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D3.9 Feasibility report non-dedicated system

Feasibility report on distributing neat biojet fuel through a non-dedicated system

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Executive summary

On January 22nd 2016, the start of sustainable jet fuel supply at Oslo Gardermoen Airport was announced by the ITAKA consortium and Air BP. The majority of this sustainable jet fuel is supplied directly into Oslo's fuel hydrant system, meaning that it became part of the airport's common storage and distribution system without having to rely on a segregated infrastructure.

With the SJF supply via Oslo's OLT tank farm and hydrant system, the ITAKA project demonstrated as a first time ever that SJF supply through an airport's existing infrastructure system is possible. Although the SJF supply to the airport was still segregated using road tankers, receiving into existing jointly operated jet fuel systems appeared feasible from both operational, organizational and administrative perspective. When scaling up, efficiency improvements may be achieved by supplying the SJF further upstream, via existing jet fuel infrastructures that are used for supplying fossil jet towards airports, eg. the various pipeline systems that are in place.

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Abbreviations

AFQRJOS = Aviation Fuel Quality Requirements for Jointly Operated Systems

ASTM = American Society for Testing and Materials

EI = Energy Institute

EU RED = European Union Renewable Energy Directive

EU ETS = European Union Emission Trading Scheme

GFS = Gardermoen Fuel Services

HEFA = Hydro-treated Esters and Fatty Acids

JIG = Joint Inspection Group

MCA = Monument Chemical Antwerp

OLT = Oslo Lufthavns Tankanlegg

OSL = Oslo Gardermoen Airport

PoS = Proof of Sustainability

SJF = Sustainable Jet Fuel

Definitions

ASTM: originally known as the American Society for Testing and Materials, this international standards organization develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems, and services. ASTM International works with aircraft and engine manufacturers, government authorities and fuel suppliers to set the standards for aviation fuels such as the required characteristics for jet fuel.

ASTM D1655: Standard Specification for Aviation Turbine Fuel. This specification defines the minimum property requirements for Jet A and Jet A-1 aviation turbine fuel and lists acceptable additives for use in civil operated engines and aircrafts. Specification D1655 is directed at civil applications, and maintained as such, but may be adopted for military, government or other specialized uses.

ASTM D7566: Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons. The main part of this standard contains the specifications for synthetic jet fuel blended with Jet A or Jet A-1. Once certified, the blended jet fuel batch is automatically recertified to ASTM D1655 and considered a drop-in fuel batch. Blending is only allowed after the neat synthetic jet fuel batch is certified to the applicable Annex of D7566. Each Annex belongs to a specific synthetic jet fuel production pathway; a total of five pathways are currently certified.

DefStan 91-91: "Defence Standard 91-91", the Aviation Turbine Fuel (Kerosene Type, Jet A-1) standard developed by the UK Aviation Fuels Committee (AFC) on behalf of the Ministry of Defence (MOD). Developed for use in the UK, but today also used in many European countries.

HEFA: Hydro-treated esters and fatty esters / the technology to treat triglycerides with hydrogen under increased pressure and temperature to convert them into hydrocarbons.

JIG: Joint Inspection Group. Established by numerous oil companies that share jet fuel infrastructure to and at airports, and developed a set of standard/guidelines which govern the operation of the shared fuel infrastructure.

EI 1530: Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports. EI/JIG 1530 provides a standard for maintaining aviation fuel quality, from production through (sometimes complex) distribution systems to airports. It provides mandatory provisions and good practice recommendations for the design/functional requirements of facilities, and operational procedures.

AFQRJOS: The Aviation Fuel Quality Requirements for Jointly Operated Systems are the agreed specification requirements for jet fuel supplied into jointly operated locations. It comprises the most stringent specifications of both ASTM D1655 and DefStan 91-91.

Nabisy: The German governmental web application for sustainable biomass (Nachhaltige Biomasse System, Nabisy), operated by the Federal Office for Agriculture and Food (BLE), serves to prove the sustainability of bioliquids and/or liquid or gaseous fuels from biomass, pursuant to EU Directive 2009/28/EC (EU RED).

1 Introduction

On January 22nd 2016, the start of sustainable jet fuel supply at Oslo Gardermoen Airport was announced by the ITAKA consortium and Air BP. The majority of this sustainable jet fuel is supplied directly into Oslo's fuel hydrant system, meaning that it became part of the airport's common storage and distribution system without having to rely on a segregated infrastructure.

