Building methodology paper

The buildings sector, comprising both the residential and services sub-sectors, consumes 35% of global final energy use and is responsible for about 17% of total direct energy-related CO_2 emissions from final energy consumers, according to IEA Energy Technology Perspective 2012. If we take into account indirect upstream emissions attributable to electricity and heat consumption, the sector contributes about one-third of global CO_2 emissions.

Energy demand in the building sector is driven by many factors. Some of them have a direct impact on energy consumption and some of them have an indirect impact. In this model we built relationships for each of these factors and simulated how different behaviour will impact the energy demand for the building sector.

Global population. The population is the biggest driving factor for energy demand in the building sector. The rapid growth of global population has led to more building floor area, higher levels of appliance ownership, and more energy demand.

Global urbanisation. In 2011, 52.1% of the global population lived in urban areas[1], which meant more people had access to commercial energy services and could improve their quality of life. In some developing counties like China, urban residents have different behaviour of energy consumption and energy supply system compared to rural residents. Urbanisation will have a big impact on the energy consumption for modern energy sources, especially in the developing countries.

Access to electricity. The International Energy Agency (IEA) estimates that about 1.2 billion people lacked access to electricity in 2009, and this was almost 20% of the world's total population. As the economy and living standards continue improving, more and more people could have access to electricity and modern energy.

[1] http://esa.un.org/unup/unup/p2k0data.asp

Building floor area. In the last fifty years, the average building floor area has increased rapidly in most developed countries and recently in the developing counties. The building floor area has a big impact on heating and cooling demand for residents.

House insulation. House insulation, also known as house efficiency, plays an important role in heating and cooling demand for both residential and services.

Heating and cooling technology. The different heating and cooling technologies will lead to totally different energy efficiency and energy consumption. For example, in some developed countries, people use more high efficiency heating technologies like heat pumps, however in some developing countries, people are more likely to use lower efficiency and more polluting technologies like solid boilers.

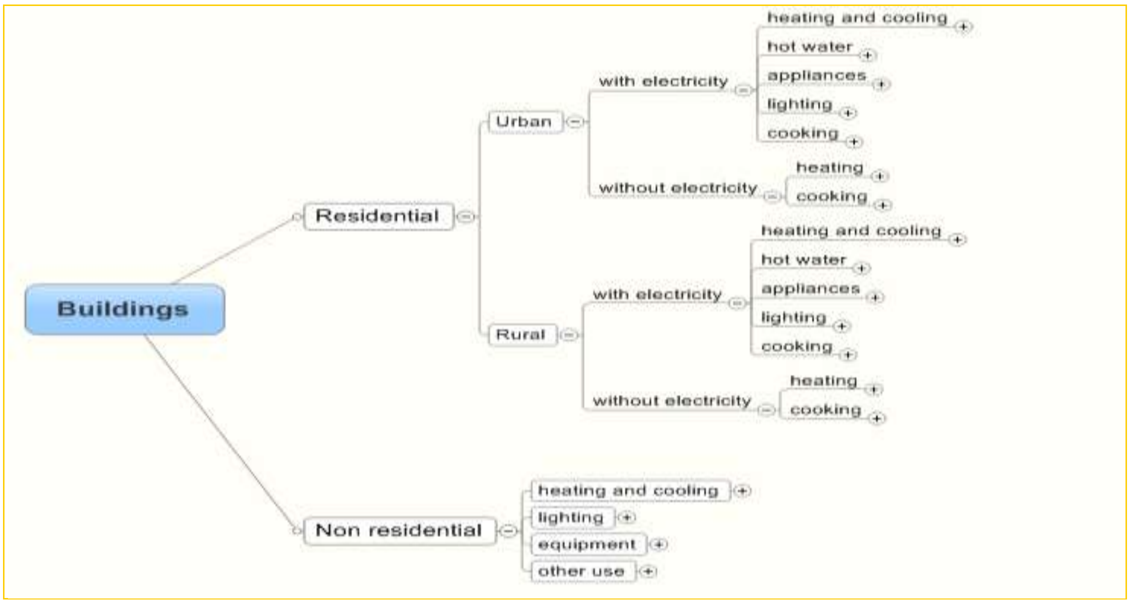
Appliances and equipment ownership. It is natural that when people get richer, they tend to acquire more appliances to improve their lives. On average, people in developed countries have 3 times more appliances units than people in developing countries. And there is also a big difference in urban and rural areas.

Efficiency of appliances and equipment. Efficiency is quite important for appliances, as it means people could have higher living standards with less energy consumption. Some countries have developed Energy Efficiency Labels to improve appliance efficiency.

