Nuh's electric conversion drive

As part of Nuh Cement's drive towards carbon neutrality, its subsidiary Çimnak Co has been working on reducing diesel fuel consumption. By replacing the diesel engines of the loading shovels and excavators with grid-connected electric motors, Nuh Cement has achieved a number of savings without sacrificing power or performance.

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Çimnak Co was founded in 1979 by Turkey-based Nuh Cement and carries out mining activities within the Nuh Group. The company provides 3.7Mta of raw materials in Nuh Cement's mining licence areas.

Since 2014 Nuh Cement's management has been actively working towards sustainable and CO_2-neutral cement production. Considering the high CO_2 emissions of cement production due to its very nature, the implementation of the carbon-neutral cement production initiative is very ambitious.

The first significant step on this journey was the commissioning of a waste heat recovery plant (WHR), which has a capacity of 100mkWh, or 23 per cent of Nuh Cement's total electricity consumption. The second step was the commissioning of a hydroelectric power plant capable of producing 30mkWh annually. Together with the WHR plant, almost 30 per cent of electricity consumption at Nuh Cement's factory is now produced from green sources.

In addition to green electricity generation, the company has looked at its use of diesel fuel, which is a considerable source of CO_2 emissions. In 2016 an in-depth study was carried out to find ways to cut diesel consumption, which is dominated by the loading shovels and excavators at Nuh's stone quarry. The proposed solution was to replace the diesel engines of the loading shovels with all-electric, grid-connected motors. A battery-based electric solution was discarded outright from the very beginning due to issues relating to cost, lifespan and power efficiency.

Conversion to electric

The first machine to be converted was a discarded 2003 Hitachi EX-1200 loading shovel. Features of the shovel include:

- bucket capacity: 6.5m^3
- engine power: 650hp
- weight: 114t.

To cut diesel consumption Nuh Cement subsidiary Çimnak Co has been converting loading shovels and excavators at the quarry to grid-tied electricity

Various technical and administrative factors were taken into account before the conversion, including:

- Will the power efficiency and loading speed be similar to the diesel engine?
- Will shovel operators be able to work with the power cable attached to the machine?
- Is there a potential risk of cable-induced work accidents?
- Can the availability and reliability of the electric-powered shovel be as high as the diesel-powered version?

A local conversion company was hired for the procurement of equipment and services related to the conversion of the loading shovel. The company was in charge of the design, equipment supply and installation works on a turnkey basis. The contract scope included:

- diesel engine and related components
- radiator
- diesel fuel tank
- turbocharger
- air filter
- fuel pump removal.

For the conversion to electricity the following was required:

- electric motor (500kW)
- cable drum behind the machine that can spread and collect cable
- 100m of cable
- 6.3/0.4kV dry-type transformer
- electrical control panels.

Assembling the necessary equipment for the conversion of the electric shovel took approximately three weeks.

Shovel performance post-conversion

The Hitachi EX-1200 hydraulic shovel became operational after the necessary connections were made and the electric motor energised. The electrically-operated machine works in a similar fashion to the diesel version in terms of power and performance, such as loading time and bucket digging force. It has reached its maximum design power using electricity, thereby saving diesel fuel, engine oil, antifreeze and cooling water, as well as fuel and engine oil filters.

The loading shovel, powered by electric motor-driven hydraulic pumps, has been turned into a more efficient, greener and quieter machine without sacrificing power and performance. The electrically-driven shovel demonstrated almost 95 per cent overall energy efficiency whereas the diesel counterpart only achieved 25 per cent.

To prevent cable-originated accidents, it was necessary to purchase the cable drum.

As of September 2020, almost 90 per cent of total loading at Nuh Cement's quarry is carried out by the all-electric shovels and excavators

The 17-year-old, almost-obsolete shovel has been revitalised and the service life extended, translating into significant savings compared to purchasing a brand new shovel.