With the SJF supply via Oslo's OLT tank farm and hydrant system, the ITAKA project demonstrated as a first time ever that SJF supply through an airport's existing infrastructure system is possible. Although the SJF supply to the airport was still segregated using road tankers, receiving into existing jointly operated jet fuel systems appeared feasible from both operational, organizational and administrative perspective. This report evaluates the supply of sustainable jet fuel via the non-segregated system at OSL, the operational requirements that had to be taken into account, the way to scale up and the reporting involved in supplying SJF via a co-mingled system.

2 Requirements for supplying sustainable jet fuel via co-mingled airport systems

Fuel quality

Given the international character and very strict safety regulations of aviation, fuel quality is carefully managed by international fuel standards. One of the best known standardization organizations is ASTM, in which subcommittee D02.J is responsible for aviation fuels standards, e.g. D1655 for Jet A and Jet A-1, and D7566 for Jet A and Jet A-1 containing synthesized hydrocarbons. These ASTM standards are well respected within the aviation industry and used globally.

Sustainable jet fuel may only be used in turbine engines after being certified to D7566 specifications for the neat sustainable jet, blended with regular (D1655 certified) Jet A/A-1 and again certified to D7566 specifications for the blend. After the blend certification, the blend is automatically recertified to D1655. The blend then meets the same specifications as regular Jet A/A-1 should meet, and from then on can be considered a drop-in jet fuel that can be handled and used in the same way as regular Jet A/A-1.

The D7566 standard consists of two parts. The Annexes contain the specifications for neat sustainable jet fuel, in which every Annex is applicable to a specific production pathway. Currently, there are five SJF production pathways certified. After blending the SJF with regular Jet A/A-1, the blend is certified according to the general part of D7566 and with this step automatically recertified to ASTM D1655. The figure below shows a schematic overview of this certification process.

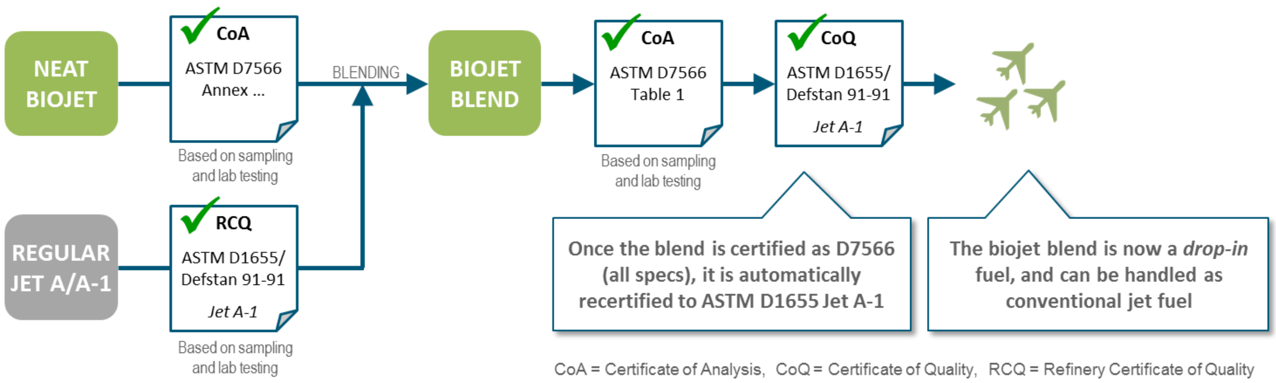

Figure 1. Schematic overview of the sustainable jet fuel certification process.

Although globally the ASTM D1655 standard is widely accepted and used, it is not the only standard for Jet A-1. The by the United Kingdom's Ministry of Defence developed Defence Standard (DefStan) 91-91 for Jet A-1 is more common in Europe. Both standards are almost identical, they only differ on some parameters, e.g. conductivity and traceability requirements. Both ASTM D1655 and DefStan 91-91 refer to the ASTM D7566 standard when it comes to synthesized hydrocarbons, hence both standards allow sustainable jet fuel to the same extend.

Operations

At large airports, many aviation fuel suppliers share the use of fuel storage tanks and fuelling systems, thereby preventing unnecessary infrastructure duplication and additional costs. The Joint Inspection Group (JIG) was established by oil companies to develop a set of standards that govern the operation of the shared fuel infrastructure on airports where the JIG companies operate. However, usage of the JIG guidelines is not limited to jointly operated locations, any operator providing aviation fuel infrastructure may use the guidelines.

