Smart Grid Solution

Olameter Inc

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1 INTRODUCTION

1.1 The Challenge

According to the International Energy Agency (IEA), global air conditioning demand alone is projected to triple by 2050, making energy efficiency improvements essential to prevent excessive grid stress (IEA, 2024). Additionally, a study by MIT highlights that unregulated electric vehicle ("EV") charging could significantly strain grid infrastructure, necessitating strategic grid enhancements (MIT Energy Initiative, 2024).

Utilities need an integrated strategy that:

- moderates the effect on the grid of heating and cooling loads by:
  - reducing the overall energy consumed through the increased use of heat pumps
  - flattening seasonal and diurnal peaks by facilitating ground-coupling rather than air-coupling for those heat pumps[1], [2].
- manages EV loads to protect the distribution infrastructure while enabling the utility to harness its clients EV batteries[3] to:
  - store the intermittent – but much cheaper – energy generated by wind turbines and solar panels
  - provide local power backup and grid stabilization capabilities through the installation of bi-directional charging stations in the home.

Unfortunately, the control systems and capital assets required to accomplish these objectives fall outside the traditional construct of regulated utilities. Fortunately, there is high demand among private sector investors, including Olameter's shareholders, for opportunities to invest in long-term infrastructure assets such as these.

1.2 Olameter's Approach

We offer the following stack of services which, taken together, address the over-arching issues described above:

- **Topological Mapping** – Olameter inspects and tests every metered site ("recce"). The results, in conjunction with other sources of field data, are used to build a reliable topological map of the distribution grid. In addition to testing each circuit, this inspection, meets the requirements of many regulators as regards fraud detection (tampered meters, etc.) and safety inspection (damaged meters, low hanging cables, etc.).
- **GCHP Mass Deployment** – Olameter facilitates the deployment of ground-coupled heat pumps ("GCHPs") to quash peak loads and reduce the overall energy[4] consumed and, most particularly, to flatten the peak loads associated with seasonal extremes of heating and cooling.
- **EV Charger Mass Deployment** – Olameter facilitates the deployment of 120/240V bi-directional EV chargers at each meter. These "smart" devices are installed outdoors (no appointments required), and act as load limiters. Most importantly, they do not require connection to the building's electric panel, and are, therefore, affordable by everyone. This facilitates the transition to EVs while managing the distribution utility's need to store renewables and stabilizing the grid.

[1] A heat pump's coefficient of performance ("COP") deteriorates badly – to the point of uselessness – during cold weather snaps if coupled to the air but remains unaffected if coupled to the ground.

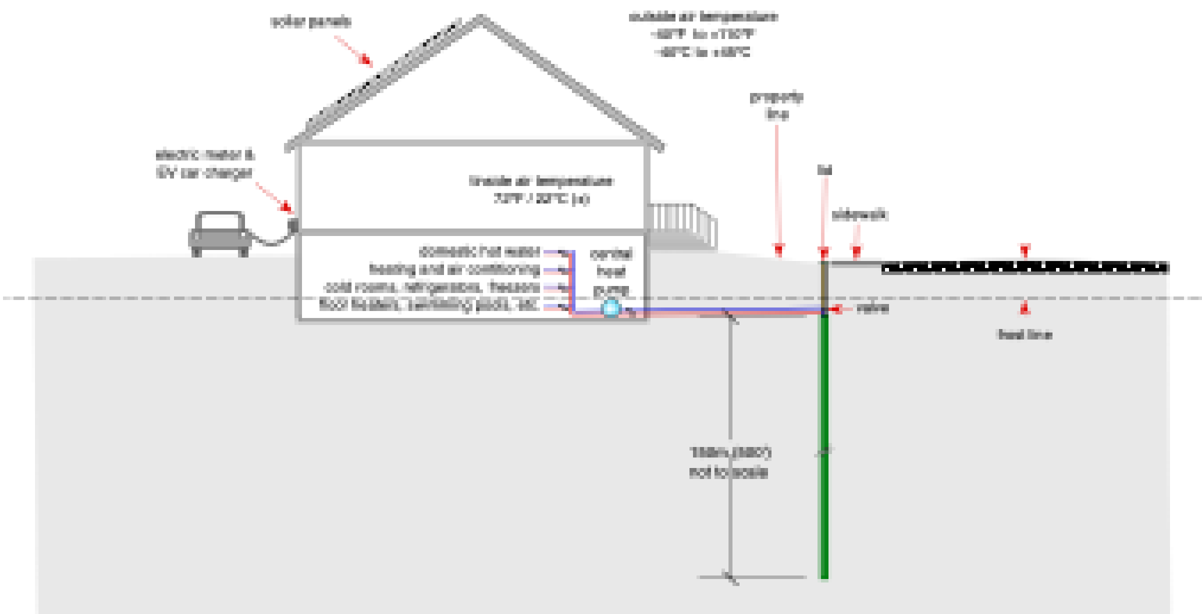
[2] A study by Oak Ridge National Laboratory has observed if 60% of US homes were retrofitted with ground coupled heat pumps the reduction in peak electrical demand during the heating season would be so significant that no new electric power plants would be needed to meet winter heating needs."

