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Building system loads and its climatic data

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Summary

This paper is considering application of stochastic models on human factor. It describes energy and environmental loads of buildings and types of data needed to be obtained in practice.

KEYWORDS: Water and electricity consumption, waste production, building occupation, climate dates and its formats.

1. TYPE OF ENERGY AND ENVIRONMENTAL BUILDING SYSTEM LOADS

1.1. Water consumption

Consumption of water depends on the type of building and its occupancy during operation. It is necessary to have a respect to behavior of users, to respect their needs, regional practice or hygienic consumer habits by assessment water consumption. It isn't important only total water consumption, but we want to know distribution of fractional water consumption in the time period. On the basis of improvement curves of water consumption for particular types of buildings is possible to design smaller reservoir for warm water and in consequence smaller heat sources. Subsequently it leads to reduction of flow warm water in circulatory pipe and it leads to lowing energy intensity of heating water.

<u>Model of water consumption depends on these characteristics:</u>

- type of building and its purpose
- number of people in the building
- direct water using (for toilet, shower, cooking, garden watering, swimming pool…)
- using water for technical equipment (production processes)

<u>Work objective:</u>

It is necessary to develop models which will correspond with real consumption profile. We have to obtain for practice two formats of data:

- average yearly values (for overall summary of water consumption)

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- water consumption distribution to time period (for precise design of heating water)

1.2. Waste water production

Waste water production is directly linked with consumption of water in most of cases. For most cases flow waste water is equal to consumption of water which means that the sum of warm and cold water consumption in time period is equal to flow waste water in the period. In some cases the water doesn't outflow (for example garden watering) or it outflows with some time-current delay (filling swimming pool, washing up or tidying up). This delay isn't important for us because it is only drainage of waste water from the building. It is important for us to know total production waste water and its quality which can be very different and again it depends on the user.

Waste water is divided on 3 types:

- waste water from toilets which are contaminated and needs biological cleaning
- waste water from wash-basins, baths, showers, roofs,…which is possible considered as almost clean and it is appropriate for recycling and reuse.
- waste water with fat, oil or petrol which needs special wastewater pretreatment.

Recycling possibilities depend on resource of waste water and on using of recycled waste water in building.

Work objective:

We need similar data as like as water consumption.

1.3. Production of solid waste

Daily profiles these waste aren't interesting because these waste collection is realized in regulated interval, for example two times a week for household waste or one times a month collection of paper and its following recycling. Average values of waste depend on the type of building, for example in the offices. There is massing more wastepaper than in other buildings over big quantity of computation techniques. It is the most important by this waste their sorting which increases efficiency liquidation of this waste and reduces energy intensity of proper liquidation.

Work objective:

We need average values waste production of solid fabric (paper, special waste, biologically liquidated waste and type of building). These values serve for design temporary storage spaces and collectors equipments.

1.4. Electricity consumption

Consumption of electricity depends on occupancy and use of building. User behavior is in this case again the key factor, next key factor is using of control systems which are setup in building service (for example automatic switch of lighting during person absence in interior) or economic running equipment (PC, printers, copiers, …). This precaution has influence on total consumption of electricity. When lighting is switch off during user's absence or offices equipment is running in economic mode so total profile will be very different from the profile, when real occupation in the building wasn't taken into calculation.

<u>The model should be made from independent part of each specific electricity use:</u>

- lighting
- heating and cooling including additional equipment (circulatory pumps, humidification and cooling boxes
- ventilation
- computers and other office equipment
- domestic electrical appliances (television, stereo, cleaning equipment, cooking, fridge, freezer)

<u>Work objective:</u>

Created model should copy real energy consumption and should have included all control systems.

2. LOADS MODELING

2.1. Building occupation

Occupation has very significant effect on energy flows in buildings.

- Directly production, for example heat production of person (in usual situations one person products around 100 watt heat which can represent significant part of need for heating of very good insulated buildings). Direct heat consumption depends on number of person in the building and their activity.
- Indirectly consumption of sources (water, electricity, energy) and production of waste linked with people behavior (for example: opening windows, using water on toilet, switching on electric equipment and lighting). It depends on number of person in the building and probably people behavior in the building.
- Indirectly consumption of sources for associate operation equipment of building (circulatory pumps, sanitation pumps, ventilators, air conditions

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units,…) and emergency equipments, for example lighting. This consumption depends mainly on time of running equipment.

Building or room occupation is independent parameter, user's profile of one need is usually independent on other variables (for example: energy consumption doesn't depend on waste water production). User's profile strongly depends on occupancy and time-current interval.