Today, most European airports operate by these JIG guidelines, including Oslo Gardermoen Airport. The guidelines are not only applicable to the airport's operations (JIG 1 and 2), but also cover the jet fuel supply chain (JIG 3). The Energy Institute (EI) and JIG jointly extended the JIG 3 guideline to cover also operations further upstream, including refineries. This has become the EI 1530 guideline. The picture below shows which pieces of the supply chain are covered by which standards.

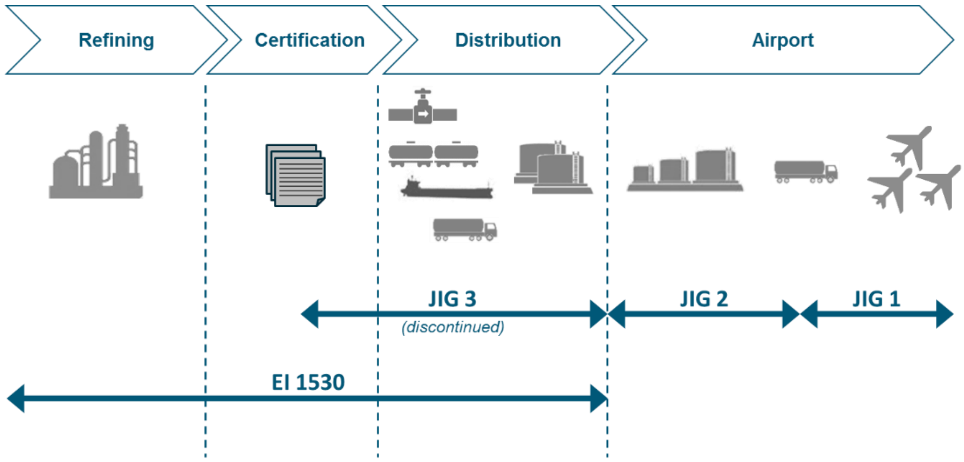

Figure 2. Overview of JIG guidelines coverage in aviation fuel supply chains.

Part of the JIG guidelines is the Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS), defining the fuel quality requirements for supply into jointly operated fuelling systems. It embodies the most stringent requirements of both ASTM D1655 and DefStan 91-91. Since 2012, both JIG and EI 1530, hence also the AFQRJOS, follow ASTM and DefStan regarding allowance of synthetic components to be blended with Jet A-1 for up to 50%. In other words, JIG allows SJF to be used in existing jet fuel infrastructure to and at airports.

Although fuel standards and operating guidelines allow the use of sustainable jet fuel in co-mingled systems for some years already, it hadn't taken place so far. Given the still relatively limited experience, combined with strict aviation safety regulations and complex and jointly operated supply chains, stakeholders tended to be a bit hesitant in using SJF via the co-mingled systems in the beginning. For the ITAKA SJF deliveries through the co-mingled system though, full support and confidence was obtained from all parties involved fuel supply at Oslo Gardermoen Airport (OSL). This included Air BP, OSL's commingled aviation fuel storage provider OLT and OSL's into planer GFS.

For the ITAKA SJF deliveries via the co-mingled system, the JIG and EI 1530 guidelines had to be taken into account throughout the entire supply chain and by all the ITAKA downstream supply chain partners. Eg. Neste followed JIG/EI 1530 Section 10 guidelines for transport and applied the HM50 procedures (prescribed by JIG/EI1530) for the vessel transport of neat and blended SJF.

One of the JIG/EI 1530 guidelines states that receiving up to three jet fuel batches into one commingled storage tank is allowed without having to fully recertify the received fuel to all AFQRJOS specifications; only a key parameters check is required (e.g. density, freeze point, flash point, etc.).

> EI/JIG 1530, section 4.6.1
> "*When batch traceability or integrity is lost, for example, when several batches are mixed in a system in unknown proportions, or where more than three batches are added to the heel in a tank (where the heel is less than 3% of the total volume), it is necessary to retest the new batch against the complete specification and produce a CoA.*"

In case more than three batches are received, it is considered a blending operation (in terms of JIG this is equal to production) and a full certification of the fuel is required. In order not to negatively influence the jet fuel operations at OSL, this implied that the SJF batch delivered into the commingled jet fuel tank needed to be one of the total three received batches, or be smaller than 120 CBM (which is 3% of the storage tanks capacity) minus the actual tank heel volume. Furthermore, following JIG guidelines, the SJF batch needed to be compliant to the AFQRJOS.

