Chapter 13

Contribution of the Compressed Air Energy Storage in the Reduction of GHG – Case Study: Application on the Remote Area Power Supply System

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Additional information is available at the end of the chapter

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1. Introduction

There are many different interpretations and classifications in use today to describe rural and/or remote areas for the purposes of discussing methods of electrification. Some useful examples are as follows [1]:

1. By density and concentration or clustering – setting the context of the environment or geography:
   - Small communities, villages or even towns that are remote from other habitation,
   - Dispersed households, farms and enterprises of low density over wide areas or regions,
   - Community clusters or villages surrounded by lower density dispersed households,
   - Geographically on the same land mass, but separated by physical obstacles such as long distances, mountainous terrain, or possibly separated by water such as island communities,
2. By energy use:
   - By power and energy (or load factor=f(energy/power)) and load profile,
   - By application: household, commercial enterprise, institution, agricultural processing, etc.
3. By choice and method of energy provision:
   - Reticulated electricity, connected to some form of larger grid, or a local micro grid,
   - Reticulated/piped fuel such as natural gas, LPG, fuel oil, diesel,

- Transported fuel such as natural gas, LPG, fuel oil, diesel, by land or sea transport,
- Reliance on renewable energy products such as hydro, solar photovoltaic (PV), wind, waves, tides,

The most suitable method of electricity provision (technology, business model, etc.) will usually depend on the combination of the geographic context, the consumer need, and the possibilities that are available and affordable to provide the energy requirements. Therefore, the most appropriate solutions in one place might be quite unsuitable in another [1].

Clusters and communities that are very remote from other habitation will generally be supplied by some form of centralised local generation, or via a connection to a larger but somewhat remote grid.

2. Challenges related to the electrification of remote areas

Today, diesel generators are mainly used, around the world, as emergency supply sets in telecommunication, public buildings, hospitals, or other technical installations (meteorological systems, tourist facilities, farms, etc.), and as standalone military and marine power plants, as well as the reliable isolated power source for islands or remote villages placed far from the power network [2]. In fact, there are two general methods of supplying electricity to remote areas: grid extension and the use of diesel generators. Grid extension can be very expensive in many locations. Diesel generators are therefore the only viable option for remote area electrification [3].

Classic gensets based on internal combustion engines are equipped with synchronous generators, therefore fixed speed operation is required. It gives low efficiency during low load operation (figure 1). It is not critical in emergency case operated sets, but very important in continuously operated systems, where fuel consumption is significant economic and logistic aspect. In fact, remote areas with relatively small communities generally show significant variation between the time of peak loads and the time of minimum loads. A typical example of a load profile of a remote community in Western Australia is shown below in figure 2. Diesel-powered electric generators are typically sized to meet the peak demand during the evening but must run at very low loads during “off-peak” hours during the day and night. This low-load operation results in poor fuel efficiency and increased operation and maintenance costs [3].

Moreover, low load operation of diesel genset at synchronous speed reduces the engine lifetime, by incomplete combustion of the fuel, therefore an additional dump load is required to improve the combustion process. The efficiency and fuel combustion at low load conditions can be improved by use of load adaptive adjustable speed operation of the genset [4]. In some remote locations, a dual diesel generator system is employed. When the load is light, the smaller generator is used; as the load increased, the manual switch is transferred to the larger generator. This approach results in some fuel savings, however managing this dual system is time consuming and impractical [3].

