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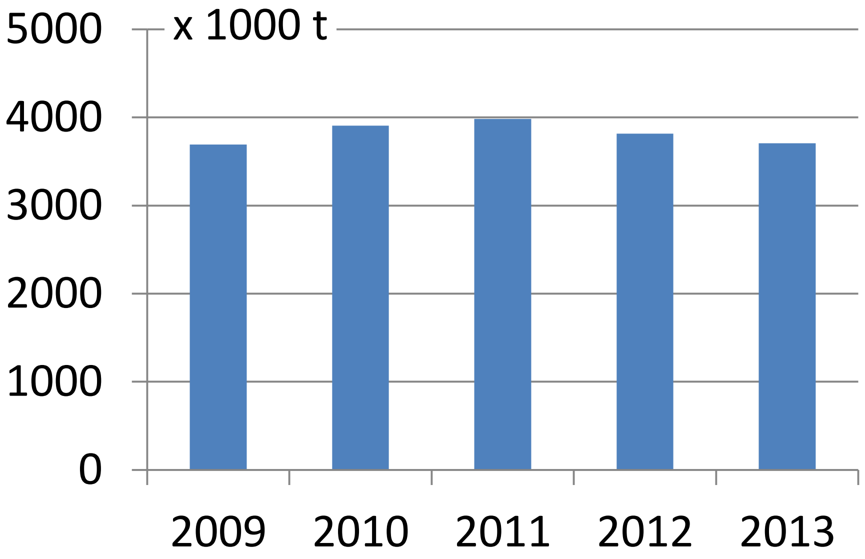
Feedstock availability in Italy

Vito Pignatelli

First Annual Workshop of ISAFF
Rome, 4 November 2014

Jet fuel consumption in Italy

Year	Total consumption (x 1000 t)	of which for military use
2009	3692	107.6
2010	3908	126.4
2011	3984	110.3
2012	3815	41.8
2013	3706	92.8



Source: Ministry of Economic Development, 2014

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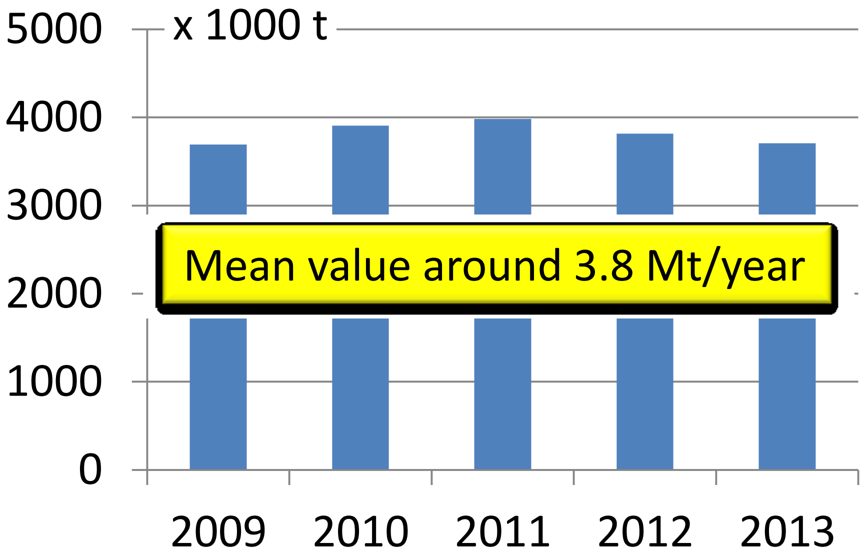
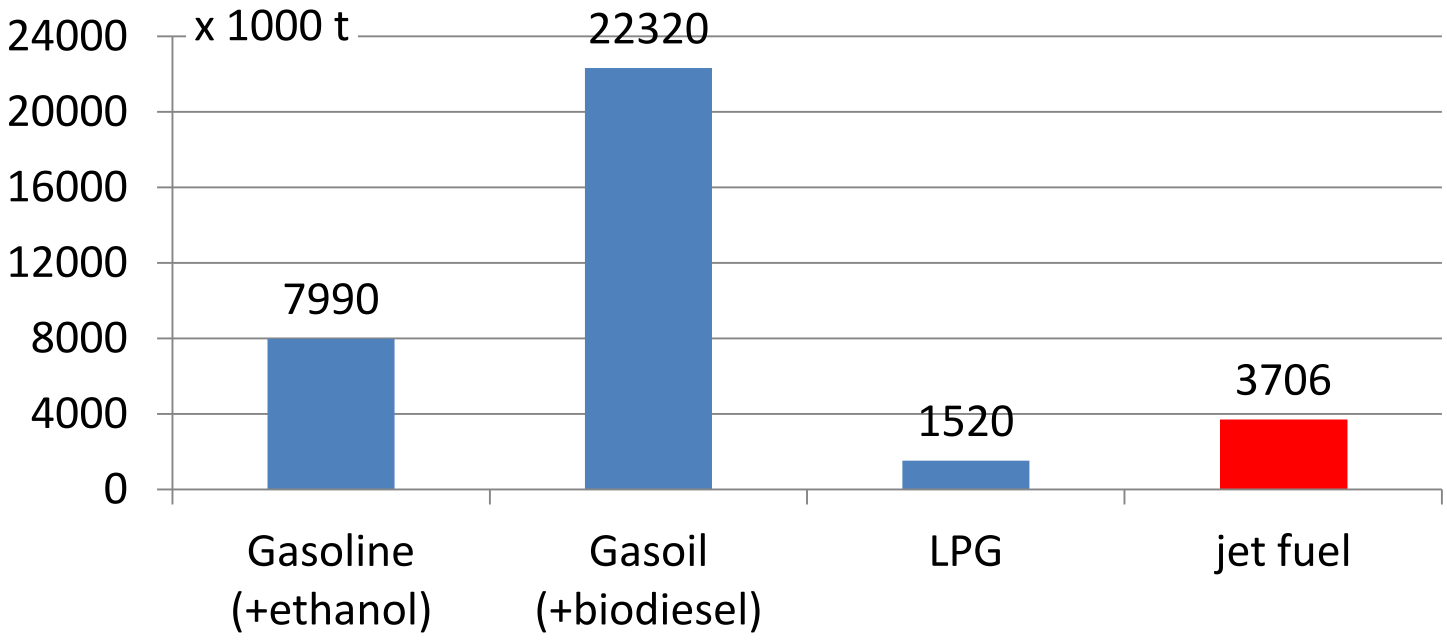