[3] Currently 125kWh per vehicle and rising

[4] by a factor of 4 to 5 according to the U.S. Department of Energy, 2024

- **Load Modelling** – Olameter models and continuously updates the dimensions, thermal characteristics, and orientation of each surface of every building serviced by the utility. The objective is to understand the heating and cooling load implicit in the structure, as well as to model the energy capture and/or usage characteristics of such external structures as solar panels and swimming pools.
- **Load Aggregation** – We tabulate and project on an hourly basis the energy characteristics of each building served by a given transformer and aggregate the results of all transformers on a given feeder line. This data serves to model the impact of the mass deployment projects described above.

The image below illustrates our view of the complete installation at a simple residential site.



2 TOPOLOGICAL MAPPING

Having installed more than 40 million meters, Olameter has observed that utility records are often deficient when it comes to identifying which homes are connected to which service line (distribution transformer). Generally, these records are based on "as designed" specifications rather than "as built" information. Furthermore, there is usually no provision for updating these diagrams interactively with live data from sensors in the field[5].

Olameter has developed "Recce," a tool and a process for identifying, among other things, which meters are on what circuit. Essentially, the tool takes advantage of the "feature" of power line carrier systems that their signals degrade or disappear entirely at the transformer. "Recce" is a simple plug-in device inserted in any 120V outdoor outlet at each building. It emits two ID signals: a powerline carrier ("PLC") signal, and a near-field wireless signal that can be "heard" at other service points in the area.

Field personnel deploy these devices as part of a utility-sponsored reconnaissance program conducted at each home. The reconnaissance process is managed by Olameter's Work Order Management ("WOM") system. The utility's list of meters with addresses is entered into the WOM system and matched against street maps, cadastral lot data, and aerial orthophotos[6]. Anomalies are identified and clarified in the office before dispatching the technician. The WOM system generates an optimum route

[5] In this regard the current generation of "smart" meters are anything but smart.

[6] Typically, spatial accuracies are ±10cm (4") in urban and suburban areas, ±25 cm (10") in rural areas.

allowing a field technician in the field to visit every site and to update records of any difficulties encountered – irate owners, locked gates, dangerous animals, etc. Typically, a trained technician can service and map 150 sites per day depending on the population density.

Among other things, the process captures context photos of each building's perimeter walls. These are interpreted by AI tools to:

- detect tampering at the meter
- identify electric safety issues such as:
  - detritus or obstructions, at the meter site,
  - sagging overhead wires,
  - proximity of gas or propane service, etc.
- update records regarding the building's dimensions and surface characteristics.

The result is a precise map of the network's distribution topology.

3 GCHP MASS DEPLOYMENT

GCHP-based heating[7], ventilating air conditioning ("HVAC ") systems are capital-intensive owing to the need for a thermal well. The cost of these wells can be reduced by ≈ 75% if three measures are taken:

- drilling contiguously to reduce the time wasted in displacing drill rigs from site to site
- dealing locally and at scale[8] with storage and materials' handling issues
- bulk buying the requisite pipes, parts and supplies

These savings can be addressed through the mass deployment of thermal wells. This involves acquiring area-wide rights rather than negotiating with each individual property owner. Municipalities have expressed interest in participating in such programs. Private sector investors, including Olameter itself, find such infrastructure investment very appealing though, ultimately, governments could elect to regulate them.