3 Overview of non-segregated supply and operations

The SJF that was supplied at OSL was produced by Neste from feedstock supplied by the Camelina Company. The fuel was blended on ship by Neste and Air BP and subsequently stored in a shore tank at the ST1 terminal in Gävle (Sweden). From there on the fuel was trucked to OSL for supply into the co-mingled storage system of OLT and (a smaller part) for supply to segregated KLM/Embraer flights. A schematic overview of the supply chain is shown below.

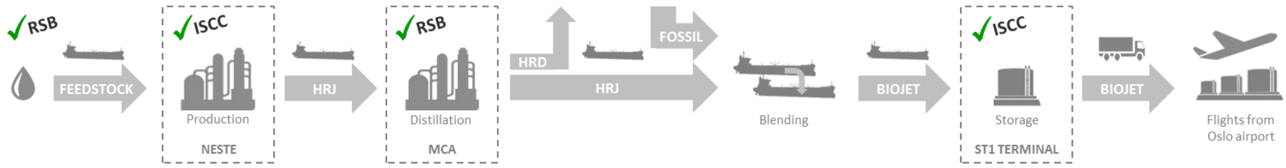

Figure 3. Schematic overview of the SJF supply chain towards Oslo Gardermoen Airport.

Supply of blended SJF to and at OSL

OLT Tank farm at Oslo airport

At OSL, OLT is responsible for the jet fuel storage in their commingled tank farm and the fuel infrastructure (pipelines, hydrant system, etc.). The tank farm consists of 3 tanks of 4.000 CBM each, filled by pipeline from the nearby rail terminal. For security of supply, jet fuel can also be received by trucks via a separate reception tank of 50 CBM. Each 4.000 CBM tank holds jet fuel for approx. 2 days and are therefore alternating operational modes: 1) receiving new jet fuel, 2) closed for certification, or 3) ready for discharge via the hydrant system or refueler trucks. GFS is responsible for actually fueling the aircrafts at OSL.

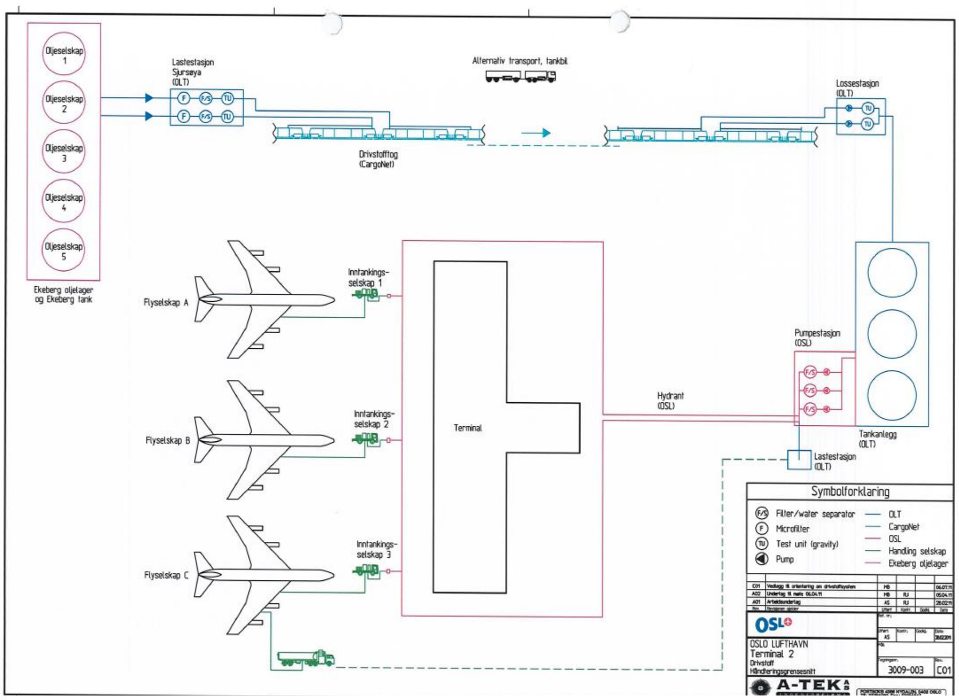

Figure 4 Hydrant system Oslo airport

They operate the dispenser trucks that connect the hydrant system to the aircrafts, and the refueler trucks for fueling aircrafts at gates where no hydrant system pit is available, or when a segregated supply is desired, e.g. the KLM/Embraer flight program. See figure 4 for an overview of the hydrant system.

