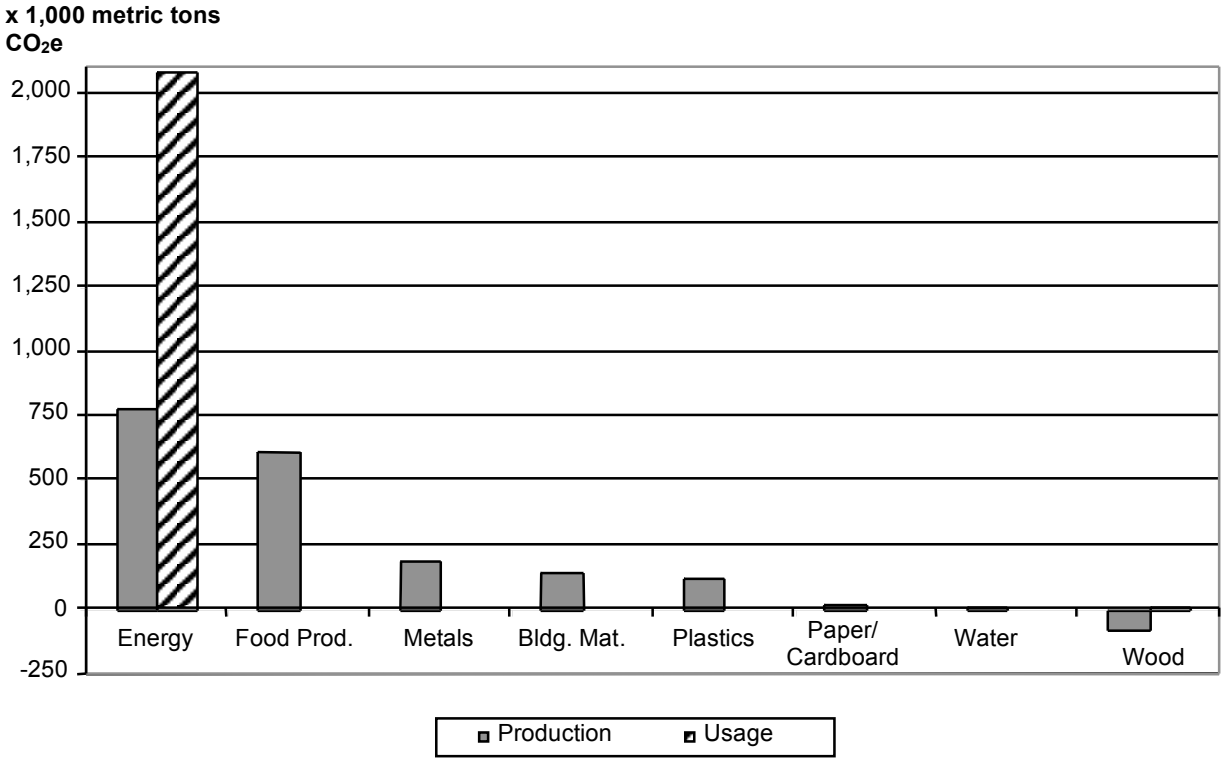

Figure 2: Greenhouse gas emissions in thousands of metric tons of CO_2 equivalents.

From the viewpoint of greenhouse gas emissions, we see that energy is the most important resource, followed by food products, metals, and in fourth place, building materials.

With the exception of energy, it must be noted that these emissions took place chiefly outside the canton since most of the goods consumed in Geneva are produced outside the canton. These indirect emissions are accounted for here.

Total energy emissions amount to approximately 2.8 million metric tons of CO_2 equivalents. The majority of these emissions (around 2.1 million metric tons) results from using energy (hatched column), mainly during the combustion of fuel oil and automobile gas. Only one third, approximately 750,000 metric tons (dark column), results from the production of energy agents (emissions produced during the extraction and refining of petroleum, in particular).

Conversely, for other resources, emissions are produced mainly during the manufacturing process and are marginal at the stage of use (the use of plastics, paper, etc. generates hardly any greenhouse gases).

For comparison's sake, we can point out that the weight of greenhouse gases emitted during the consumption of energy in the canton (2.8 million metric tons) is more than double the 1.3 million metric tons of building materials used annually in Geneva! This gives an idea of the considerable importance of the consumption of energy from fossils fuels (chiefly petroleum) compared to other resources.

The final value, at the far right, relates to wood. We can see that the production of wood translates into a negative value, which might be surprising. The explanation is simple: trees remove CO_2 from the air to fuel their growth. The wood consumed in Geneva reflects the net absorption of nearly 81,000 metric tons of CO_2 equivalents. In comparison, the combustion of wood (notably in boilers) emits low amounts of CO_2.

Relative Importance of Economic Sectors

The study of the canton's metabolism highlights the fact that two economic sectors are clearly the primary consumers of resources in Geneva: in first place, households, and in second place, the tertiary sector. This is readily apparent in the table below, which shows the relative share of consumption by different sectors for the resources studied.

