Prometec

Comprehensive
Sampling
Solution

Automated sampling

Achieving efficiency in biofuel supply chains

Robot

Fuel Energy Balance Error

Proper sampling is a major challenge in biofuel quality control. According to studies, deficiencies in sampling methodology cause approximately a 5% Fuel Energy Balance Error in biofuel energy content calculation.

The Fuel Energy Balance Error is caused by inaccurate fuel sampling. The error describes the difference between the energy content presented in the inaccurate sample and the actual energy gained from burning the entire load of fuel the sample was taken from.

As the lorry is weighed before delivering the fuel, all impurities in the fuel load will be included in measuring the mass. Depending on the fuel source, this fuel mass contains water, ice and other non-burning impurities, such sand or rocks. These impurities usually do not end up in samples taken manually, leading to falsity in the fuel measurement.

Fuel suppliers are paid based on calculated energy content in the sample and the volume of fuel delivered. However, as Power Plants perform their monthly boiler-side balance calculations, it will show on average a 5% error between the sample's energy content and the actual energy gained. Over time, errors in pricing caused by this inaccuracy will start to accumulate for both the supplier and purchaser.

Significant Impact On Operations

Fuel Energy Balance Error varies between 5%-10%, depending on geographical and other factors. If all the impurities could be accounted for in the invoicing, this 5-10% could be directly saved in total fuel purchasing costs.

The Three Challenges of Sampling Manually

Usually, the fuel load has been manually sampled after unloading, either by the truck driver or Power Plant personnel.

Challenge 1 | Lacking In Accuracy

Humans make errors. Our cognition is an optimized engine, but it doesn't always connect with the surrounding context very well. We operate on autopilot relying on our intuition to get us through any immediate tasks while our brains either save energy or work on something else entirely.

For sampling biomass, this can mean we are unlikely to pick representative samples for the laboratory. We see snow, and intuitively know it is not a fuel, so it never makes it to the sample.

Our brains also wish to conserve energy, and the required diligence to distribute our manual sampling evenly throughout the load is much greater than exerting a little less effort and sampling only a limited portion

Sometimes it is just not possible for a human to take a representative sample. Fuel loads that are layered during transport provide a challenge as the required depth for representative sampling is unreachable with a sampling scoop while unloading.

Layout of the sampling area can also be organized in a way that a safe sampling procedure cannot be performed.

Lastly, there is of course the challenge of conscious bias. Conflicts of interest can tilt the samples towards either end of the scale, away from being representative of the whole load.

Challenge 2 | Occupational Safety Concerns

Additional challenges to manual sampling is that the drivers have to get out of their vehicle and into the unloading area. Unloading area has pits, crevices, cross-irons and beams that drivers need to balance on and be mindful of as they try to reach the fuel with their sampling scoop.

The small-particle dust involved at times can get overwhelming. Breathing in the small particles launched into the air from unloading of biomass can cause acute respiratory ailments and momentarily disable the employee from continuing the sampling. Long-term effect of breathing in specifically solid biomass particles is unstudied, but comparable studies by the Finnish Institute of Occupational Health on the effects of inhaling dust, mold and bacteria are clear on the related health hazards.

Challenge 3 | Low Efficiency

Turning the trucks over quickly is vital to process efficiency at the power plant's unloading area. Turnover times can get excruciatingly long if drivers are required to exit their vehicles and manually sample their cargo while unloading, given all the probable delays related to manual sampling and sample handling.

Automated Sampling

Automated Sampling is a robot-aided methodology that introduces a single point of sampling for all incoming granular fuel. It provides representative samples from each individual truck and can enrich the entire fuel supply chain with real-time information on fuel quality.

Improvements Over Manual Sampling

Manual sampling is performed by either by the fuel provider, or by power plant personnel. The common denominator is, that it is always done by humans.

Automated Sampling is performed by state-of-the-art systems combining learning algorithms and precision automation.

Each truck coming in will have their cargo sampled precisely, the sample labeled and categorized meticulously, and the truck will exit the sampling area within 10 minutes of arriving.

Precision

Automation produces samples that will always be representative. The samples will include impurities and content that was previously hard to access. The automated sampling instrument will change the position it will sample, while navigating successfully all known structural obstructions to avoid instrument damage.

Cost-effectiveness

Automated Sampling allows for a single piece of machinery to take representative samples from any incoming granular fuel.

Trucks are turned over in a time window simply unachievable by manual sampling. In addition to the length of the actual sampling process itself, manual sampling requires squaring the samples as defined by the EN ISO 14780 standard. Done by a human this entails setting up the sample on a table, separating it into quadrants and removing a portion of it back into the fuel pile before acquiring the actual sample to be used.