SJF deliveries to OLT: per truck

In the existing infrastructure, jet fuel is delivered on a regular basis to OLT by rail cars from the port of Oslo to a rail terminal 20 km outside OSL, and from there by pipeline into OLT. It was evaluated whether it would be efficient to use this infrastructure as well for supplying the SJF to OLT. However, based on Air BP's airline agreement to supply SJF ratably throughout the year, the total SJF volume was divided into smaller monthly batches, making the logistics per vessel to the port of Oslo, or per rail to OSL unnecessarily expensive. In addition, for supplying jet fuel to smaller regional airports, Air BP used road tankers already connecting Gävle and Oslo on a weekly basis. It was therefore decided to supply the SJF from the ST1 terminal to OLT on a weekly basis using Air BP's existing road tanker route. Next to the SJF deliveries no other jet fuel deliveries by road tankers occurred.

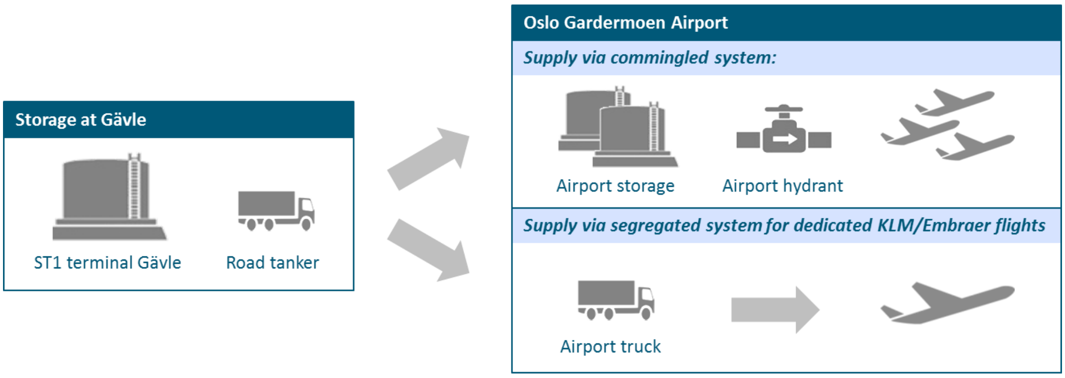

Figure 5. Schematic overview of SJF supply from Gävle to OSL.

Batch volume requirements

Given OLT's limited fuel storage capacity, OLT prevents in their normal operations the full certification of the stored fuel, by not storing more than three different batches at a time and performing a key performance analysis. In order not to deviate from this procedure, the delivered SJF volume either needed to be less than 3% of the storage tank capacity, or be one of the three supplied batches.

As the SJF was to be delivered rateably and a schedule of one truck per week (40 CBM) turned out to work best from operational perspective, the delivered volume was significantly smaller than 3% of the storage tank capacity (120 CBM) and hence didn't form an issue. Also, during the KLM/Embraer flight program, where the delivery frequency was temporarily increased to two deliveries per week, we were still well below the 3% limit.

For future, larger supply chains, meeting the <3% tank capacity will become difficult. The SJF batch to be inserted in the co-mingled airport system would then become a separate batch according to JIG. Once supply is big enough this will not form an issue in terms of preventing recertification, as an SJF batch would just replace a fossil jet A batch. There will probably be an intermediate period in which the SJF supply chain would result in SJF batches supplied to the co-mingled systems, that are bigger than the 3% limit, but not big enough to be one of three batches. Solutions for this intermediate period, would be either to allow for this recertification, concentrate deliveries so batch size is big enough to be one of the three batches or to already commingle the SJF more upstream at locations where less batches are commingled per tank, or where storage capacity is less constraint, e.g. at large tank terminals.

Discharge into commingled jet fuel pool
Following standard procedures, the truck driver was registered at OLT in advance, and subsequently allowed to enter OLT's truck terminal. Discharging jet fuel into the reception tank without supervision of OLT was possible if the time between loading and discharging road tankers was less than 4 hours and the road tanker was sealed directly after loading. All road tankers were sealed after loading, but the large distance between Gävle and Oslo, more than 4 hours, required that OLT performed a Control Check (water test, density measurement and clear & bright test) on the delivered SJF prior to discharging. After each delivery, the volume in the reception tank was pumped through OLT's general import filter and into one of the large storage tanks, making it part of the commingled jet fuel pool.

