Energy Tobacco Solaris in the bio-jet fuel industry: integrated value chain approach

# Smoking new option?

Aviation, a global industry and one of the strongest growing transportation sectors, faces problems and challenges that require global solutions. In the period leading up to 2050, worldwide aviation is expected to grow by 4.5% annually. If fuel consumption and $CO_2$ emissions were to grow at the same rate, $CO_2$ emissions from aviation would be nearly six times their current figure.

As such, the potential importance of renewable fuel-based aviation cannot be over-emphasised in terms of its role in driving biofuel demand worldwide.

Yet it is a technologically complex and politically sensitive sector which is reliant on the global green energy community coming together to drive forward both production and demand in order that potential can be truly realised (IEA, 2012).

Bio-jet fuel currently represents the only viable option for significantly reducing aviation-caused emissions without cutting the number of flights. The key for a successful implementation of bio-jet fuel is the availability of feedstock in a large and sustainable scale, plus it must be available on a significant global scale.

Of the various feedstock assessed (at the time of writing), the most economic option is edible oils. However, given the implications with food security, non-edible oils might have a more sustainable potential. So, let focus on a new non-edible oily crops (see table 1).

So-called energy Tobacco Solaris can offer considerable potential for bio-jet fuel and technology provider Sunchem holds the exclusive rights for the exploitation of energy Tobacco Solaris and works with it at an industrial level.

## Multiple avenues

The main issues, opportunities and problems related to bio-jet fuel are[1]:

1. The production (inputs, raw material, technology) is cost intensive
2. The bio-jet fuel industry supply chain lacks a clear structure
3. The commercial price of bio-jet fuel is higher than conventional jet-fuel (called Jet A-1)
4. Investments in the industry are perceived to be 'high-risk'.

Sunchem developed a new strategic integrated value chain approach called genetic to market as a solution to overcome these implications. This approach centres on a new agricultural plant-species called energy Tobacco Solaris.

This approach aims to control all primary and supporting processes and activities involved in the bio-jet fuel value chain; and, thus, establishing a close and strong cooperation between the constituents involved at four different analytical levels: research and development, agriculture, processing and demand.

Sunchem Holding holds the international patent of energy tobacco (PCT(IB/2007/053412). This patent has been deposited in 57 countries and granted in 38. The company aims to developan approach integrated with the territory creating small, decentralised plants, with dedicated cultivation close to airports, sized to meet their need with a short, integrated supply chain to reduce time to market and obtain logistics optimisation.

In addition, Sunchem Holding is working with its partner in the US – Tyton Bioscience – in order to promote a new technology named 'sub-critical water' to extract the plant sugar (for ethanol) and oil (for biodiesel and jet-fuel) at the same time. This new technology could improve the project portfolio on the worldwide basis.

Energy Tobacco Solaris is a crop that is 100% sustainable as all economic, social and environmental sustainability criteria are met, ranging from the production of the seed used to obtain oil for biodiesel, bio-jet-fuel and cake to the generation of fresh biomass.

Tobacco Solaris has strong potential as an energy crop: first, oil production per hectare using existing varieties bred for seed production, exceeds sunflower, soyabean and oil seed rape.

Second, historically, breeding efforts in Tobacco Solaris have focused on biomass yield and leaf characteristics, such as nicotine content and size, so there is great potential for further rapid gain in seed and oil yield by shifting selection to the development of high seed-yielding varieties using conventional breeding, molecular marker technology and modification of key genes for oil biosynthesis through biotechnology.

Thirdly, Tobacco Solaris is already commonly cultivated throughout many climatic zones and soil types, so the required changes in agronomic production practices to produce it as an energy crop would not be as extensive as the introduction of a new crop. Tobacco Solaris can be grown on marginal soils, so energy Tobacco Solaris would not likely displace food crops from fertile soils.

Tobacco Solaris plants produced for oil can be used as a further energy sources. From one hectare of cultivation an average of between 6 to 10 tonnes of seed was taken, dependant on the country of cultivation and climatic

| Raw material | Brief description | Pros | Cons |
|---|---|---|---|
| Jatropha | Non food, evergreen, produces oil seeds (30-40%), lifetime 30 years, drought resistant | Can grow on marginal land | Marginal land means marginal yields, or at least unpredictable crop yields. (Herreras, 2010) |
| Camelina sativa | Edible plant, requires little water and fertiliser, short growth season, can be grown in rotation with wheat | Products can be used as animal feed | Deters surrounding plant growth (PFAF, 2010) |
| Salicornia bigelovii | Grows in salt marshes, seeds 20% oil | Can be integrated with fish farming and mangroves (Charlesworth, 2010) | Lower yield (606 l/ha) than jatropha (> 1500 l/ha) (Garnham, 2011) |
| Algae | Can be grown in photobioreactors or open ponds (Wenner, 2009) | Rapid growth rate, efficient photosynthesis, can recycle $CO_2$, algae can be genetically modified to produce specific sub-products | Economically they are very uncertain, high capital costs, long-term investments, oil extraction can be complex |
| Solaris tobacco | Non food, integrated seed and biomass production, one seed contains 38-39% of oil fresh biomass produces an average of 180-200 $m^3$ of methane gas, nicotine-free. | Can grown on marginal land, adapts to various climates and to various farming situations, integrated approach which favours several market outlets. | Requires irrigation and/or rainwater for adequate production, the plant is technological. |

