

## Stock and flows of energy

Every country and every city has a specific way to acquire, transform and distribute energy. The chapter on infrastructure will describe the physical necessities to transform and transport energy. In this chapter, we are interested in the different sources and uses of energy.

A comparison between Switzerland and Singapore reveals significant differences. While Switzerland has a broad mix of different energy sources or supplies, ranging from hydropower to gas, crude oil, nuclear and biomass, Singapore relies mostly on natural gas and crude oil. As a result, Switzerland's electricity production is almost carbon free, whereas in Singapore there is almost no carbon free electricity production.

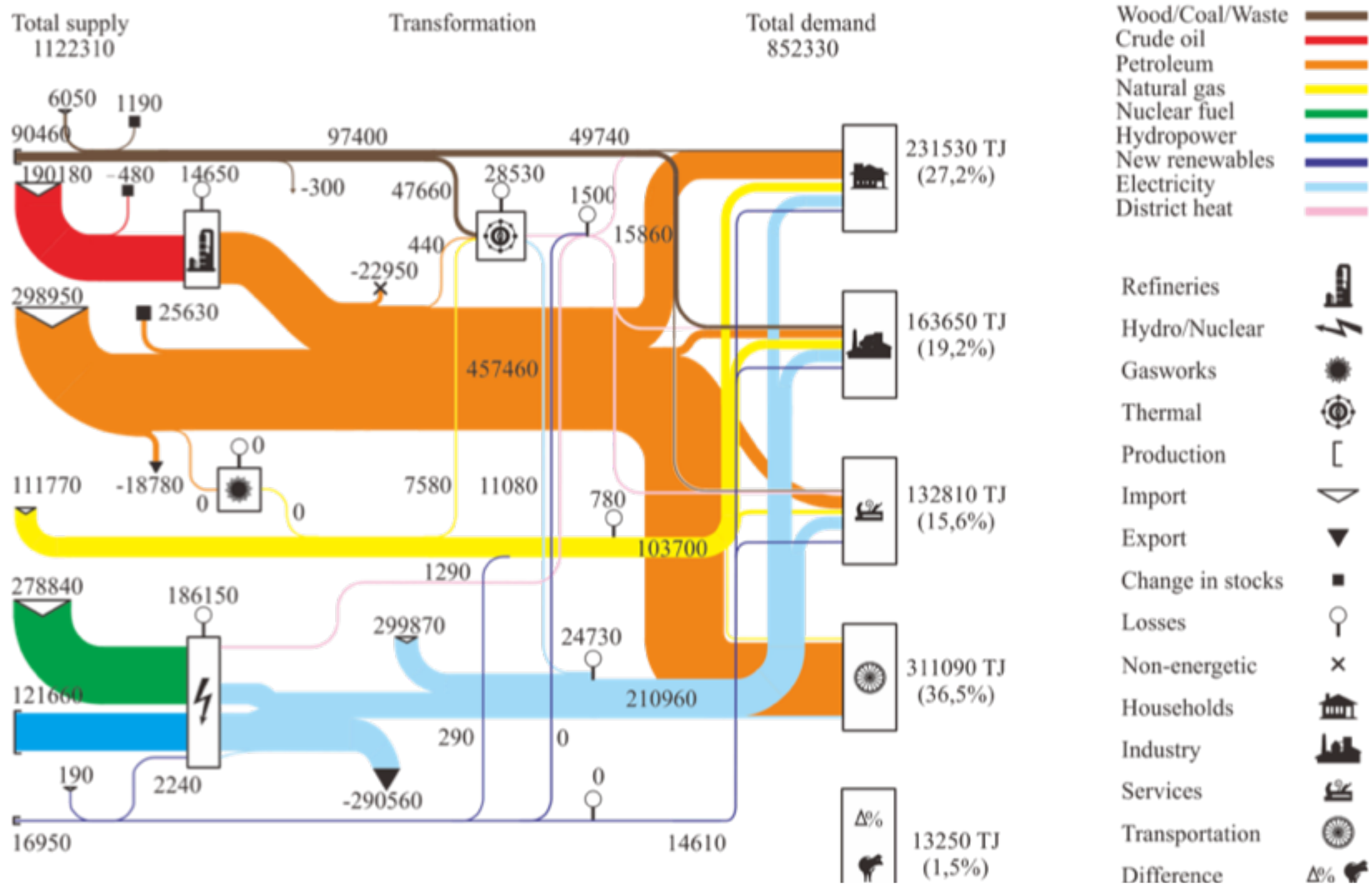
The uses of or demands for energy are also different in the two countries. In Switzerland a large percentage of the energy is used to heat residential buildings, offices and factories, whereas the need for heating fuel in Singapore is zero. Instead, electricity is needed to cool factories, residential buildings and offices. Large differences are also visible in transportation. While Switzerland is a mountainous country with a multitude of centres, Singapore is a small island with short paths and no mountains. As a consequence, the per capita energy use for transportation is smaller than that of Switzerland.