Effortless Standard-Compliance

Q-Robot sampling increments comply with the EN ISO 18135 and EN ISO 14780 standards by design. Samples are squared as standard operating procedure during the operation of each sampling round.

Instant Measurements

Instant information delivery on our roadmap for automated sampling solutions will provide near real-time information on moisture content throughout the supply chain.

Enriched Information Flow for the Entire Supply Chain

When distributed in real-time, the data gathered at the automated sampling station will enable higher efficiency throughout the Fuel Supply Chain. Breaking down fuel quality information for individual truck loads offers many new possibilities for all stakeholders:

- Fuel suppliers can select their subcontractors more efficiently
- Machinery life cycle length is improved and maintenance costs lowered due to higher fuel quality
- Power plants can receive timely deliveries of the fuel types they require
- Subcontractors learn more of their fuel and can make improvements on their sources and processes
- Storage methods and periods for inbound fuel can be more precisely arranged

Occupational Safety Improvements

Only personnel involved in automated sampling is the truck driver. Their responsibilities are limited to driving the truck in and out of the sampling hall, and initiating the Automated Sampling process from the designated safety area by pressing a single button.

This way the driver is not required to balance on unloading area structures or be subjected to hazardous small-particle dust.

Requirements

Sampling Hall

Truck cargo is sampled inside a specialized Sampling Hall, which houses the Automated Sampling Robot. Sampling hall can also optionally be equipped with a separate handling container that can automatically form representative combined samples. These combined samples are then available for analysis in the laboratory.

Automated Sampler

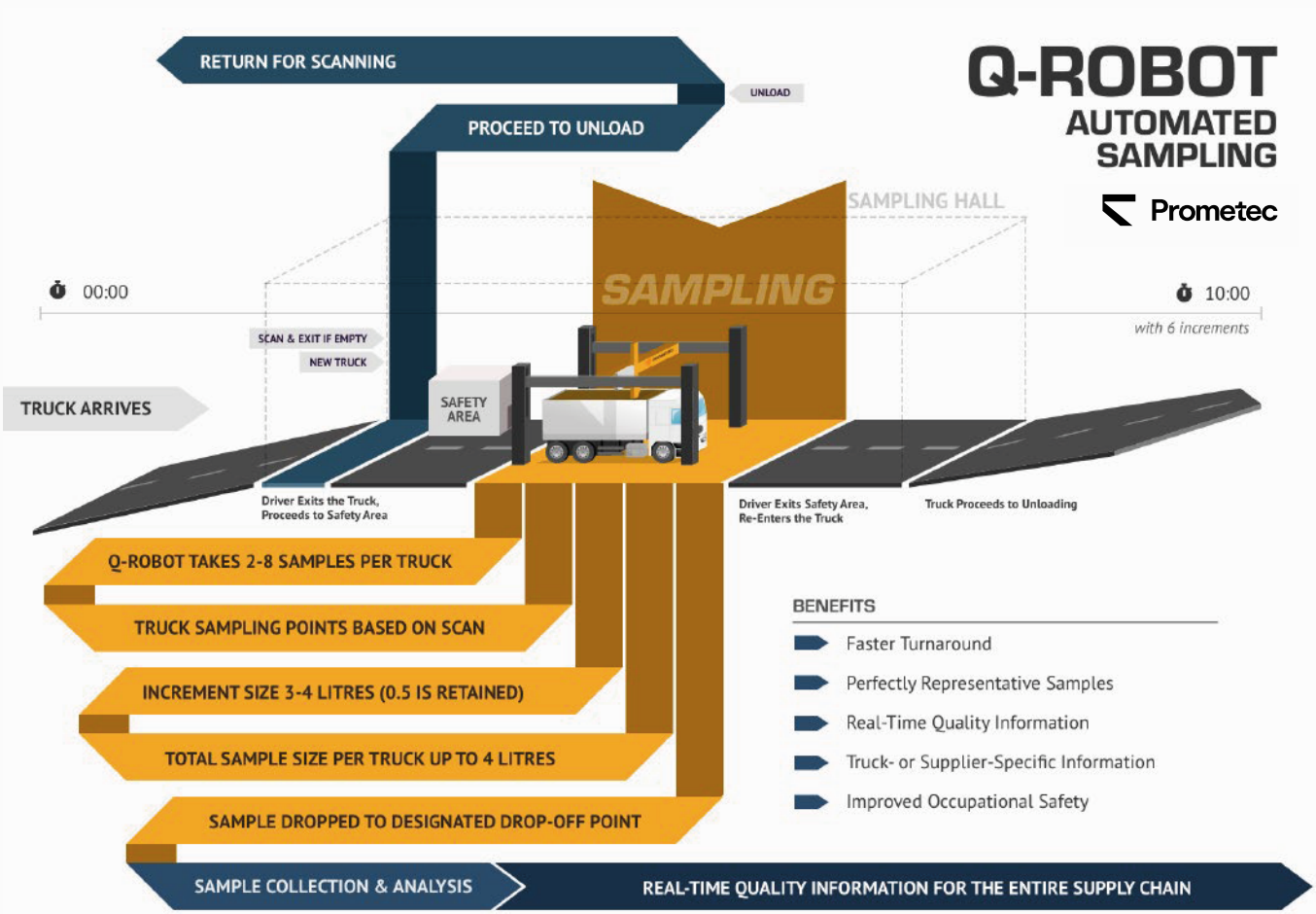
The Q-Robot Automated Sampler is specialized equipment developed by Prometec. It houses instruments required for machine vision as well as sampling and it can produce representative samples from a fuel truck within 10 minutes.