2.2. Models type of people behavior in the building

- fixed profile which depends on time: day, weekday, month (we are taking into consideration leave and arrival time, weekdays plan and holidays)
- stochastic models based on Markov chains, which are giving probably transition from one state to another, are processed on real dates in similar building type.
- empiric models based on obtaining information from real dates of occupancy in similar building.

2.3. Description principles of building loads

Buildings loads which depended on human factor we call stochastic processes. Stochastic processes are such process where are physical laws supplying laws of probability which are showing for random time interval probability values. The processes are developing randomly from one to second state and future these states is possible to determine only on the basis probability.

For description these states are using Markov chains which are stochastic processes with final number of states where is time divided on individual time intervals. Markov chains are possible to use only when it discharge following condition: "Future development of process depends only on existent process state and no on its history.

2.4. How do we use Markov chains?

Mainly idea this method is building matrixes (Markov matrix) which expressive probability of process in time interval which is going from the one state to another state during next time step. Every element $P_{ij}(t)$ represent probability of change process from state i in time t to state j in the future time step t+1, which we call "change probability" state i to state j.

Theory of Markov chain gives information to us about probability behavior of process and calculation "static vector of probability". This vector gives probability apparition each state in long-time interval.

2.5. Model

It is necessary to have enough dates in acceptably period which will designate and probability of use. We have to determinate time step about which we interest and we have to be sure that it is possible to obtain data with time results. Because this method use union of discreet states, we need again to group parameters values to final number intervals where every interval is termed represent values (often it is maximum, minimum, or average value from the interval) We can use dates for derivation to transition probability as per cent of incident which we interest and total number of events. Now we have "catalogue" of transition probability from one state to other. Next it is possible use this information for simulation behavior of parameters by simple method which is calling reverse method.

3. CLIMATIC DATA, ITS FORMATS AND USE IN THE SIMULATION COMPUTER PROGRAM

Except people behavior in the building, exterior climatic conditions influence energy and environmental building systems loads modeling. It influences consumption of energy for heating and cooling by these exterior conditions. Climatic conditions are simultaneously impulse for user which for example in summer, when it is hot, switches on air-conditioning or ventilator.

In winter user can increase temperature on term regulator in required room or heating sources output. Public notice 152/2001Sb. establishes rules for heating and assessment consumption of energy. This notice fixes start (1. September) and end (31. May) of heating period. Heat supply starts in heating period, when average daily temperature of exterior air goes down below 13°C in two tandems following days and cannot expect increasing this temperature above 13°C for following day. Heat consumption is currently assessing by day-degrees method where we know number of days and average exterior temperature in heating period for every locality.

$$Q_{VYT,r} = \frac{24 Q_c \bullet \varepsilon \bullet D}{t_{is} - t_e} [Wh/rok] \qquad (1)$$

where:

$Q_{VYT,r}$ - yearly need of heat [Wh/rok]

Q_c - heat loss of building [W]

ε - correction factor

D - number of day-degrees [d.K]

t_{is} - average interior temperature [°C]

t_e - calculating exterior temperature (it is assigned according to locality). [°C]

$$D = (t_{is}-t_{es})\cdot d \qquad (2)$$

where:

t_{es} - average exterior temperature in heating period [°C]
d - number of days in heating period [-].

A Day-degrees pattern shows that it is two-times influenced by climatic dates. Firstly, average exterior temperature and than number of days in heating period are influenced. Number of days in heating period is possible to determine returnly for each heating period.

Nowadays average daily exterior temperature is assessed as:

$$t_{ed} = \frac{t_7 + t_{14} + 2 \bullet t_{21}}{4} \qquad (3)$$

Nowadays, when it is going to building-up development from thermal properties aspect of building, this assessment way is unsatisfactory. Using existing average exterior temperature by very good insulated building leads to deviation of calculated and real values. Today, it is setup in some meteorological stations automatic monitoring and writing climatic dates.

By using existing thermal average, it is necessary to make a difference between average daily temperatures, average monthly temperatures and thermal average of individual years. The long-term average values show smaller fluctuations of temperatures. The daily average exterior temperature is assessed from measured values:

$$t_{ed} = \frac{\sum_{e=1}^{e=24} t_e}{24} \qquad (4)$$

We can obtain average exterior temperature in heating period t_{es} from this assessment daily average exterior temperature

$$t_{es} = \frac{\sum_{d=1}^{d=n} t_{ed}}{d} \qquad (5)$$

where *d* is number of days in heating period.