Lighting technology. Lighting takes a large proportion of energy consumption in building sector. Several countries treat Green lighting as their low carbon and energy efficiency strategy; they encourage more advanced lighting technology while eliminating outdated technologies.

Cooking demand and technology. Cooking is quite important for people, especially in rural areas. Rural people use much more traditional bioenergy with very low efficiency, meanwhile urban people could use much more electricity, which could potentially be decarbonised in the future.

The following chart shows the structure of the building model.



This model calculates residential and non-residential energy separately for the building sector. For the residential sub-sector, the model considers urban and rural residential base on the big different behaviour.

The model also includes access to electricity which is a very important factor. The model simulates four categories of people, which are:

1. urban people with access to electricity;
2. urban people without access to electricity;
3. rural people with access to electricity;
4. rural people without access to electricity.

In each category, the model calculates six types of energy consumption behaviour, such as: 1.heating; 2.cooling; 3.hot water; 4. appliances; 5.lighting; 6. cooking.

Finally, each type of energy consumption behaviour is a function of several factors, which is quite clear in the model.

Energy Calculation Methodology

Each type of energy consumption is a function of different factors introduced above.

1. Heating. Heating energy demand = f(numbers of household, house floor area per household, inside temperature, house insulation, heating hours, heating technologies)

2. Cooling. Cooling energy demand = f(numbers of household, house floor area per household, inside temperature, house insulation, cooling hours, cooling technologies)

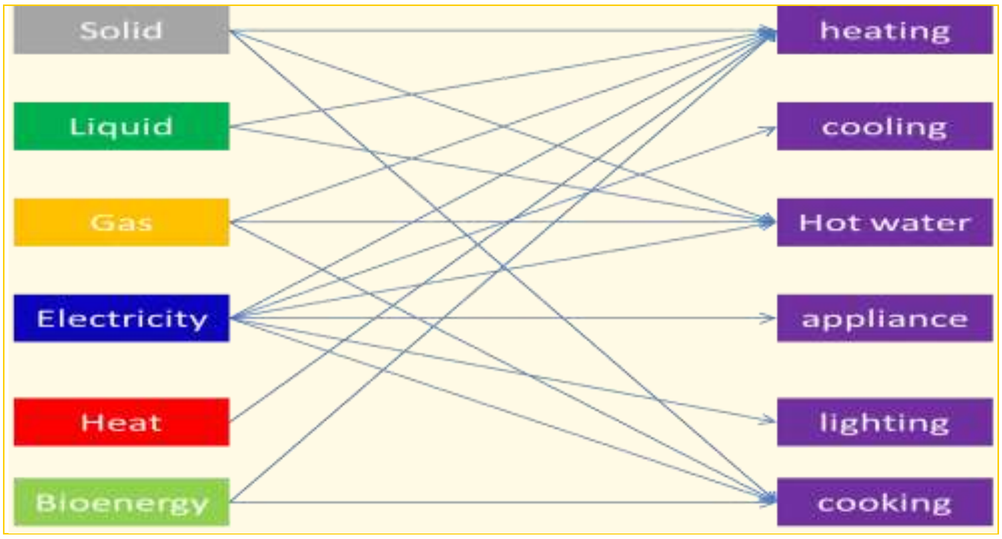
3. Hot water. Hot water energy demand = f(population, hot water demand per capita, hot water technologies)

4. Appliances. Appliance energy demand = f(numbers of household, appliances ownership per household, appliances use hours, appliances efficiency)

5. Lighting. Lighting energy demand = f(numbers of household, lighting ownership per household, lighting hours, lighting technologies)

6. Cooking. Cooking energy demand = f(numbers of household, cooking energy demand per capita, cooking technologies)

The following chart shows the energy flow in the building model.



Emissions Calculation Methodology

Once the model calculates the energy consumption, we use a very simple methodology to calculate the emissions. This is based on the amount of each fuel used, multiplied by the emissions factor for that fuel.

$$\text{Total emissions} = \sum Fuel_i \; * \; emissions\ factor_i$$

There are some specific assumptions to highlight:

1. In the model, we use average emissions factors for solid, liquid and gas fuels. That means in other parts of the model (such as power generation, material and transport), the emissions factors are the same number.
2. In the building sector, the electricity and heat emissions factors are zero. This is because the model assumes that electricity and commercial heat are generated by other sectors. We need to avoid calculating the emissions twice, so in the building sector we assume that the factors are zero.
3. The model in the building sector assumes that bioenergy is considered carbon neutral.