3.1 Design

Advanced HVAC systems can take advantage of the key features of ground-coupled heat-pumps:

- heat pumping is the most efficient[9] approach to both domestic heating and cooling
- unlike conventional heat pumps, GCHP efficiencies are unaffected by the temperature of the outside air
- GCHP facilities have very long useful lives[10] owing to the stability of the operating conditions
- GCHP facilities are much quieter[11] than conventional air-coupled systems.

The HVAC engineer's design methodology involves the entry of each building's characteristics and age, climate particulars, geological and hydrological data, and, when available, the property owner's utility bills to size the wells. Olameter has upgraded this methodology to enable the data capture for whole towns (see 2. Topological Mapping).

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[7] including domestic hot water

[8] e.g.: water, fuel, drilling mud, bentonite clay (for backfill)

[9] measured as the ratio of kWh transferred as heat to the kWh used to operate the heat pump. This is known as the co-efficient of performance ("COP"). Ratios of 4.5:1 are typical.

[10] Greater than 75 years with routine pump maintenance

[11] Many municipalities report that noise generated by air-coupled heat pumps, typically 50dB, is the biggest single source of complaints to City Hall.

Olameter's system produces installation and site location specifications, enabling contractors to bid for the provision of mass-installation of thermal wells. These specifications include:

i. drilling depths (overburden and bedrock)
ii. installation and backfilling specifications
iii. white lining and location of other nearby buried assets (gas, water, sewer, electricity, gas, communications cables)[12]

3.2 Description of a thermal well

A thermal well resembles a water well. A hole is bored in the ground and is lined with a casing[13] until the drill hits bedrock. This prevents dirt from collapsing into the well until the work is complete. Depending on the local geology and hydrology, a typical 500-foot deep well can provide up to five tons (60,000 BTU or 17.6 kW). But drilling wells presents significant material handling challenges. For instance, several tons of water are needed to flush out the grindings (≈ 6 tons). The water needs to be filtered at site and, even then, the municipality may insist on its disposal offsite. When done at scale, the contractor will usually operate a local sorting facility rather than paying tipping fees at nearby landfills. Some of the fines will be mixed with bentonite clay for backfill, thus reducing costs. The residual waste materials are clean and can be sold.

A "heat exchanger" is lowered into the well. Traditionally, this resembles a pair of 3cm (1.25") inside diameter ("ID") pipes configured as an elongated letter U. More recent designs take the form of a coaxial system, consisting of a 3 cm (1.25"ID) pipe that snakes its way to the bottom of a sealed 12.5cm (5"ID) outer pipe. The inner pipe is designed to ensure turbulent rather than laminar flow in the outside pipe.

Olameter recommends using plain water as the heat exchange medium to minimize the environmental impact of leaks or spills (some contractors prefer ethanol, or glycol mixes rather than burying the pipes below the frost line). Pure water is the cheapest and most efficient heat transfer medium.

Once completed, the well is backfilled with a mix of sand and bentonite clay. It is capped with a cast iron collar and lid. The down pipe is equipped with a shut-off valve accessible from the surface. The cast iron collar also acts as a ground for a tracer wire which the HVAC specialist will use to trace the path of the HDPE[14] supply lines.

Ambient ground temperatures are roughly equal to the weighted average annual air temperatures[15]. At a depth of ≈ 5m, these temperatures are unaffected by diurnal and seasonal temperature swings. At greater depths, the ground temperature rises, typically by 1.5ºC for every 100m. Furthermore, the thermal mass of rocks and soil is such that more than 100 days of continuously extreme outside air temperatures would be needed to shift the temperature of the ground by 1ºC. Our systems model the cumulative impact of the HVAC system over 20 years and monitor it continuously.