Fuel conductivity
Since the SJF is supplied into the jointly operated commingled fuel storage systems, the AFQRJOS specifications applied to the SJF. AFQRJOS requires conductivity to be in between 50 pS/m and 600 pS/m), which is achieved by the addition of Stadis 450, the only allowed Static Dissipater Additive (SDA). Usually, SDA is added at the refinery, or when more practical further downstream at large tank terminals. Due to SDA's poor solubility, the addition of SDA in small fuel volumes is a cumbersome operation and hence not preferred.

Within the ITAKA supply chain, Stadis 450 was added during production at Neste and re-added during blending at Gävle. The blended SJF was stored at Gävle with a reported conductivity of 160 pS/m (at 18°C). Usually this is sufficient for supplying to airports, however, two factors may significantly influence the conductivity:

- Transport; conductivity dropping more with turbulent transports, e.g. in road tankers.
- Temperature; conductivity dropping with lower temperatures, especially in winter conditions like in Sweden and Norway.

Since the ITAKA 'non-dedicated' deliveries still involved truck transport to the airport, there was a risk of conductivity dropping that needed to be taken into account. OLT and AirBP were prepared to re-add Stadis at the airport, but conductivity checks at the airport in the end turned out that this was not to necessary.

Evaluation operations supply via non-dedicated system

The SJF supply via Oslo's OLT tank farm and hydrant system, was the first-ever SJF supply through an airport's existing infrastructure system. We can look back on a very successful process; there were no serious issues reported other than usual operational challenges, i.e. minor planning mistakes or simple miscommunications. Although the SJF supply to the airport was still segregated using road tankers, receiving into existing jointly operated jet fuel systems appeared very feasible from both operational and organizational perspective.

When scaling up, efficiency improvements may be achieved by supplying the SJF further upstream, via existing jet fuel infrastructures that are used for supplying fossil jet towards airports, eg. the various pipeline systems that are in place. Most (international) airports are supplied with jet fuel by pipelines. These pipelines can be multi-product pipelines (e.g. for jet and diesel use) and, can be part of a network supplying multiple locations, including military airports. For example, the Central European Pipeline System (CEPS), owned by the NATO, is an international pipeline system supplying both civil and military airports in Central and Western Europe. The pipeline system is operated by the national Ministries of Defence. Military aviation uses jet fuel with slightly different specifications than Jet A-1, with the most important difference being the use of additives (SDA, FSII, corrosion inhibitor, etc.). The use of synthetic components (i.e. bio jet) in military jet fuel is allowed by international military fuel standards, however, there are some military aircraft manufacturers that don’t accept the use of synthetic components in their aircrafts yet. Since in CEPS, but also in other pipeline networks, military airports are supplied by a pipeline network also supplying civil airports, in theory bio jet molecules may end up in the military airport tank farm when bio jet is supplied to civil airport via this pipeline network. This is one of the main reasons for CEPS to not yet allow bio jet fuel through their system. However, discussions are progressing to change this, as from a fuel perspective the use of synthetic components is allowed by international military jet fuel standards.

4 Accounting and administration of SJF via co-mingled system at Oslo

The traceability of an SJF batch starts at its production; the SJF is given a unique batch number that travels through the entire supply chain and is shown on all relevant documentation accompanying the SJF batch. As such the SJF delivered can be traced back to its origin (also see the ITAKA D3.5 report). In case of supplying SJF via non-dedicated infrastructure, the SJF batch at a certain moment is co-mingled with other batches and hence the physical presence of SJF gets somehow uncoupled from its administration.

Administration/reporting SJF delivery at Oslo airport

OLT's jet fuel administration only registers "Jet A-1" as the fuel type, the system does not allow to introduce a second type like "Sustainable Jet A-1". It does however register volumes and the batch numbers of all incoming jet fuel, and since the documents throughout the paper trail of an SJF batch is linked by means of among others batch numbers, this batch number registration can demonstrate that SJF has been delivered at the Oslo airport tank farm. For the ITAKA SJF deliveries at OLT, volume and batch number registration was based on the road tanker loading documentation provided by the ST1 terminal.