Using average daily exterior temperature is by using spreadsheet program possible and calculated value of energy consumption is most approached to real energy consumption. Use of average hourly temperatures is possibility of next improvement of energy consumption. The average hourly temperatures for heating

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period are used in simulating programs with using climatic databases due to big number of this values (for example: TMY, IWEC, WEA,…etc.)

4. TYPICAL METEOROLOGICAL YEAR

It is most significant format of climatic dates. It is a group of meteorological dates with values for typical year which is making from selection month of separate years (long-time measured during 30 or 50 years). Individual selections are linked to typical meteorological year format. Typical meteorological year has two format types: TMY and TMY2. In this formats are including hourly and monthly dates. Every file have to obtain head with title of measured station, WBAN number (this is identification number of station), town, state, time zone, latitude, longitude and camber. For get date it is necessary to know its position in the column, type of date and range their values. Measured dates are divided to groups. A-D is calibration measured dates, E-I is data which isn't directly measured, but it are generating by other inputs or are obtaining from prediction models. Further are data divided to groups (1-9) according to uncertainly of measured or generation where the group 1 has smallest % uncertainly.

<u>Mainly dates of meteorological year:</u>
- dry-bulb temperature
- dew point temperature
- relative humidity
- static pressure
- direct solar radiation
- diffusion solar radiation
- global solar radiation
- wind direction
- wind speed
- precipitation
- cloudiness

TMY and TMY2 has different time format and units hence isn't possible change it. Sometimes is directly and complex data hard to obtain or it is available in other format which we need. In this case we have to use for example Weather manager which can analysis and conversation to other dates formats. Among most supported dates formats is:
- TMY Climate Data (TMY)
- TMY2 Climate Data (TMY2)
- Energy plus weather files (EPW)
- Weather data file (WEA)

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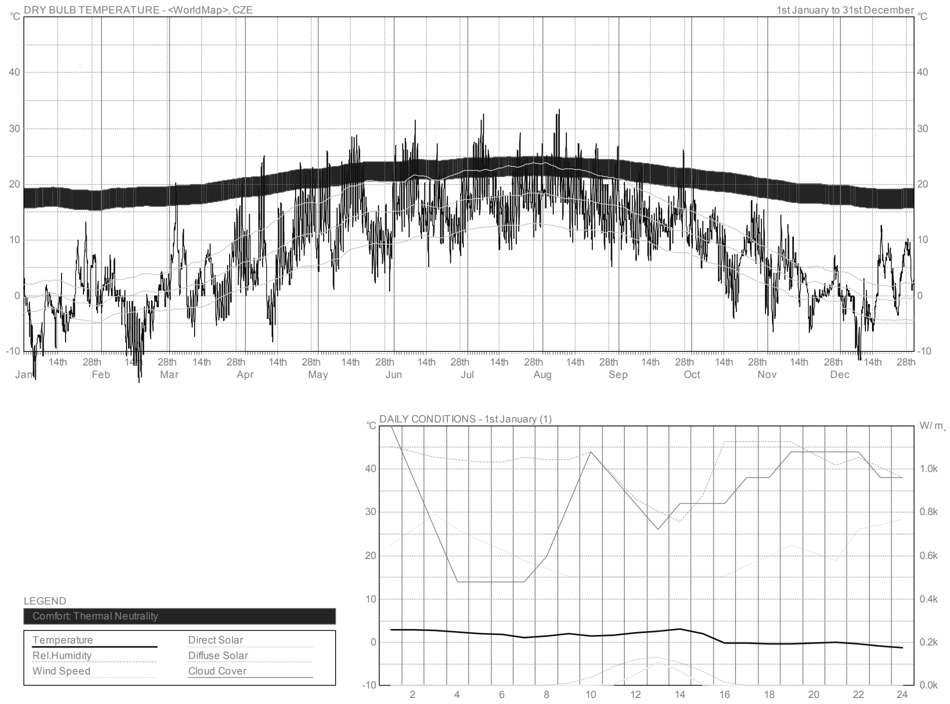

Figure 1. Example of graphic representation TMY which is generation from the Weather data manager

5. CONCLUSION

Using input data in simulation calculations is one from dominates element which determines result quality and its application for practice. Building face, its structural solution or acquisition costs, aren't only important by new projects realization. Nowadays, when continually grow energy costs and environmental importance increase, we are essentially more interested in real building service during its lifetime. It is important to consider building working state, already at projection documentation. Simulating programs are used for expectant building behavior. Every simulating program is as good as good are used input data. This paper shows overview of input data which are necessary to compile for characteristic building types.

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