	Sector 1	Sector 2	Sector 3	Households
Water	**6%**	**25%**	**27%**	**42%**
Energy (heat)	**3%**	**10%**	**30%**	**57%**
Energy (electricity)	**3%**	**12%**	**60%**	**25%**
Metals (iron)	**2%**	**13%**	**40%**	**45%**
Wood	**2%**	**26%**	**35%**	**36%**
Plastics	**2%**	**10%**	**39%**	**49%**
Building Materials	**2%**	**6%**	**43%**	**49%**
Food Products	_	**4%**	**45%**	**51%**

Figure 3: Table showing the relative importance of different economic sectors in relation to the consumption of the main resources in Geneva. The consumption of food products by the primary sector can be considered negligible (Source: M. Faist Emmenegger, ESU-services, 2004).

Conclusions and Recommendations

The initial findings, and the conclusions it is possible to draw from them, have enabled the Ecosite work group to formulate recommendations for the State Council on the next phase of the project. These conclusions and recommendations are presented in the following pages.

CONCLUSIONS AND RECOMMENDATIONS FROM THE ECOSITE WORK GROUP

(Draft version, 7 June 2005, 6.0, v.3)

On the basis of results from the preliminary study of the metabolism of economic activities in Geneva, it is possible to present the State Council with a series of conclusions and recommendations.

General Recommendations

Clarify the notion of durability

The study of the metabolism of economic activities offers interesting information about the quantity of resources used. It clearly underlines the unsustainable nature of Geneva's economy in its current form. Geneva's metabolism reflects the modern industrial economy: it consumes more resources than the planet can provide and renew, and it produces more waste than the environment can absorb. Moreover, the Genevan economy presents one particular weakness: it depends extensively on outside sources for its metabolism.

On the basis of this observation, one key question arises: for a given resource, what level of consumption can be considered sustainable? Despite its apparent simplicity, this is a highly complex question for which we still do not have satisfactory answers. The answers can be extremely varied depending on the resource and the region under consideration, as well as the criteria chosen to define the notion of durability.

In Geneva, objectives have already been set for energy consumption and waste recycling. The usefulness of such figures goes without saying. Nonetheless, it is worth more precisely determining the validity of these objectives, which is not possible unless we better understand the notion of durability for a given resource. For this reason, one priority is to better understand the notion of the durability of a resource in the context of Geneva. The findings will perhaps lead to setting new objectives in other areas and for other categories of resources and waste.

Role of the Various Economic Players

The economic fabric of Geneva is composed mainly of a multitude of small players: households and numerous businesses representing the primary, secondary, and tertiary sectors. There are few major industrial businesses in Geneva consuming large quantities of raw materials.

As a result, improving the canton's metabolism will not result simply from a few spectacular measures aimed at a small number of major players, but above all many individual and localized actions.

Moreover, the study of the canton's metabolism clearly emphasizes the fact that two economic sectors are clearly the leading consumers of resources in Geneva: first, households and, second, the tertiary sector.

Therefore, we should act first and foremost with regard to these two areas, and the Ecosite work group recommends that the programs already in place be resolutely pursued. This includes all the steps that have been taken to promote and encourage action by the cantonal master energy plan, as well as measures related to recycling waste included in the waste management plan for 2003–2007. These initiatives are implemented and monitored by the canton's energy service (SCANE) and its waste management service (GEDEC). In the

particular case of the canton of Geneva, the secondary sector is a less important consumer of resources. It has been the target of multiple restructuring plans and is marked by what is now considerable structural unemployment. The influence of the primary sector on the overall consumption of resources in Geneva is rather negligible.

Consequently, while taking action in these two sectors is less of a priority, they can contribute to conserving resources to the extent that it is economically feasible for the businesses concerned.

In the spirit of industrial ecology, we need to look first and foremost at creating opportunities for companies to work together with the goal of conserving resources. If several economic players reuse a resource (such as cooling water used successively by several businesses) or share certain investments (such as energy), they should see short-term gains that give them better long-term economic footing while improving their environmental performance and image.

One such successful project is Genève Lac Nations. The project, which is currently underway, involves a shared heating and cooling supply for a major biotechnology industry and an entire neighborhood of the city that includes several international organizations thanks to water pumped from the lake.

The main reason for the Ecosite work group lies precisely in the search for new opportunities such as this. Concrete steps to achieving this goal are presented below (see “Specific Recommendations for a Better Use of Resources”).

The State’s Key Role

The State plays an essential economic role: it is the number one buyer (public commissions), it owns and manages the largest amount of real estate, and it is the largest civil engineering contractor (roads, infrastructure, etc.). Above all, it is the canton’s chief employer with more than 10% of jobs. From a different perspective, it is responsible for educating and training young people.

Given the importance of its economic role, the State serves as an example. It falls to the State to implement itself the measures it recommends to the rest of society, particularly in three key areas: energy, transportation, and waste sorting.