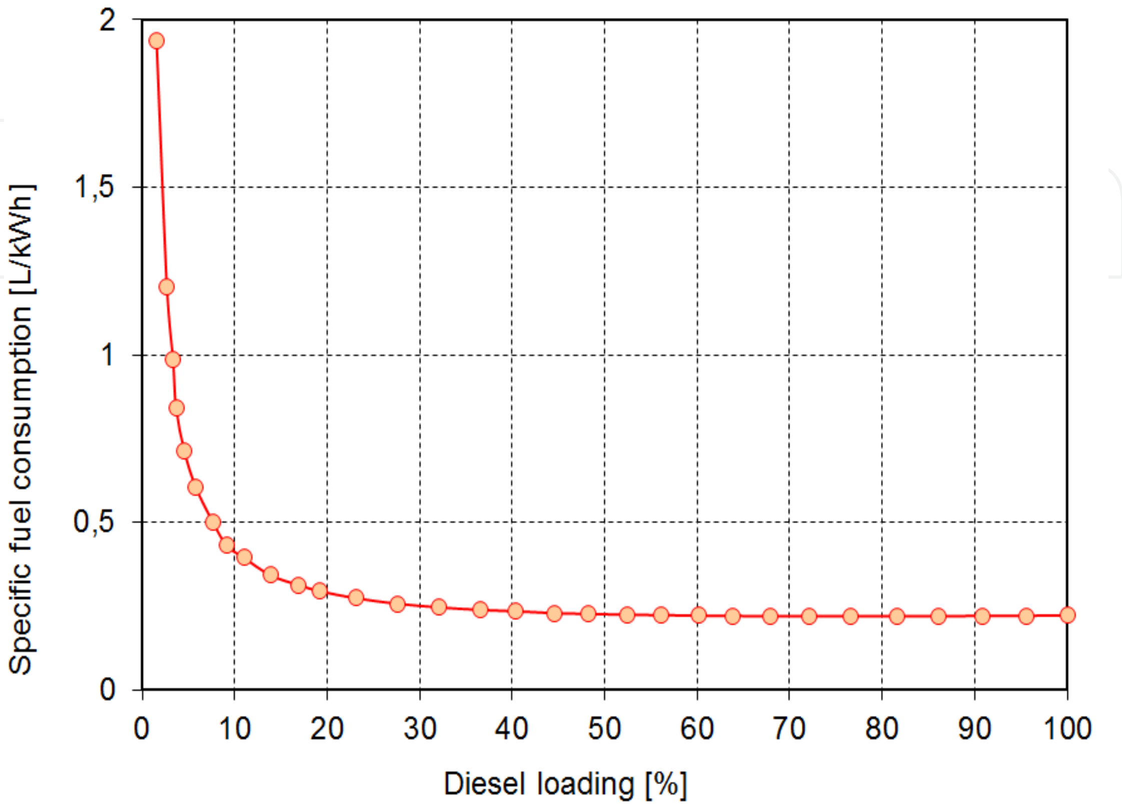

Figure 1. Example of a variation of diesel fuel consumption with loading

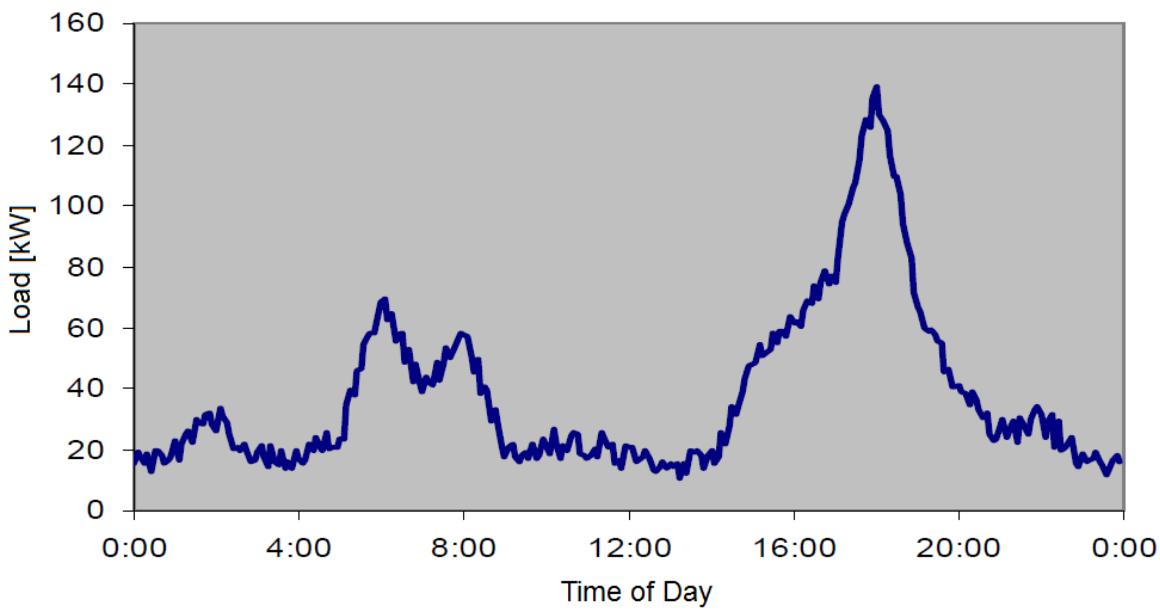

Figure 2. Typical load profile of a remote community [3]