The storage of energy is also different. In Switzerland, artificial lakes with dams in high altitude serve as energy reservoirs and

energy buffers during times when excess energy can be generated. This water can later be used to generate electricity that can be produced exactly when it is needed. The water in the reservoir is at the same time a stock of water for drinking purposes, but also for energy storage purposes. The flow of water for drinking purposes is normally from higher elevation areas into the lakes, whereas the flow of water for energy storage purposes can be reversed, which means that large amounts of water are pumped from lower situated lakes into higher situated ones.

The stocks and flows of other energy sources may not be as spectacular, but they are also interesting. For example, the stock of wood is growing in forests. After harvesting, it turns into a stock of heating materials. The stock and flow of oil begins its cycle as a stock in the subterranean caverns of Saudi Arabia, flows into tankers or pipelines, ends up as temporary stock in oil tanks, and is finally transported as a flow into the individual heating appliances.

## Gallery 6.1 Stocks and flows of energy



Berger, M. *Energy supplies, energy transformation, and energy demand in Switzerland in 2012.*

## **Stocks and flows of materials in the city**

Concrete is a good example to explain the concept of stocks and flows of materials in a city. The components of concrete are mixed with water, concrete is then poured, hardens and becomes a stock. This is almost a literal translation of the stocks and flows principle. What happens with concrete after the lifetime of the structures in which it has been used expires? In an era when recycling was neither an ecological nor an economical necessity, it was exploded, torn down, crashed, and dumped in the city itself or, more often, in its hinterland.

But concrete is a very valuable material with high energy embodiment and thus a major cause for greenhouse gas emission during the production of its components. When a city is being built or expanded, the need for concrete is immense. Every emerging economy and country shows this extensive need. At the beginning of the 21st-century, this is the case in Asia, Africa, and South America, while in Europe and North America the need for concrete has decreased.