Table 1

### Key characteristics of tabacco oil

| | | |
|---|---|---|
| Flash point | UNI EN ISO 2719-05 | 258 °C |
| Volumic mass at 15° | UNI EN ISO 12185-99 | 928.6 kg/$m^3$ |
| Viscosity at 40° | UNI EN ISO 3104-00 | 32.1 $mm^2$/s |
| Yield value | IS) 3016-94 | -21 °C |
| Acid number | ASTM D 664 | 3.88 mg KOH/g |
| Hydrogen | ASTM D5291-07 | 8820 kcal/kg |
| Net calorific value | UNIEN14107 | 13.8 mg/kg |
| Potassium | UNIEN14538 | 2.4 mg/kg |

Table 2

### Key characteristics of tabacco residual cake

| | | |
|---|---|---|
| Humidity | ASTM D 5142-04 | 8.0 % |
| Ashes | ASTM D 5142-04 | 5.5 % |
| Carbon | ASTM D 5373-07 | 47.6 % m/m |
| Hydrogen | ASTM D 5373-07 | 6.1 % m/m |
| Nitrogen | ASTM D 5373-07 | 5.8 % m/m |
| Net calorific value | ASTM D 5865-07 | 4618 kcal/kg |
| Macroelements | | |
| Calcium | UNI CEN/TS 15290 | 2450 mg/kg |
| Magnesium | UNI CEN/TS 15290 | 6287 mg/kg |
| Potassium | UNI CEN/TS 15290 | 15594 mg/kg |
| Sodium | UNI CEN/TS 15290 | 25 mg/kg |
| Ashes | | |
| Softening temperature | DIN 51730 | 1065 °C |
| Melting point | DIN 51730 | 1290 °C |

Table 3

conditions. The seed contains about 40% of oil and, with a process of cold pressure, get to more than 3 tonnes of oil and 5 or 6 tonnes of expeller (as shown in tables 2 and 3).

The oil is intended for the biofuel industry while the panel will be marketed as a dietary supplement for animal husbandry. These factors make Tobacco Solaris an attractive new energy plant and, in addition, that use represents a viable alternative to defeat the so-called crisis that the Tobacco Solaris farmer industry was facing up to a couple of years ago.

## Addiction?

The Tobacco Solaris variety cannot be used for smoking due to its lower (under 1%) nicotine content and the fact that it is OGM free. Agronomic production trials are currently underway in several countries like Brazil, Namibia and South Africa to develop systems of direct seeding of Tobacco Solaris into fields, as opposed to transplanting germinated seedlings, and multiple harvesting especially in temperate areas.

These species potentially contain desirable characteristics which would influence greater seed production or larger seeds with more storage reserves, because greater fecundity and seed storage reserves are survival advantages in the wild. Tobacco Solaris has great potential to be grown on marginal lands, such as those on hillsides or with poor soil quality, as this is where it is typically grown in African and South American Tobacco Solaris producing countries.

One of the most critical components of developing or domesticating a new energy crop is to develop agronomic production, management and harvest practices which allow the value of the crop to be realised. As the focus for growing Tobacco Solaris as an energy crop is seed production and not leaf quality, it is possible that Tobacco Solaris with high seed yields could be produced on low fertility or marginal soil.

Although Tobacco Solaris is already considered a 'domesticated' agricultural crop, production of Tobacco Solaris for energy will likely be very different than for Tobacco Solaris products. A great deal of emphasis on testing several agricultural production scenarios for Tobacco Solaris as an energy crop has been almost completed. Tobacco Solaris produced for human leaf consumption is first sown in greenhouse beds or trays and then moved into the field. This labour intensive method will simply not be feasible to produce Tobacco Solaris on large areas as an energy crop.

Field studies have been done to determine the feasibility of direct Tobacco Solaris seeding into field beds. Optimisation of planting density to achieve the highest yield of seed produced per hectare has to be conducted by performing field trials comparing yield versus number of plants per hectare.

Tobacco Solaris oil is proven to be an excellent raw material for the production of bio-jet fuels. The kerosene fraction showed an extraordinary freezing point, below -65°C, with perfect density and viscosity . Sunchem carried out a series of tests on Tobacco Solaris oil to obtain a bio-jet fuel according to the ASTM D7566-11 specification named *Kerosene from hydroprocessed esters and fatty acids.*

## Conclusion

Tobacco Solaris truly has great potential as a high energy crop, with three potential energy products: seed oil, biomass and seed cake. The utilisation of all three of these plant portions will ensure a high energy yield, input ratio for Tobacco Solaris production and a net energy gain making Tobacco Solaris a profitable and renewable energy crop, without the end product competing for food use.

So we can assume that energy sourced from Tobacco Solaris is sustainable in terms of economical, social and environmental criteria because:

1. It is not edible and consequently not in competition with food supply chain
2. It is an annual and, under specific conditions, a multi-annual crop
3. It does not contain nicotine
4. Global demand for traditional Tobacco Solaris farming is starting to decrease so the current existing Tobacco Solaris infrastructure could be converted
5. It provides multiple market products: biodiesel, bio-jet fuel, biomethane, bioliquid for electrical energy, animal feed and more
6. Unique agronomic protocol – high adaptation to different climate and soil conditions.

**References**

1 Blakey, 2011; IEA, 2012; Garnham, 2011; Gudmundsson, 2012; Nilsson, 2007; SWAFEA, 2010

**For more information:**

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