OLT's administration subsequently only registers the *volume* that is delivered from their tank farm into the aircraft, thereby not referring to batch numbers anymore. The same holds when GFS fuels aircrafts; only the volume and "Jet A-1" is mentioned on the fuel ticket, no batch or SJF reference.

So strictly speaking, the SJF coming in at Oslo airport can be traced, but the SJF delivered to airlines flying from Oslo airport cannot be traced at an aircraft level anymore.

However, the SJF can still be administratively linked to the airline having the SJF contract in place at the specific airport. This can be done via the contract, the invoices and delivery documents up to the airport, further supported by a traceability package tracing the delivery back to its origin. Agreements should be made with the airline on what level of detail and documentation they need. In case the SJF deliveries do not take place under a certification scheme, reporting requirements are not determined by the rules of such certification schemes, but should be the result of the suppliers' agreement with the airline.

Reporting SJF consumption under EU ETS

In case SJF deliveries do take place under a (voluntary) certification scheme, the procedures of the certification scheme and subsequent claiming process (claim GHG savings under EU ETS or in another way receive government support or count towards national renewable energy targets) require certain reporting/accounting to demonstrate delivery of SJF (and its sustainability).

The ITAKA SJF that was delivered at Oslo airport was delivered under a fully EU-RED compliant supply chain (see figure 3 in chapter 3). This enabled Lufthansa as one of the one airlines that received SJF at Oslo airport, to claim the GHG savings of the ITAKA SJF batch under EU ETS for its intra-European flights. The below summarizes the process followed.

Demonstrate fuel delivery
In order to proof sustainability of the fuel delivered, evidence on the SJF supply and use are required. It was in this case AirBP, as supplier to the airline, to demonstrate the supply, and the following documents were used for the SJF deliveries at Oslo:

- SJF procurement records
- SJF import documents at ST1 terminal in Gävle
- Proof of Sustainability (PoS) from supplier Neste, confirming the SJF's EU RED compliancy of the entire chain
- Transport documents to OLT, i.e. loading documents from ST1 terminal and Bill of Ladings of road transports to OLT
- PoS to AirBP's customers (e.g. airlines)

In addition, Air BP as supplier also holds an administration of their jet fuel inventory. One of the requirements following from their ISCC sustainability certification is that they need to keep an administration of their sustainable biomaterials, hence Air BP held a separate SJF administration.

Aboe process will be audited by Air BP's independent ISCC certification body.

Demonstrate fuel consumption
It is the responsibility of the airline to prove the SJF reception through the PoS provided by their supplier, and the use of the SJF on intra-European flights by comparing their fuel consumption on all flights with intra-European flights (non-reportable vs. reportable flights), using EU ETS standard procedures for reporting fuel usage.

With the supply of SJF into the commingled fuel pool at OSL, full traceability of the SJF to specific airlines was only possible on paper as in practice the SJF molecules end up in the entire fuel system. EU ETS recognizes this difficulty and EU ETS verifiers allow airlines to use a mass balancing approach for demonstrating their sustainable fuel use. This mass balancing method should show the amount of SJF used compared to the total fuel use, and with this the jet fuel emission factor is lowered using following formula:

$$Emission\ factor = 3{,}15\ \frac{MT\ CO_2}{MT\ jet\ fuel} \times \left(1 - \frac{Total\ delivery\ of\ SJF\ to\ tank\ farm}{Total\ fuel\ consumption\ of\ all\ relevant\ flights\ after\ first\ delivery\ of\ SJF}\right)$$

With this method EU ETS doesn't require an analysis of the SJF blend (the emission factor of certified SJF equals zero in EU ETS), the mixing ratio of the SJF in the fuel pool needs to be proven instead, e.g. by using the mass balance approach (fuel in = fuel out).

Nabisy
Although the SJF was consumed at Olso airport, with Lufthansa being a German based airline, they are required to report under EU ETS through the German authorities. The *Bundesanstalt für Landwirtschaft und Ernährung* (Federal Office for Agriculture and Food, BLE) developed *Nabisy*, a web-based system for sustainable fuel users.

In Nabisy, the use of sustainable fuels is reported by the airline by means of forwarding the Proof of Sustainability within the Nabisy system to the *Deutsche Emissionshandelsstelle* (German Emissions Trading Authority, DEHSt). To do so, the airline first needs to receive the PoS in the Nabisy system from their supplier.

