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Abstract:

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An analysis of Electric Thermal Storage and Heat Pump performance in a variable-electricity supply environment

To many Nova Scotians, space heating has become an energy security issue as prices exceed household energy budgets. To address this issue, some households are lowering temperatures to potentially unsafe levels, while others are changing how they heat their homes. An increasingly popular method of space heating is electricity, as Nova Scotia Power's seemingly unexpected rise in residential electricity demand in 2013.

Electric heating by itself is not necessarily a cheaper alternative, but it can be made less expensive if heating devices like Electric Thermal Storage (ETS) units and heat pumps are employed. ETS units utilize electric energy to charge (store heat) and discharge heat on demand. They also have the capacity to charge overnight or during off-peak hours and hence save money on heating costs by utilizing lower energy costs during these times. On the other hand, heat pumps offer a highly efficient alternative, although typically without storage.

The growth in electricity demand in Nova Scotia's residential sector will not be without its challenges, since Nova Scotia Power, which previously relied primarily on a non-renewable energy-mix, is increasing its use of renewable sources. The percentage contribution of renewables into the energy mix is to rise to 40% by 2020, from 10% share in 2000. Much of the renewable energy-mix is to come from variable-electricity sources, principally wind.

Variable-electricity sources are a particular challenge to electricity providers in that they require some form of backup that can be dispatched quickly in order to handle those periods when the variable-supply is unavailable. Backup methods include natural gas, hydroelectricity, and storage (such as compressed air, pumped storage, or battery). In all cases, relying on backup increases the cost of electricity.

Since there is no restriction on when an ETS unit is recharged, it lends itself naturally to work with a variable-electricity source. Moreover, the stored heat can be utilized in the absence of the variable supply – only when the stored heat is depleted and the variable supply is unavailable does the ETS have to rely on the continuous supply. However, the inability of heat pump to store energy requires a continuous electricity supply in the absence of variable-electricity source to resume its heating operations.

To ensure the operation of the heating devices in such an environment, it is important that the electricity provider be aware of the state of the system. This can be done using a smart-grid communicating with the household to determine its heating requirements and its current energy-mix (from both variable- and continuous-electricity sources).

In light of the recent Ivany report, sustainability is seen as essential in Nova Scotia; in the residential sector, this means that space heating will need to be made affordable. Given the growing popularity of electric heating, it will be necessary to find the best possible approaches to incorporating heating devices such as ETS and heat pumps with variable-electricity sources such as wind.

This research will compare the performances of ETS units and heat pumps by conducting a detailed analysis of their performance in a variable-electricity supply environment controlled by a smart grid.