Sample Analysis

Soon our solution will provide real-time, calculated moisture information from the sample. For further analysis the samples can be transferred from the sample holding area to the Power Plant's own laboratory.

Prometec's Q-Link is a service that can includes on-site dedicated personnel processing the samples rapidly inside a specialized mobile laboratory.

Automated Sampling Process



Step 1: Truck Arrives

The traffic light outside will show when the drive can drive their truck in. With an RFID tag the driver can open the sliding doors and drive into the hall. After they have cleared, the door will close automatically and the traffic light will indicate the hall is in use. Next driver will move into position to wait until the first driver is finished.

Step 2: Truck Is Stopped

Driver will drive their truck until the guiding lights inside the hall will tell them to stop. This happens at a precise location in the hall so the Q-Robot will have full use of its reach available. Driver will then exit the truck cabin and move into the designated safety area to operate the control panel.

Step 3: Sampling Begins

Truck Is Under Sampler For First Time

If this is the first time the truck is under the sampler, the driver will be instructed to unload the fuel at the proper station and return under the machine vision for a full scan of the empty truck.

Adaptive Machine Vision And Sampling Depth

Machine vision scans of empty trucks are used to determine the optimal, randomized sampling positions. Depth perception in the machine vision will help determine proper sampling depth for each round of sampling. Cross-bars and other structural features of the truck are scanned to ensure safe sampling.

10-minute Turnaround

Sampling takes around 7 minutes, during which time Q-Robot will have determined the correct amount of samples to take and proper variables for each individual sample, such as position and depth. From start to finish, the whole process takes only 10 minutes.

Step 3: Sampling Is Completed

Once the sampling is complete, the Q-Robot will unload the sample to the correct sample tube Depending on the set-up, the sample tube can lead to a single drop-point or batch-specific mixer bins in the sample handling system.

Step 5: Truck Proceeds To Unloading Area

Once the sampling is complete, the driver can proceed to unload the fuel at the proper unloading area.

When The Fuel Is Too Moist Or Too Dry

Once the Instant Measurements feature is launched, it will be possible to even turn back fuel that is either too moist or too dry.

HUGE ICE BLOCKS

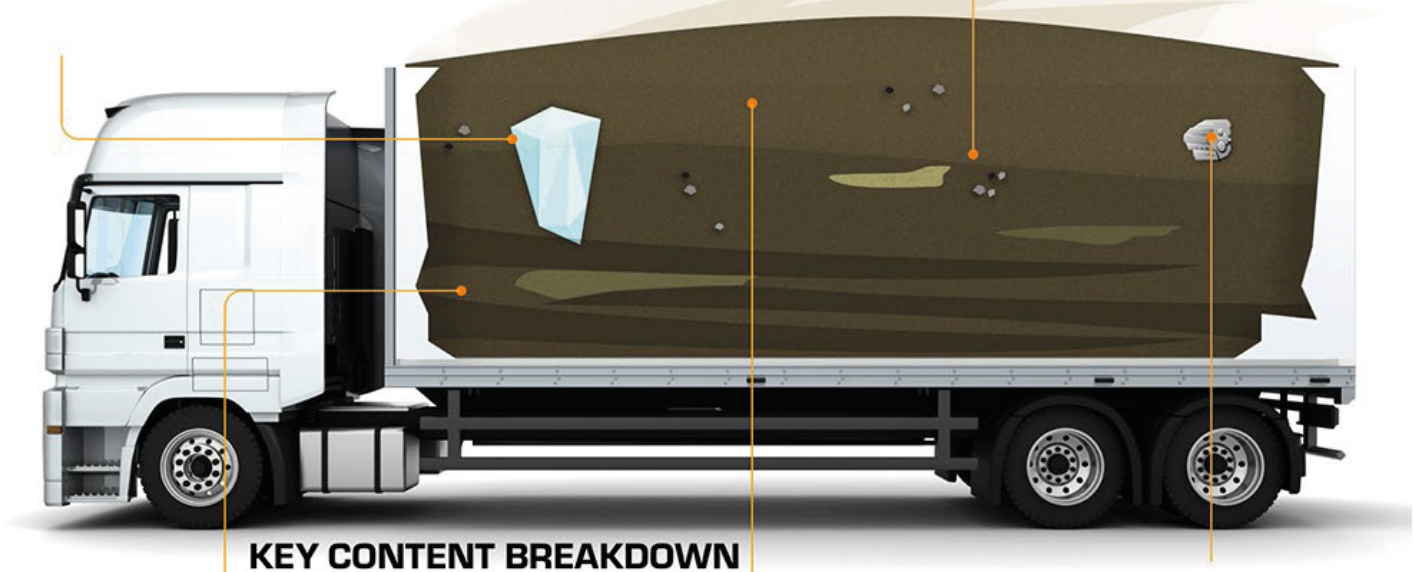
Winter in the Nordics is harsh, and loads often contain huge blocks of frozen fuel. During unloading, there is a significant **risk of injury** if personnel are struck by falling blocks of frozen fuel.