As the maker and enforcer of laws, the State must continue to be resolutely committed with quantitative objectives to programs that promote the more efficient use of resources, especially in the three areas cited above (energy, transportation, waste sorting) for households and the tertiary sector, first and foremost. The programs the State has already launched in these areas are headed in the right direction, and it is important not to let up the efforts already underway. For the State, this also means promoting work that has already been done and distributing useful information to the public.

Today, preparing the public accounts is one of the State’s key tasks. The accounts provide as precise a picture as possible of the financial flows generated by different economic activities. From the perspective of sustainable development, it would be desirable to complement these financial accounts with “material” or “physical” accounts that describe the flow of resources essential to all economic activity.

Physical accounting is a vital tool for assisting with decision-making and implementing sustainable development: for monitoring and objectively evaluating the situation, for diagnosing and detecting problems, and for future planning. The methodology of the metabolism of economic activities constitutes the foundation of just such a material account.

Consequently, the Ecosite work group suggests examining the possibility and the feasibility of the State implementing a physical accounting system. Implementing this sort of accounting

could be done in collaboration with the Cantonal Office of Statistics and coordinated with similar existing initiatives at the federal and international levels. Indeed, this approach reflects a trend across Switzerland (Federal Office of Statistics) and around the industrialized world: in 2004, the OECD officially recommended that its member countries conduct studies of the metabolism of their economic activities.

Specific Recommendations for a Better Use of Resources

When taking the approach of industrial ecology, we strive to make the flows of resources as cyclical as possible. Various proposals follow for the resources studied, categorized here by decreasing order of quantitative importance.

Energy

The metabolism study clearly points out that energy is the leading problem in Geneva.

For starters, Geneva depends a great deal on outside sources for its energy supply since it must import fuel for transportation, fuel for heating, as well as a large part of its electricity.

Moreover, Genevans' consumption of energy is clearly not sustainable. In the case of greenhouse gas emissions, 80% of which come from the use of fossil fuels for transportation (mainly petroleum) and other purposes in Geneva, the sustainable amount appears to be approximately 1 to 2 metric tons of CO_2 equivalents per person per year. Geneva is decidedly above this level, with approximately 9.5 metric tons per resident per year (including emissions due to the manufacture of goods outside the canton and transporting them to Geneva).

The metabolism study shows that energy consumption is essentially due to local activities that take place in the canton and that can be attributed primarily to households and the tertiary sector: 50% of the total energy is used for heating, 25% for transportation, and the balance for other economic activities. As already pointed out, programs aimed at these areas are underway as part of the cantonal master energy plan.

Beyond the programs targeting households and the tertiary sector, the Ecosite work group suggests, in the spirit of industrial ecology, to step up efforts in three main areas.

First, we must focus on reusing the heat lost through various economic activities. Thanks to financial resources and technical assistance from SCANE, this involves identifying buildings (existing or proposed) that release significant amounts of heat or cooled air, coordinating those affected by the production of these wastes with others who are potentially interested in using them, and facilitating the process of turning such recovery projects into reality. It is worth noting that reusing a lost resource generally results in a financial gain for the businesses or entities concerned. Project CADIOM (remote heating through the incineration of household refuse) is a good example.

Second, we can improve the energy efficiency of different industrial processes, which requires refining our understanding of their metabolism. Within the framework of the canton's master energy plan, SCANE suggests conducting energy audits of interested businesses. The resulting information would be integrated (to ensure confidentiality) and transmitted to the industries involved so that the greatest number of businesses in the same industry can benefit from them. Similarly, businesses that are major energy consumers could conduct an energy audit with technical and financial assistance from SCANE, particularly as part of measures that accompany the new electricity rates. In addition, improving energy performance systematically results in financial savings for the businesses involved.

Finally, the resources provided by Geneva's ecosystem should be reused better. Renewable energy sources (solar, wood, geothermal, biogas, etc.) are still largely underused. It is the State's job to encourage the emergence of concrete projects.

Water

In terms of mass, water is the main resource consumed in Geneva. However, given the characteristics of the region's ecosystem, the consumption of water does not pose any particular problem. Indeed, Geneva is lucky to have abundant water resources, which, of course, does not mean that we can waste them! The durability of the water supply appears to be secure at least as long as it remains possible to use water from Lake Geneva (which will no longer be the case if the quality of the lake water declines, for example).

Nonetheless, water consumption is not simply a question of quantity. The qualitative aspects are no less important and must be constantly monitored: water purity, the biodiversity of the aquatic environments, the restoration of waterways, etc.

Building Materials

Building materials, principally gravel for road construction and cement-making, represent the primary flow of solid resources (1.3 million metric tons transported annually over the roads). In particular, the consumption of gravel poses a two-pronged problem.

