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Overview of Internet of Things with Energy and Electricity Industries
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Abstract

This document introduces general problems of energy and electricity industries and discusses how these industries could benefit from Internet of Things (IoT). Use cases are provided and potential technical gaps and protocol needs in IETF are evaluated.

Status of this Memo

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1. Introduction

The traditional energy and electricity industries have not changed a lot in recent years, comparing with the ICT industries. The rise of Internet of Things (IoT) has bring new chances to the energy and electricity industries.

A large proportion of energy consumption is in the form of electric energy. Human generate electric energy from fossil fuels, hydroenergy, nuclear energy, etc, and consume electric energy for industry, residential, transport, and other uses. The root cause of most energy and electricity relevant problems is that electric energy can not be easily stored on such a big scale.

The development of ICT technologies as well as IoT provides possible solutions on a totally different aspect: focus on the "thing". A thing could generate, consume, or store electric energy. A thing could also have other limited capabilities, e.g., monitoring, communicating, and computing. Using the limited capabilities of those

things (constrained nodes) could enable data acquisition and analysis, (electric power) demand prediction and response, energy routing, etc. Thus, the energy and electricity industries could get benefit and the overall energy consumption of human-being could be reduced.

To make a better cooperation and convergence for IoT with energy and electricity industries, the idea of edge intelligence (edge computing) as well as cloud computing are important. There are also protocol needs in IETF, accompanied with the development of different kinds of ICT enabling technologies. These protocols are relevant (but not limited) to connectivity and communication among things that generate, consume, or store energy, and configuration and management between the thing and its controller (IoT gateway) or any higher level servers.

2. Acronyms and Terminology

IoT: Internet of Things

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

3. Problem Statement

As electric energy can not be easily stored on such a big scale, thus causing problems.

3.1. Peak Shaving and Valley Filling of Electrical Grid

Peak shaving and valley filling is actually a common behavior of the electrical grid to balance the overall energy generating and consuming, but it does cause huge loss of the energy and abrasion of the generating facilities. The peak load of a grid could be twice as the valley load, which means, for example, a 100MW power station

switches its output from 100MW to 50MW and then back to 100MW within 24 hours, over and over again. The intuition here is similar to driving a car, accelerating and braking continuously not only consumes more oil, but also harms the engine.

3.2. Connecting Renewable Energy to the Grid

Wind or solar energy stations are "weather sensitive" so that their electrical power output are unstable. Connecting renewable energy stations to the grid could make it more difficult for the grid to do the peak shaving and valley filling job. For example, the wind is averagely more stronger during the night than daytime, meanwhile, the

average load of the grid is higher during daytime than night.

4. IoT Benefits

By implementing IoT nodes (e.g. an IoT specific gateway) to interact with traditional energy generation facilities and energy consumption devices, or embedding edge computing capabilities into these facilities and devices, IoT could benefit the energy and electricity industries.

4.1. Data Acquisition and Analysis

Data acquisition, including metering, data pre-processing, and communicating, are core capabilities of edge computing. Data analysis can be done at the edge or in the cloud. This enables demand prediction and response, strategy distribution, predictive maintenance, emergency response, etc.

4.2. Demand Prediction and Response

Data acquired from the consumer side could be used by a data center (cloud) to predict the behavior of consumers in total. For the generating side, most of the power output could be controlled, others such as the maximum output of a wind or solar station could be roughly predicted based on weather forecast. Therefore, the generation-consumption balance for the next time period could be roughly calculated and the grid could be prepared to response properly.

Generally, the response contains load control and supply control. A great number of distributed energy consumers could be involved in the load control issue. An IoT gateway or controller that manages a specific kind of consumers could automatically apply different strategies respect to the response needs, e.g., switch down the air-conditioning system when the load is high, switch up the battery charging rate when the load is low.

4.3. Energy Routing

As the electrical grid has many similar features comparing to the Internet, it could be helpful to introduce the idea of routing into the energy world. Based on real-time supply and demand relationship, a grid could alter its topology to reach an optimized state. Distributed storage stations could act as "buffers" to support energy routing.

5. Use Cases

5.1. Smart (Micro-)Grid

A smart grid that includes smart meters and appliances and different kinds of energy resources could condition the electronic power and control the electricity production and distribution. A smart micro-grid is a localized group of electricity sources and loads. The micro-grid can be connected to the traditional centralized electrical grid (macro-grid), but it can also disconnect from the macro-grid into island mode, depending on the electricity load-supply balance or other needs. The micro-grid is good at integrating various sources of distributed generation, especially renewable energy sources.

5.2. Distributed Storage

The idea of making huge electric-energy-storage-dedicated batteries does not make sense. Instead, distributed, non-electric-energy-storage-dedicated batteries could be helpful.

One good example of distributed energy storage is the Electric Vehicles.

Electric vehicles neither save energy nor reduce carbon emission

directly, as the electric power they use are mostly generated from fossil fuels. But electric vehicles do help with valley filling of the grid, for a large amount of the electric vehicles are charged at night. In that case, electric vehicles act as batteries, charging when the load is low, via charging points that are 'things' connected to the Internet.

6. Gap Analysis and Protocol Needs

Internet-related protocols are to be defined, including but not limited to connectivity and communication among things that generate, consume, or store energy, and configuration and management between the thing and its controller or any higher level servers. As there are more than one scenarios within the energy and electricity industries, and each scenario may need a set of Internet-related protocols to support rather than one single protocol, new Internet-related protocols should be defined properly, concluding generally demands as well as mapping different use cases. For example, various wired/wireless protocols should be defined to support communications needs, however, each use case may utilize one or two of these protocols depending on the use case features and that would be enough to match its communication need.

[IIoT-EC] has listed some general gaps of edge computing.

More details are to be determined.

7. Security Considerations

TBD.

8. IANA Considerations

This document does not require any allocations by the IANA and therefore does not have any new IANA considerations.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI

10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

9.2. Informative References

[IIoT-EC] L. Geng, et al, "Problem Statement of Edge Computing beyond Access Network for Industrial IoT", draft-geng-iiot-edge-computing-problem-statement-00, work in progress.

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