SMALL-PARTICLE DUST

The dust contains mold, bacteria and fungi. It is **hazardous to health**. Concentrations are strongest during unloading.

ROCKS & OTHER IMPURITIES

Besides moisture, impurities like rock and sand are a primary cause for the **Fuel Energy Balance Error**.



KEY CONTENT BREAKDOWN OF A BIOFUEL TRUCKLOAD

FUEL LAYERS

Granular fuel often gets layered during transport. Finer fuel types form a **zebra-type** pattern on the bottom of the fuel load.

BIOFUEL TYPES

In Nordic ares, the biofuel most often used in Power Plants consists of peat and peat derivatives, wood and wood-derived fuels created during logging and milling as well as a minor portion of herbaceous biomass.

#STUFFYOUFINDINBIOFUEL

We know of someone who's come across a car's **ENGINE BLOCK** in their fuel load.

It is uncertain whether there was any mileage left in the engine.

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Check Your Own Savings

Here is a quick cheat sheet for estimating the savings you can get from driving down your Fuel Energy Balance Error.

Fuel Energy Balance Error in this model is 5% and it is based on study (Järvinen 2012, VTT-R-01322-12) by Technical Research Center of Finland (VTT).

ANNUAL FUEL USAGE

FUEL PRICE per **MWh**	**500 GWh**	**1000 GWh**	**1500 GWh**	**2000 GWh**	**2500 GWh**	**3000 GWh**
5 €	125 000 €	250 000 €	375 000 €	500 000 €	625 000 €	750 000 €
6 €	150 000 €	300 000 €	450 000 €	600 000 €	750 000 €	900 000 €
7 €	175 000 €	350 000 €	525 000 €	700 000 €	875 000 €	1 050 000 €
8 €	200 000 €	400 000 €	600 000 €	800 000 €	1 000 000 €	1 200 000 €
9 €	225 000 €	450 000 €	675 000 €	900 000 €	1 125 000 €	1 350 000 €
10 €	250 000 €	500 000 €	750 000 €	1 000 000 €	1 250 000 €	1 500 000 €
15 €	375 000 €	750 000 €	1 125 000 €	1 500 000 €	1 875 000 €	2 250 000 €
20 €	500 000 €	1 000 000 €	1 500 000 €	2 000 000 €	2 500 000 €	3 000 000 €
25 €	625 000 €	1 250 000 €	1 875 000 €	2 500 000 €	3 125 000 €	3 750 000 €
30€	750 000 €	1 500 000 €	2 250 000 €	3 000 000 €	3 750 000 €	4 500 000 €

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Prometec Solutions was founded in 2012 around their novel Q-Link service concept. The Q-Link service provides dedicated and highly-trained personnel for Power Plants who will execute the entire process from sample taking to sample analysis according to standards.

Two years after starting with Q-Link at Kuopio, the Q-Robot pilot was started in cooperation with Kuopion Energia.

Prometec has focused heavily on product development since Q-Robot's inception. With the Q-Robot going live at Kuopion Energia in June 2017, a full commercial offering is finally out and rapid growth is expected from the year 2018 onwards.

Prometec is fully owned by its employee founders, and funding for the development of Q-Robot has been provided by ELY and Leverage from EU fund.

European Union
European Regional Development Fund

Leverage from the EU 2014–2020

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