First, local gravel resources are limited. At the current rate of use, the gravel from Geneva's gravel pits should last some fifty years, according to the master plan for gravel pits. However, industry professionals believe useful reserves will be depleted 15 to 20 years from now, which is clearly unsustainable. A large number of trucks will be needed to bring gravel from far away when it is no longer available in Geneva.

Second, at the other end of the chain, as operations at the gravel pits shrink, we have fewer and fewer suitable locations to dump the waste left behind by construction and demolition.

The metabolism study highlights the existence of a serious problem in Geneva with gravel used for building. Therefore, the building materials sector in general has been identified as a priority for action. Measures have already been taken through various studies designed to better understand the issue, including: an in-depth study of the metabolism of building materials, a study of the various outlets for recycled materials, and an economic study. The latter has shown that the widespread use of recycled materials should not entail increased costs for the construction industry. The metabolism study has indicated that it is possible to double Geneva's gravel reserves by systematically using the possible outlets for various recycled materials.

We should now work on improving the quality of recycled gravel in order to increase its acceptance by the construction industry. These efforts fall to GEDEC as part of the operating permits awarded to facilities that work with recycled building materials. We also need to ensure that the materials used do not pose any special technical problems. For this reason, the study on opportunities proposed a certain number of possibilities that still need to be reviewed from a technical standpoint.

Finally, various steps should be taken to raise awareness about recycled products within the construction industry, particularly the construction of demonstration sites and the systematic use of recycled gravel at State-funded work sites. The Department of the Interior, Agriculture, and the Environment (DIAE) is building two collection sites entirely out of recycled materials. The Department of Town and Country Planning, Equipment, and Housing (DAEL) is preparing, as part of the program "Environmental Awareness in the Workplace," a directive regarding the use of recycled materials at State-funded work sites.

Food Products
After building materials, food products make up the main flow of resources consumed in Geneva.

To produce the 322,000 metric tons of food consumed annually by the people of Geneva, the equivalent of 2,500 m^2 of farmland per person per year is needed. Yet only 300 m^2 per person per year is available in Geneva and 1,500 m^2 in Switzerland. This explains why 85% of the food products consumed come from outside the canton.

On the face of it, this situation is not sustainable. Nonetheless, it can be if we reason in terms of the area needed for production on a larger regional or international scale.

As the metabolism study points out, the majority of this surface area is used as fodder for livestock. The total quantity of grazing land needed to feed livestock (in order to produce the milk and meat eaten in Geneva) is more than six times greater than the total quantity of food consumed in the canton.

Paper and Wood
Most of the wood consumed in Geneva is in the form of wood fibers in paper. The collection rate for old paper could still be improved, and the use of recycled paper should be more widespread, which is far from being the case today. This is very important since virgin forests are still being and continue to be destroyed to feed world demand for paper.

As far as wood itself is concerned, the study shows that the flow of wood waste from demolition is four times greater than the amount of wood supplied by Geneva's forests. An annual flow of 13,000 metric tons of used wood is even exported abroad to be reused as particleboard. To avoid the lengthy transportation process, reusing wood as an energy source within the canton is, therefore, a priority.

Metals
Most metals are already well incorporated into the recycling process at an average rate of approximately 90%, especially in the secondary sector. Nevertheless, we still do not know the sustainable level of consumption for these resources. Therefore, the priority in this area is to determine the threshold of long-term sustainable consumption for the various metals.

Plastics
In the area of plastics, we need to begin by estimating the levels of consumption considered sustainable. However, since plastics are currently manufactured using petroleum, their consumption is clearly not sustainable. As for disposing of plastics, the best option, given the current state of technology, seems to be incineration and the reuse of the heat released during combustion, as is current practice in Geneva.

Qualitative Considerations

The metabolism study highlights the quantities of resources consumed and shows that we must seriously improve the canton's metabolism if we intend to make it more sustainable. However, we must not lose sight of the qualitative considerations. Indeed, certain flows of resources, even if they are relatively inconsequential, deserve close attention since they could contain substances harmful to the environment or health. In particular, we are referring to heavy metals and other organic pollutants.

In addition to a few mass market products, such as batteries, these kinds of substances are found, in particular, in the secondary sector. For this reason, it is important to keep these points in mind as part of the aforementioned research into new opportunities for cooperation among companies. An example of the way we intend to take action to uncover opportunities for cooperation is the pilot study dedicated to researching synergies among industrial activities. Some twenty companies in Geneva, representing as many branches of the economy, are now voluntarily providing the full range of their data related to the use of

resources and the production of waste. With the help of a specialized software program, these data will be cross-referenced among themselves as well as with data from other areas of the economy to reveal new possibilities for collaboration. The pilot study, financed by the State as part of Project Ecosite, immediately sparked keen interest from companies that recognized straightaway its potential benefits.

A FIRST STEP TOWARD SUSTAINABLE DEVELOPMENT

Understanding the metabolism of economic activities represents a vital first step toward putting the Canton of Geneva on the road to sustainable development.