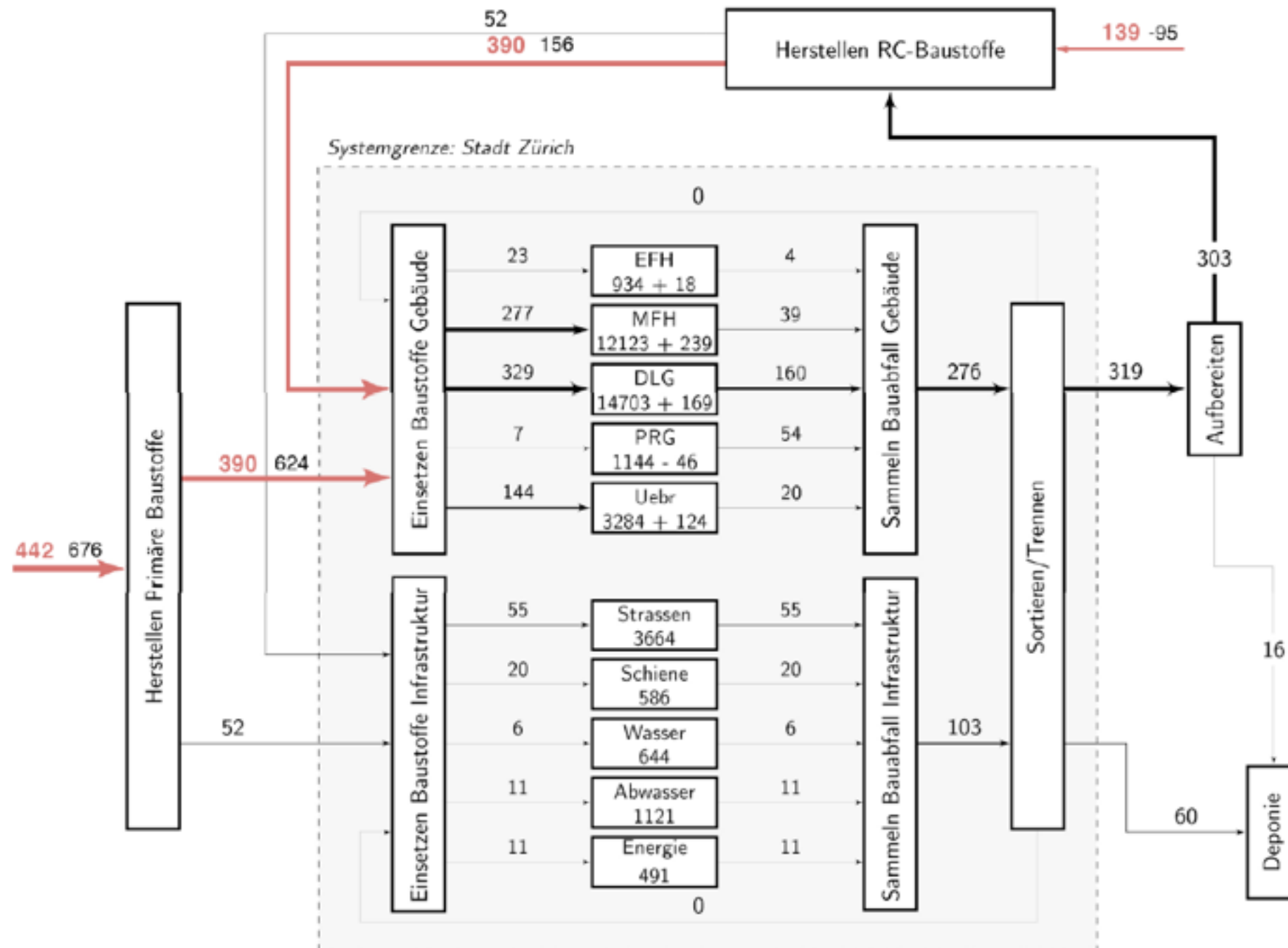
Recycling of concrete is a relatively new concept and describes the decomposition and crushing of a stock of concrete to prepare its parts for reuse in another context. If a city is not growing very much any more, such as in Europe, the recycling of concrete makes very much sense for ecological and also economic reasons. In the new emerging cities in China that grow from a few hundred thousand to several millions inhabitants within a few

decades, there is no possibility to recycle, because the stock of material does not exist beforehand. In other cities, such as Singapore, where there is a consistent scarcity of building materials, especially sand, there is a high economic incentive to recycle every tonne of concrete when a building is torn down or a broken infrastructure is renewed.

A concrete example might show dimensions of the stocks and flows of concrete in a city. The first step is to define the system boundary within the observations and the measurements that are to be made. In Zurich, for example, this would be the city boundary. Looking at a particular year, in this case 2005, researchers from ETH Zurich have analysed the stocks and flows of concrete precisely. They found that 676,000 tonnes (t) of concrete gravel flowed into the city and that 379,000 t of concrete material left the city boundaries. Almost half of the inflow, approximately 329,000 t, went into new office buildings, which at the same time produced with 160,000 t also the highest outflow. The present increase of population of Zurich is reflected in 277,000 t of concrete flowing into the city for apartment buildings, and only 39,000 t from demolished apartment buildings leaving the city. At the same time, only 7000 t of concrete went into the construction of new factory buildings, while 54,000 t of demolished factory buildings left the city.

This glimpse of material flow in and out of the city shows how closely related it is to the history of the city.