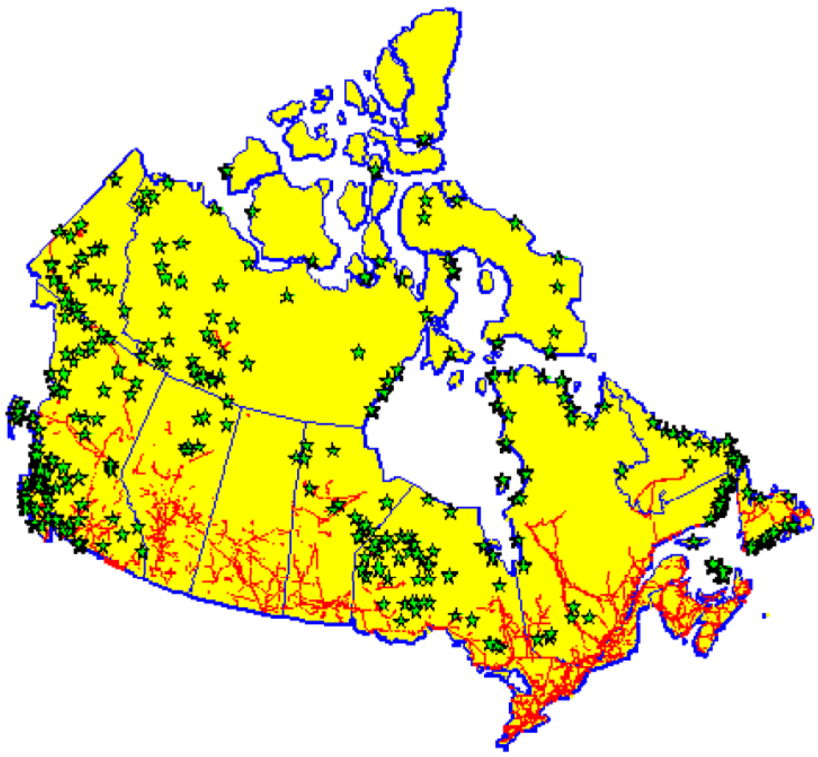

Figure 3. Canadian remote communities [5]

In Canada, approximately 200,000 people live in more than 300 remote communities (Yukon, TNO, Nunavut, islands) (figure 3) and are using diesel-generated electricity, responsible for the emission of 1.2 million tons of greenhouse gases (GHG) annually [6]. In Quebec province, there are over 14,000 subscribers distributed in about forty communities not connected to the main grid. Each community constitutes an autonomous network that uses diesel generators.

In Quebec, the total production of diesel power generating units is approximately 300 GWh per year. In the meantime, the exploitation of the diesel generators is extremely expensive due to the oil price increase and transportation costs. Indeed, the communities are dependent on imported fossil fuels for most of their energy requirements. Also, there are exposed to diesel fuel price volatility, frequent fuel spills and high operation and maintenance costs including fuel transportation and bulk storage. Having said this however, in the past decade, diesel prices have more than doubled. High fuel costs have translated into tremendous increases in the cost of energy generation [3]. In Quebec for example, as the fuel should be delivered to remote locations, some of them reachable only during summer periods by barge, the cost of electricity produced by diesel generators reached in 2007 more than 50 cent/kWh in some communities, while the price for selling the electricity is established, as in the rest of Quebec, at approximately 6 cent/kWh [7]. The deficit is spread among all Quebec population as the total consumption of the autonomous grids is far from being negligible. In 2004, the autonomous networks represented 144MW of installed power, and the consumption was established at 300 GWh. Hydro-Quebec, the provincial utility, estimated at approximately 133 million CAD$ the annual loss, resulting from the difference between the diesel electricity production cost and the uniform selling price of electricity [7].

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