The conclusions and recommendations presented here concern first and foremost the actions of the State given that Project Ecosite is part of the framework of the "Law on the Public Initiative for Sustainable Development."

However, implementing industrial ecology and sustainable development is a lengthy process that requires, in addition to clear political will and commitment from the State, the cooperation of all members of society: local governments, companies, and, of course, all citizens intent on preserving the quality of life today and tomorrow.

APPENDIX 1

THE METHODOLOGY OF THE METABOLISM OF ECONOMIC ACTIVITIES

In 2002, the Ecosite work group ordered the preliminary study of the metabolism of the Canton of Geneva. The study was conducted by Ms. Mireille Faist Emmenegger and Mr. Rolf Frischknecht of ESU-services in Uster (Zurich) in collaboration with Mr. Laurent Cornaglia of Maneco in Geneva and Mr. Stefan Rubli of Wertstoff-Börse GmbH in Zurich.

The methodology chosen for the study of Geneva's metabolism has been developed by Prof. Peter Baccini and his colleagues at the Swiss Federal Institute of Technology Zurich (EPFZ) since the early 1990s. It is especially well adapted to analyzing the metabolism of economic activities on a regional scale.

Figure 4 illustrates the principle of physical accounting applied at the level of a region such as the Canton of Geneva.

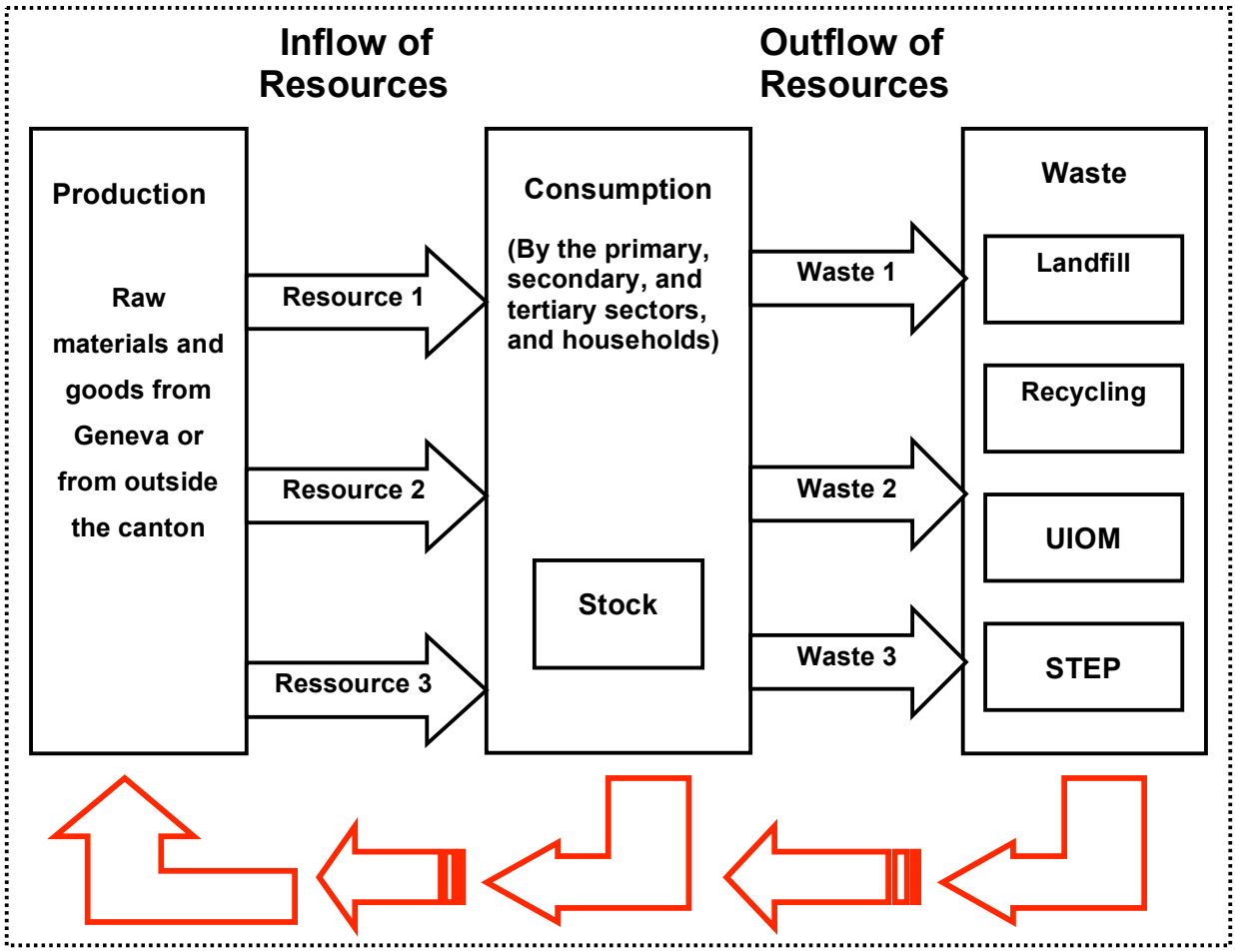

Figure 4: Schematic diagram for studying the metabolism of economic activities at the regional level, in this case the Canton of Geneva (UIOM = household refuse incineration plant; STEP = wastewater treatment plant).