(International) Fuel producers can register a sustainable fuel batch in the system (by providing data on the biofuel), and (international) fuel suppliers can subsequently forward sustainable batches in the Nabisy system to a next supplier or end-user with a PoS; they can split a sustainable fuel batch to multiple receivers with Partial Proofs of Sustainability (PPoS), or combine multiple sustainable batches from different producers.

For the ITAKA deliveries, this implied that Neste, Air BP Sweden, Air BP Norway and Lufthansa all had to be registered at Nabisy so that the complete supply chain was covered in the system. Neste registered the entire fuel batch in Nabisy, based on the PoS they issued with supplying to Air BP and the Saybolt independent surveyor report of the blending and transfer at Gävle. They subsequently forwarded the fuel to Air BP Sweden, which subsequently forwarded the fuel batch in monthly parts to Air BP Norway. Air BP Norway then supplied the final Proofs of Sustainability to Lufthansa.

From an EU ETS auditor’s perspective, the PoS stream in Nabisy is not offering sufficient evidence as there is no fuel batch numbers in Nabisy. So, there are actually two paper chains that need to be connected at some point:

- The Nabisy PoS stream, forming a closed chain as the original PoS number is stated on all downstream PoS
- The proofs of delivery (production, independent surveyor and transport documents), forming a closed chain based on batch numbers

Neste made a connection between both streams by formally declaring the original PoS in Nabisy is linked to the actual fuel transfer to Air BP, based on the volume registered in Nabisy and the identical volume plus fuel batch number stated on their ISCC PoS to Air BP. Figure 6 gives a schematic overview of the document chains.

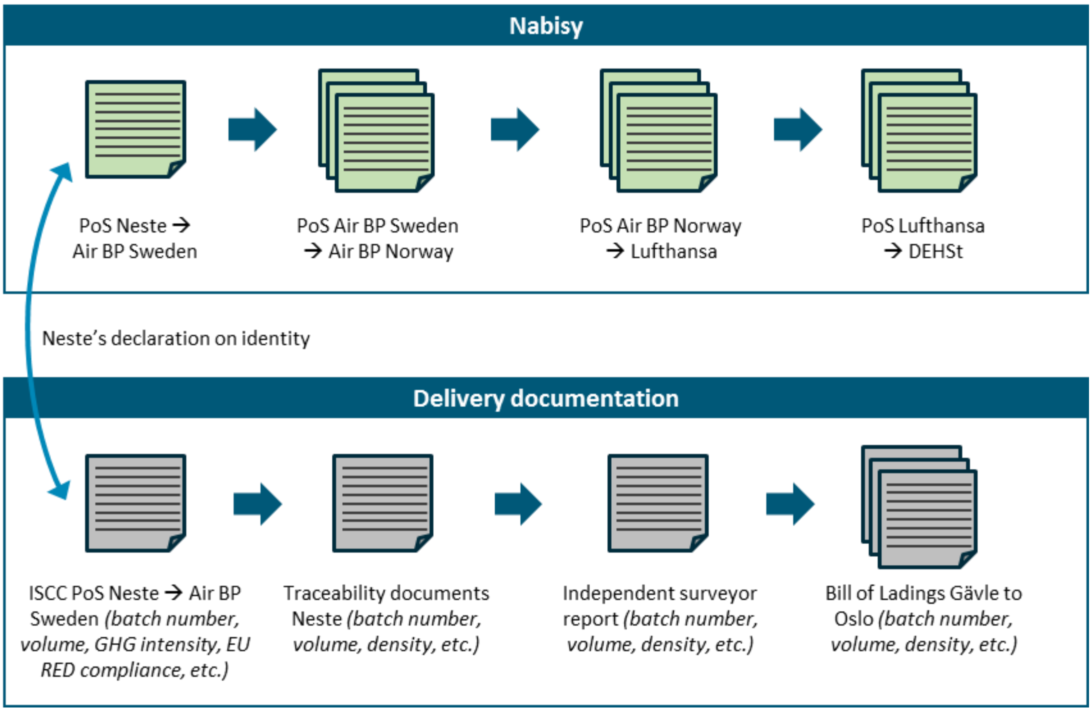

Figure 6. Schematic overview of PoS and delivery documents chains.

5 Conclusion

On January 22nd 2016, the start of sustainable jet fuel supply at Oslo Gardermoen Airport was announced by the ITAKA consortium and Air BP. The majority of this sustainable jet fuel is supplied directly into Oslo's fuel hydrant system, meaning that it became part of the airport's common storage and distribution system without having to rely on a segregated infrastructure.

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