Challenges faced during conversion

Nuh Cement faced a number of challenges during the conversion project, including:

- Shovel operator training for cable drum usage was crucial to maintain smooth operation.
- It is essential that care is taken not to crush the cable laid on the ground by other machines working in the vicinity.
- It is good practice to protect the cable laid on the ground by placing it inside a pipe.
- A machine-mounted cable drum must be purchased to avoid over-laid cables.
- It is necessary to employ a technician with medium-voltage (34.5kV) experience.

Measured benefits

Relying on the lessons learned from the conversion of the EX-1200 shovel, other loading shovels and excavators were converted to grid-tied electricity over the course of two years. These are the:

- Hitachi EX-1800 (180t shovel)
- Hitachi EX-1900 (190t shovel)
- Komatsu PC-300 (30t excavator)
- Komatsu PC-450 (45t excavator).

As of September 2020, almost 90 per cent of total loading at the quarry is carried out by all-electric shovels and excavators.

Benefits reported after almost two years of operation include:

- Based on the yearly average data, loading shovels EX-1200, EX-1800 and EX-1900 used to consume an average of 0.175l of diesel fuel per tonne of marl loaded. After the conversion, the shovels consume an average of 0.45kWh/t of marl loaded, based on yearly average data.
- Per tonne of marl loaded onto the trucks, 1.7kWh (0.1751 x 9.73) of diesel has to be spent whereas 0.45kWh of electricity is just enough for an all-electric loading shovel.
- In other words, the energy efficiency associated with the diesel-to-electric conversion can be calculated as 3.8x (1.70/0.45), which is independent of geographical location, cost of fuel or type of operation.
- To calculate the total savings of the conversion, the kWh cost of diesel fuel and electricity has to be incorporated into the equation. The cost changes from region to region and from time to time for a specific location. In this case, Nuh Cement's diesel fuel procurement rate is roughly 1.4x more expensive than the electricity procurement rate on a yearly average. It should be noted that the cost comparison has to be made on a kWh basis.
- Therefore, the cost per tonne of fuel of a diesel-powered shovel is 5.3x (3.8 x 1.4) that of an all-electric shovel.
- Savings associated with periodic maintenance costs of diesel engines are not included in the calculations and will further increase the savings of the electric conversion.
- The conversion has also reduced the maintenance team's workload because the most time-consuming maintenance workload of quarry machinery stems from the diesel engine, radiator and diesel pump.
- More than 520,000l of diesel per annum has been saved, which translates into a CO_2 emissions reduction of 1400t.
- Moreover, the EX-1200 shovel, which had completed its useful service life, has been rejuvenated.

Since the electricity consumed at the shovels was fed from the waste heat recovery plant of Nuh Cement, the conversion project is all-green and believed to be one of its kind globally. ■

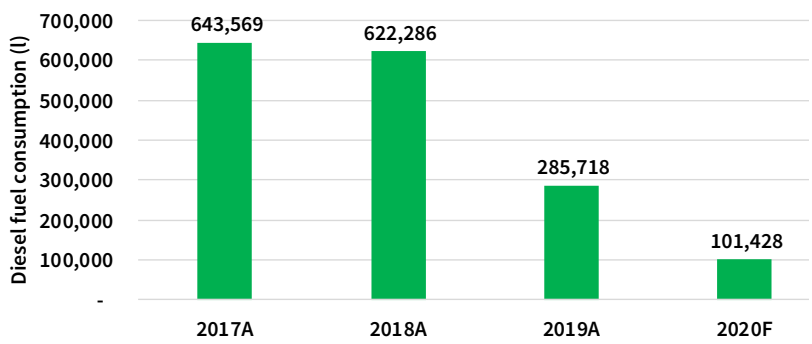

Figure 1: annual diesel fuel consumption

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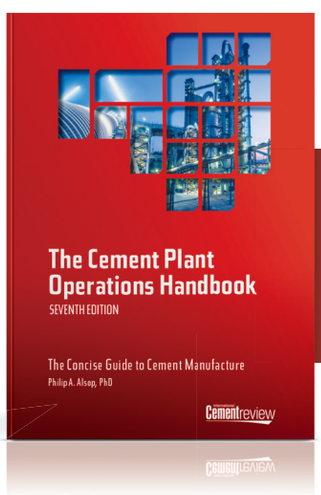

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