## Gallery 6.2 Stocks and flows of concrete material in Zurich in 2005



From: "Entwicklung einer Ressourcenstrategie für mineralische Baustoffe für die Stadt Zurich", Martin Schneider, Stefan Rubli, Heinrich Gugerli, 16. Status-Seminar «Forschen und Bauen im Kontext von Energie und Umwelt», 2010, <http://www.stadt-zuerich.ch/nachhaltiges-bauen>

## Stocks and flows of water in the city

There is no city without water. Water decides on the survival of a city, and always did. In ancient times, water was transported in aqueducts over large distances, when the city's internal water resources dried up or were not sufficient any more. In the city, water is used as a stock in lakes, drinking water reservoirs or in individual water tanks on, in and below buildings. Water is a technical, an artistic, an architectural and a landscape architecture element.

### Gallery 6.3 Stocks and flows of water in the city



Schmitt, E. 2013. *The Marina Bay Singapore, previously open sea, now a freshwater reservoir*. [Photograph].



## Stocks and flows of wood in the city

Wood used to be a crucial stock and flow contributor in early cities. It was at the same time construction material and heating resource. Its overuse around cities might have caused climate changes in the cities and in some cases led to the demise of the city. Wood is prone to fire and was therefore replaced, when possible, by more fire resistant materials. It has a comeback today as a construction and heating material. Wood stores CO<sub>2</sub> in large quantities.

### Gallery 6.4 Stocks and flows of wood in the city



Schmitt, G. 2011. *Wooden Royal structure in Mandalay*. [Photograph]. Myanmar.





## Stocks and flows of food in the city

Food used to be grown directly around buildings. With the growth of cities, its production moved further away from the centre. Today, food in almost every city comes from global sources. This causes high levels of CO<sub>2</sub> during its production, its processing, and its transportation. In Singapore, more than 96% of the food needs to be imported. As “Urban Farming”, food in the city is making an important comeback in cities that had completely lost their direct relation with food production.

**Gallery 6.5** Stocks and flows of food in the city



Schmitt, G. 2011. *On the way to the market in the morning*. [Photograph]. Mandalay, Myanmar.



## Stocks and flows of capital in the city

There is no city without capital, and the stocks and flows of capital are a decisive factor in the development of the urban system. As capital is a virtual entity, it has a different effect on the shape, size, and liveability of a city than material stocks and flows, such as concrete or water. Yet there is a strong relation between the location and the spatial quality of the city, and the flows and stocks of capital.

**Gallery 6.6** Stocks and flows of capital in the city



Schmitt, G. 2013. *Hotel and convention centre in Moscow, constructed after the end of the Soviet Union*. [Photograph].



## Stocks and flows of land in the city

Land appears to be a stable stock at first sight, with little flow possible. Yet if we take a closer look at any of the ancient or newer cities, we will find significant flow of land, either to increase the buildable area into the sea or into a lake, or from natural accumulation of material which leads to vertical growth of land. Singapore, for example, has increased its land area by several hundred square kilometres, but also Zurich has claimed land from the lake of Zurich.

### Gallery 6.7 Stocks and flows of land in the city



Bettschart, F. 2012. *Artificial land made in Singapore. The entire Marina Bay area is reclaimed from the sea.* [Photograph].

## Stocks and flows of people in the city

It is not correct to place people in the same category as other stocks and flows in the city, but there are similarities. Areas of the city, for example, which have been inhabited for a long time by generations of people from similar backgrounds, could be called to represent a stock of people. The flow of people is characterised by those who newly came into the city from the outside and by those who leave the city or die in the city.

### Gallery 6.8 Stocks and flows of people in the city



Bettschart, F. 2012. *People, cars and motor scooters mixing as a stock and flow in the street.* [Photograph]. Ho Chi Minh City.



## Stocks and flows of density in the city

It appears surprising at first to list density or space under the stocks and flows characteristics of the city. Yet the concept becomes immediately clear if we imagine the difference between a mediaeval Italian city, such as Siena, and a suburban sprawl area in Phoenix Arizona. The example of Detroit in the beginning of the 21st century demonstrates that density does not remain a stock for ever, but that rapid changes of density can happen within few years.