As we can see in the diagram, economic activities are broken down into three stages:

- At left are the resources (raw materials, various goods) that constitute inflows. These flows originate from either within the canton of Geneva or outside of it (elsewhere in Switzerland or abroad).
- In the middle the resources required by the various sectors of the economy (primary, secondary, tertiary, and households) are consumed. A portion of the resources accumulate in the form of stock (roads, buildings, etc.).
- At right are the outflows, which are the wastes resulting from the consumption of resources.

In practice, a metabolism study consists mainly in establishing a balance sheet for mass by assessing or measuring the flows of matter and energy. The approach derives directly from the principle of the conservation of mass and energy: "matter cannot be created or destroyed" (Lavoisier's Law). Consequently, any flow of resources that enters a system (a region, a company, a household, etc.) exits it sooner or later, or accumulates as stock.

The study covers the three economic sectors and households. The sectors are divided into sub-sectors based on nomenclature from the Federal Office of Statistics.

The spatial and temporal limits of the system studied are as follows: the area defined by the political borders of the Canton of Geneva for the period from 1 January to 31 December 2000.

Naturally, we must bear in mind that these limits are relatively arbitrary. The metabolism of the Canton of Geneva is characterized by a very high percentage of resources imported from outside sources. For this reason, we recommend that, in a subsequent phase, trade with the rest of Switzerland and other countries, mainly neighboring France, be examined more closely.

Initially, metabolism studies are often conducted based on preexisting data and statistics, making it possible to paint a good idea of the system under study at a minimal cost. This was the option chosen for the first phase of the study of Geneva's metabolism.

As a result, we stress that the figures presented in this study are approximations. These preliminary results provide an overall perspective, a sense of scale, which is extremely useful for an initial evaluation, but which must be taken with some caution.

Presenting the detailed results of such a study would be too long. However, for the interested reader, a detailed summary is available on the State of Geneva's Web site: http://www.geneve.ch/agenda21/

The complete study, entitled "Metabolism of the Economic Activities of the Canton of Geneva — Phase 1" (September 2003), can be obtained upon request from the Cantonal Waste Management Service (GEDEC), Department of the Interior, Agriculture, and the Environment (DIAE), Chemin de la Gravière 6, CH - 1227 Les Acacias.

Example: Wood

As an example, study results for the resource "wood" (including paper and cardboard) are presented below.

The flows that were studied represent the direct consumption of wood (for building, furniture, etc.) as well as indirect consumption in the form of paper and cardboard. In 2000, the total consumption of wood, direct and indirect, equaled approximately 140,000 metric tons.

Wood

The direct consumption of wood is approximately 44,000 metric tons. The majority, or 38,000 metric tons, is imported from elsewhere in Switzerland or abroad. The forests of the canton of Geneva produce only 4,000 metric tons of wood annually.

It is interesting to note that the stock of wood tied up in buildings belonging to the three economic sectors and households, or approximately 1.3 million metric tons, is three times greater than the total stock of wood in Geneva's forests.

Wood is used in about half of households (furniture and construction). Wood used for heating represents only some 10% of total consumption (used chiefly in two high-capacity boilers at the Lullier Horticultural Center and the Troinex heating station).

Details of the flows and stocks of wood appear in Figure 5 below:

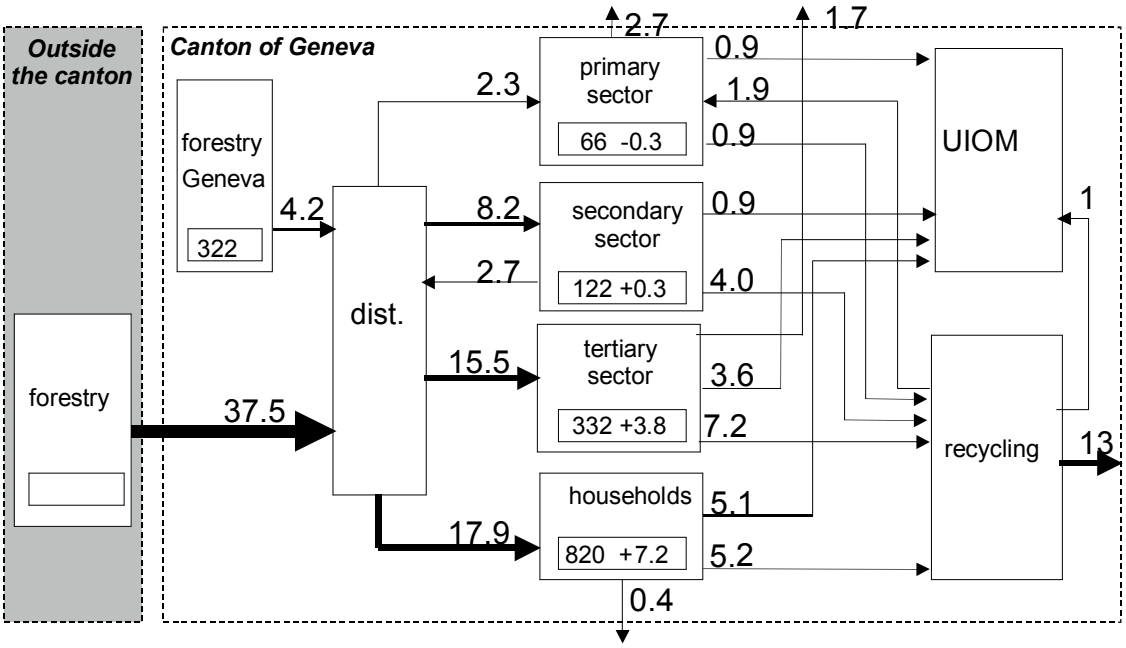

Figure 5: Flow of wood in the Canton of Geneva in thousands of metric tons per year.

Flows of 2.7, 1.7, and 0.4 thousands of metric tons leave the primary and tertiary sectors and households, representing quantities of wood burned in boilers. The flow of production from the joinery industry (windows, etc.) is estimated at 2,700 metric tons.

More than half of used wood (55%), or 16,000 metric tons, is collected separately. Most (13,000 metric tons) is exported to Italy to a chipwood manufacturer. Approximately 1,000 metric tons, which cannot be recycled, are incinerated at Cheneviers.

A small amount of wood is recycled: clean, used wood (1,900 metric tons) is reused by being burned in a boiler for horticultural greenhouses.

Paper

Total paper consumption was around 80,000 metric tons in 2000, and the paper was entirely imported from elsewhere in Switzerland or abroad. This included newspapers, graphics paper (magazines, copy paper), toilet paper, and household paper. As there is no longer a paper manufacturer in Geneva, recycling takes place outside the canton. The 80,000 metric tons of paper that were consumed required approximately 70,000 metric tons of wood fibers to be produced, or nearly double the amount of wood that was consumed directly!

As shown in Figure 6, the main consumers of paper are the tertiary sector (42,000 metric tons) and households (39,200 metric tons).

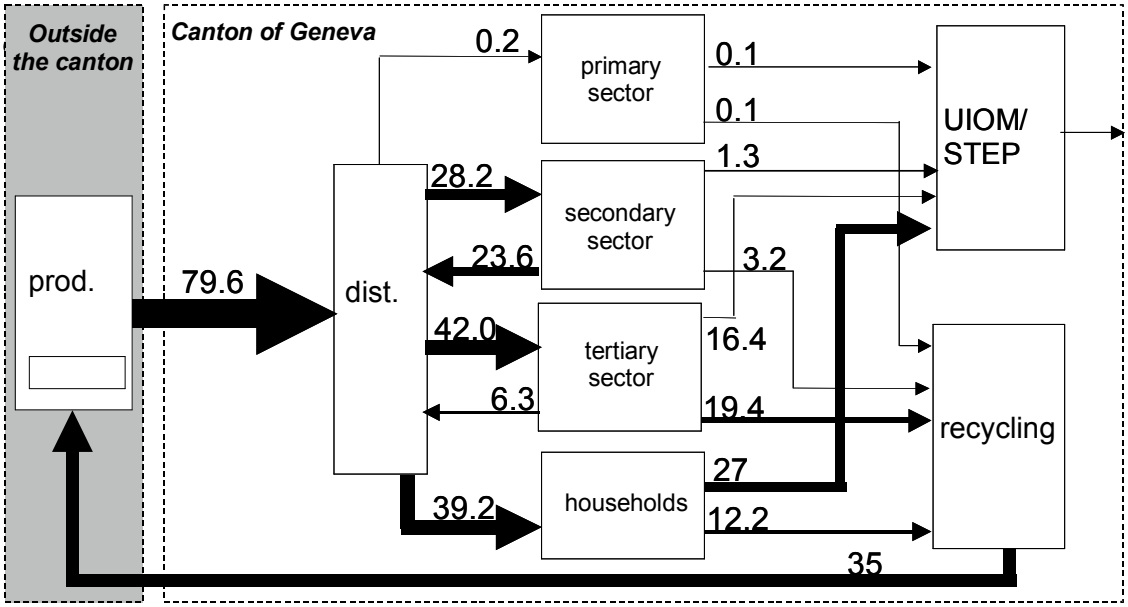

Figure 6: Flow of paper in the Canton of Geneva in thousands of metric tons for the year 2000. Due to a lack of data, the stocks of paper (archives) were not able to be calculated. Nevertheless, they should represent only a small amount of the paper consumed.