3.3 Metering and Signaling

The system contains two sets of meters:

- A thermal meter to measure the volume of liquid pumped per hour through the heat exchanger and the temperature difference between the outbound and return flows

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[12] Call center systems, such as InfoEx in Québec, use Olameter software to track and map the results of all underground locates carried out in their territory.

[13] Typically a 15cm (6") pipe.

[14] HDPE high density polyethylene is a stable eco-friendly plastic

[15] e.g. Houston TX – 21ºC; Denver CO – 11ºC, Toronto ON – 9ºC; Montreal QC – 8ºC, Victoria BC, – 6ºC; Edmonton AL– 3ºC

- An electrical sub-meter to capture hourly kWh readings

The signals are collected by the controller attached to electrical sub-meter and transmitted daily multi-carrier CAT-M1[16]. The electrical submeter is also equipped with PLC signaling to confirm the topology of the electrical grid.

4 ELECTRIC VEHICLE MASS DEPLOYMENT

Despite the existence of high-speed charging stations, 80% of EVs are charged at home. This creates the opportunity for distribution utilities to encourage the adoption of EVs while harnessing their ability to act as:

- storage for intermittent renewable energy,
- provide local grid stabilization,
- back-up for use in power during blackouts.

– *ConnectDER – exploded view*

Collar mounted units, such as the one shown to the right, are installed between the existing smart meter and the socket. Installation takes approximately 15 minutes since it does not require any changes to the occupant's electric panel.[17] These devices act as load limiters to protect utility service lines.

Olameter's hardware and software specialists are working with manufacturers, such as ConnectDER (see diagram) and electronics manufacturers such as ST Microelectronics, to create reference designs and build prototypes with submetering and signaling capabilities. They are also integrating 120V/240V inverters to enable bi-directional energy flow.

4.1 Metering and Signaling

The system contains an electrical sub-meter to capture the hourly kWh readings associated with charging the vehicle. Readings and set-points are transmitted daily using multicarrier CAT–M1 signaling. The electrical submeter is also equipped with PLC signaling to confirm the topology of the electrical grid.

[16] Olameter operates such a system in the United States and Canada on behalf of certain clients. Each unit has access to the strongest provider of signals locally from among Bell Canada, Rogers, Telus, AT&T, Verizon and T-Mobile. The device

[17] The primary deterrent to the installation of advanced EV chargers in the home

5 LOAD MODELLING

The Olameter system computes the capacity of the heat pump(s) and the depth of the thermal well(s) needed to heat a building in winter, cool it in summer, produce domestic hot water, and sustain other thermal loads (swimming pools, walk-in refrigerators, etc.). Olameter provides thermal meters, electric submeters, and related signaling requirements for these systems. [Among other things, this data is used to monitor the coefficient of performance ("COP") at each site, as well as to train Olameter's GCHP design system on a going forward basis.]

Olameter's system generates an hourly model of the electricity to be consumed and the thermal load to be pumped by the HVAC system in each building for a full year[18]. Since thermal heating and cooling loads represent a significant portion of a utility's loads, Olameter has incorporated this data into its meter data repository (below).

6 LOAD AGGREGATION

Olameter has provided meter data aggregation services to commercial and industrial clients, energy resellers, and independent system operators ("ISOs") for more than two decades. Typically, this data is aggregated in 15-minute or hourly intervals.

We have updated and adapted this software to create historic and projected data for "virtual meters" corresponding to each phase of each transformer. This allows the utility to:

- generate transformer life-cycle projections.
- estimate peak load and total demand of the distribution grid down to the level of each home for each individual home, transformer, and feeder line.
- project the effect of the using thermal well infrastructure as ground-coupled heat pumps are deployed to:
  - decrease historic peaks and overall loads on the distribution grid
  - cut greenhouse gas emissions
- project the effect of EV propagation from the perspective of:
  - increasing peaks and overall loads on the distribution grid
  - providing distributed storage and emergency power management to the distribution grid[19]

[18] In fact, a 20-year projection is also made to ensure that the system has no long-term effect on ground temperatures.

[19] the typical electric vehicle stores 100 kWh of electricity while the typical fully electrified home consumes less than 30 kWh per day. This makes EVs the key to storing renewable energy storage.