### Gallery 6.9 Stocks and flows of density in the city



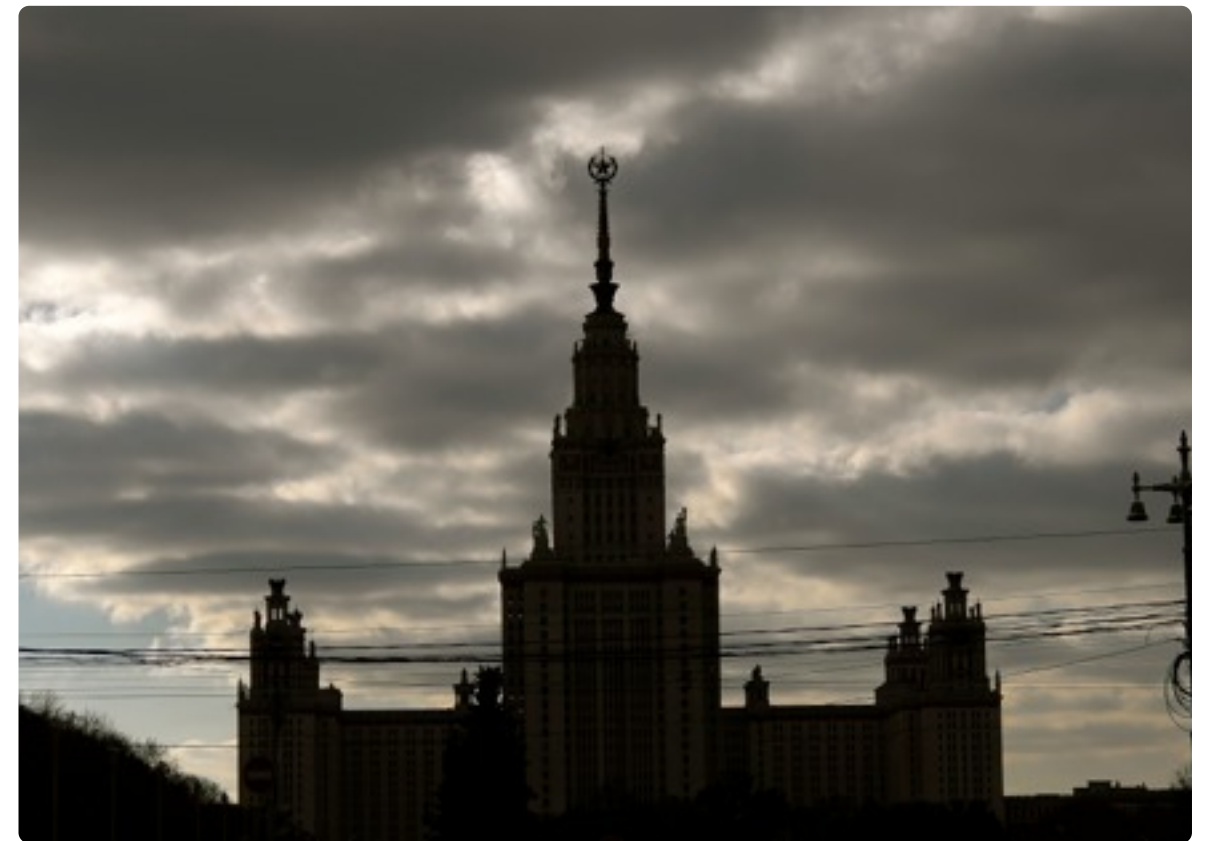
Schmitt, G. 2013. *Different planned densities in the city of Moscow, seen from the tower of Lomonosov University.* [Photograph].



## Stocks and flows of information in the city

In the information city, stocks and flows of information are almost as important as water or materials. A stock of information is any library or data warehouse. The flow of information is ubiquitous and continuously increasing in all cities of the world. In many places, the storage of information has led to its own infrastructure, which is increasingly consuming space and energy and thus influences the other stocks and flows of the city, as the chapters on information architecture and information city show.

### Gallery 6.10 Stocks and flows of information in the city



Schmitt, G. 2013. *Architecture to foster the flows and stocks of information.* [Photograph]. Lomonosov University, Moscow.

