Smart Recycling of Wasted Heat

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Combustion, appliances and the meat industry, these are the three subjects that have become synonymous with the carbon footprint in the atmosphere, if one were to read any recent articles discussing global warming. UNEP:s Emissions Gap Report from 2015 presents a sector that by itself has the potential to reduce as much CO_2 emissions as those three sectors combined, the energy sector. In order to do this, we need to reimagine how we use energy today.

Everything that humans have ever done, has led to an increase in temperature. This is not some fundamental flaw of humanity, it is rather a consequence of the second law of thermodynamics. The increase in entropy implies that there exists heat generation somewhere, be it in our bodies or in whatever device you are reading this article on. This heat is often thrown out into the environment to obtain some comfortable temperature of the room. Similarly, when you exit one room and enter another, you require that that room is heated too, all while the heat left in the previous room is simply discarded as waste.

The next generation of heating technologies promises to take care of this wasted heat in a good manner. Using temporary energy storage, heat transportation and machine learning, scientists believe that it is possible to not only minimize heat loss as compared to current district heating, but the cost of heat generation is severely lowered. A calculation given by EON, whose implementation of the next generation district heating is called ectogrid, estimates that it is possible to lower energy consumption by 70%, which converts to about a 20% reduction in green house gas emission for a western country[1].

This thesis presents a structured way to mathematically model such a next generation thermal grid, so that an integrated approach between heating and cooling could be analyzed. It was found that if someone tries to singlehandedly change the temperature in their room, the effect is felt by the others that are connected in the grid such that their machines temporarily start to fluctuate in their energy consumption, creating larger tear on the machines responsible for the interaction with the grid. A new type of control strategy was also proposed, one that substantially reduces these effects, giving the equipment a longer life span.

Since the energy consumption becomes dependent on how much free energy is available in the thermal grid, it could be possible to introduce a thief in the system, so that they extract an unnecessary amount of energy from the grid, for example by trying to keep the temperature of a room high, while they have an open window in the middle of winter. This energy loss drives the costs up for everybody else in the grid. A control strategy to reduce the effects of this thief, while at the same time making it possible to figure out who in the network was the bad actor a posteriori, was proposed.

Using these strategies, this thesis managed to show that it was possible to change the temperature in the entire network so that the energy usage in every building is minimal and so that there is as little heat expulsion to the environment as possible. Using this tool will help to push the emissions of greenhouse gases down because of the energy usage reductions. If this control strategy would in turn become coupled with machine learning algorithms that can predict our behaviour, additional reductions of greenhouse gas emissions would be possible without the need of impacting our current lifestyle.

[1] UK Houses of Parliament, 2016, "Carbon Footprint of Heat Generation", Postnote Number 523.