A significant amount of paper, nearly 45,000 metric tons (or more than half of total consumption) is still eliminated through incineration or at the wastewater treatment plant. It would seem possible to recycle at least half of the 45,000 metric tons of paper, or approximately 14,000 metric tons from households and 8,000 metric tons from the secondary and tertiary sectors.

In Geneva, more old paper is recycled than recycled paper is used. Indeed, the amount of old paper recovered for recycling totals 35,000 metric tons. In comparison, the amount of recycled paper used in Geneva is estimated at only 27,000 metric tons, or 34% of total paper consumption.

Cardboard

Cardboard consumption measured approximately 16,000 metric tons in 2000, and it came exclusively from elsewhere in Switzerland or abroad (see Figure 7). This reflects only around 2,000 metric tons of wood since cardboard contains a considerable proportion of recycled fibers.

The flow of cardboard is poorly understood, but it is estimated that 50% of used cardboard is burned at an incinerator for household refuse and the rest is recycled. It should be possible to recycle at least half of the incinerated cardboard.

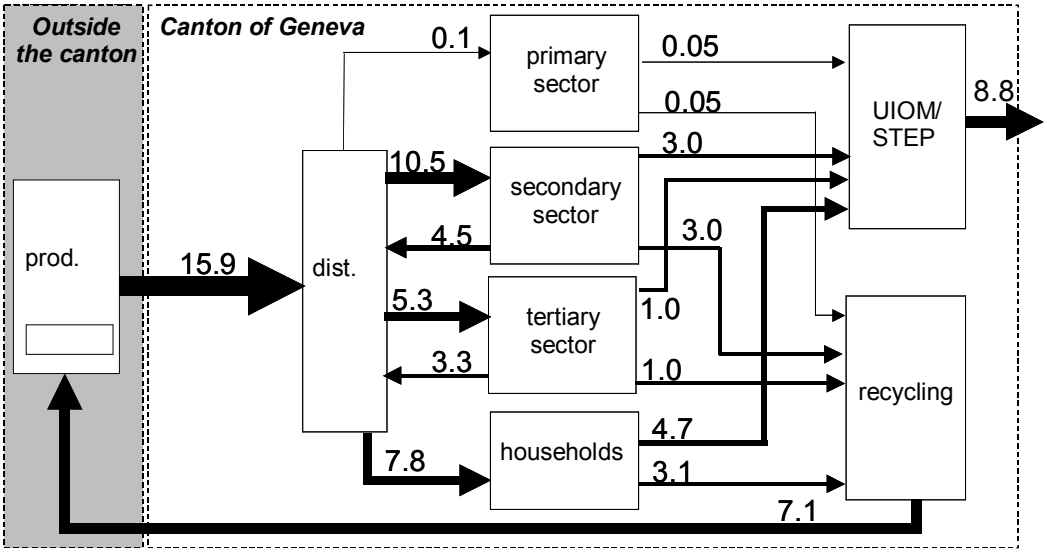

Figure 7: Flow of cardboard in the Canton of Geneva in thousands of metric tons for the year 2000.

APPENDIX 2

LIST OF MEMBERS OF THE ECOSITE WORK GROUP

President

Mr. Daniel Chambaz, Director, Cantonal Waste Management Service (DIAE)

Representatives from the cantonal administration

Mr. Alexandre Epalle, Director, Cantonal Sustainable Development Service (DIAE)

Mr. Jean-Charles Magnin, Director, Office of Economic Affairs (DEEE)

Mr. Philippe Möschinger, Director, Foundation for Industrial Land in Geneva, (FTI)

Mr. Olivier Ouzilou, Director, Cantonal Energy Service (DIAE)

Mr. Richard de Senarclens, Deputy, Office of Buildings (DAEL)

Outside Consultants

Mr. Peter Baccini, ETHZ-EAWAG, Zurich

Mr. Suren Erkman, ICAST, Geneva

Secretariat

Ms. Joëlle Mathey and Mr. Eric Zellweger, Evaluanda, Geneva

APPENDIX 3

LIST OF EXPERTS CONSULTED

The study of the metabolism of economic activities of the Canton of Geneva was the focus of an in-depth evaluation by the cantonal administration. The following experts were consulted:

Mr. Michel Agassiz, Director, Cantonal Geology Service

Mr. Philippe Burri, Director, Office of Transportation and Traffic

Mr. François Cupelin, Director, Cantonal Air Protection Service

Mr. Gilles Gardet, Director, Office of Town and Country Planning

Mr. Christian Keimer, Executive Assistant, Agricultural Service

Mr. Gilles Mulhauser, Director, Forestry and Environmental Protection Service

Mr. Roland Rietschin, Deputy Director, Cantonal Office of Statistics

Ms. Aline Sauter, Engineer, Cantonal Environmental Impact Study

Mr. Charles Stalder, Director, Water Policy