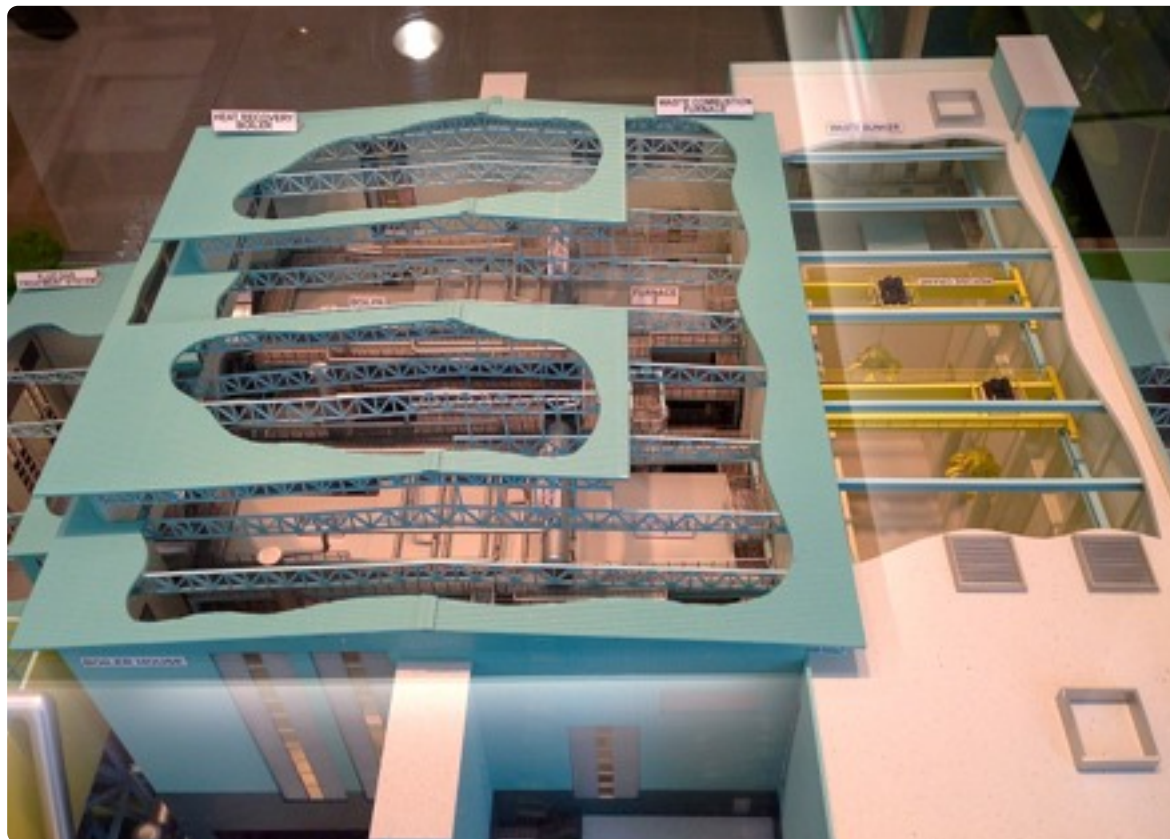




## Stocks and flows of waste in the city

In the mid-term future, there will be no waste. Waste is a temporary expression that exists in times and places of surplus, but really in times and places of scarcity or in sustainable communities and societies. Progress in science and in the understanding of the composition of materials has helped to reduce the amount of landfills, which is common in industrialised cities, and has led to a much more intelligent and value creating recycling – something known since antiquity.

### Gallery 6.11 Stocks and flows of waste in the city



Schmitt, G. 2013. *Model of a “waste to energy” power-plant, turning household waste into electricity and ash for landfill. [Photograph]. Singapore.*

## Stocks and flows of pollution in the city

Pollution of any kind – be it noise, aerosols, smoke, smog, haze, oil spills or unclean water – reduces the quality of life of the city, its livability, its attractiveness, and most importantly, the health of its inhabitants. With progress in turning waste into resources of new products, pollution will automatically decrease, but it will remain a major problem, for many years to come, in cities that do not have a holistic view of the urban system as an organism.

### Gallery 6.12 Stocks and flows of pollution in the city



BBC News, June 19, 2013. *Singapore haze and its impact on the economy.* [Screenshot].