Source: Ministry of Economic Development, 2014

Fuel consumption in Italy (2013)



Source: Ministry of Economic Development, 2014

Biofuels and other RES consumption in the Italian transport sector (ktoe)

	2009	2010	2011	2012
Bioethanol / bio-ETBE	92	122	114	103
- of which from non-food feedstock	0	0	7	3
- of which imported	51	50	50	45
Biodiesel	1,052	1,297	1,296	1,262
- of which from non-food feedstock	38	38	57	338
- of which imported	346	592	764	1,009
Electricity from RES	145	153	175	186
- of which for road transport	0	4	5	5
Total consumption	1,289	1,617	1,575	1,552
% RES on total consumption (with multiple counting)	3.69	4.58	4.69	5.84
Mandatory RES % on total consumption	3	3.5	4	4.5

Source: Ministry of Economic Development, 2013

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Source: Ministry of Economic Development, 2013

Biofuels in Italy

- Widespread use in road transport, mainly for biodiesel (1,429,000 t in 2012)
- Mainly imported (81.3% biodiesel in 2012) or made from imported feedstock
- Plant capacity underutilized (only 12.5% for biodiesel industry in 2012)
- About 25% from non-food feedstock

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New markets and opportunities

- Increasing use expected for electricity (from RES) in private road transport (cars), but …
- For transport systems requiring high energy density (mainly aviation, but also marine shipping and long distance trucking), there are no realistic alternatives to liquid fuel
- Such transport systems are uniquely dependent on biofuels for RES alternatives

Biofuels for aviation

- Bioethanol and biodiesel suitable, at a low blending rate with conventional fuels, only for small planes and UAVs (unmanned aerial vehicles) with internal combustion engines, but …
- Because of their chemical properties, these biofuels do not fulfill key jet fuel requirements such as stringent cold flow viscosity and energy density specification

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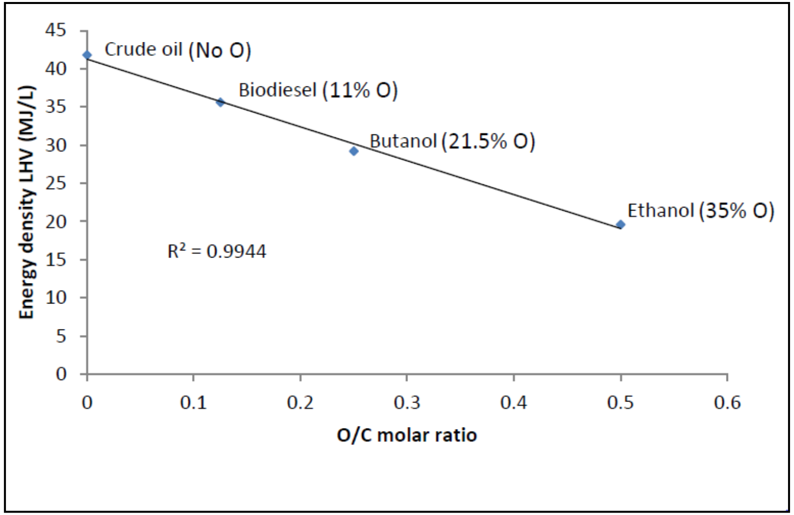
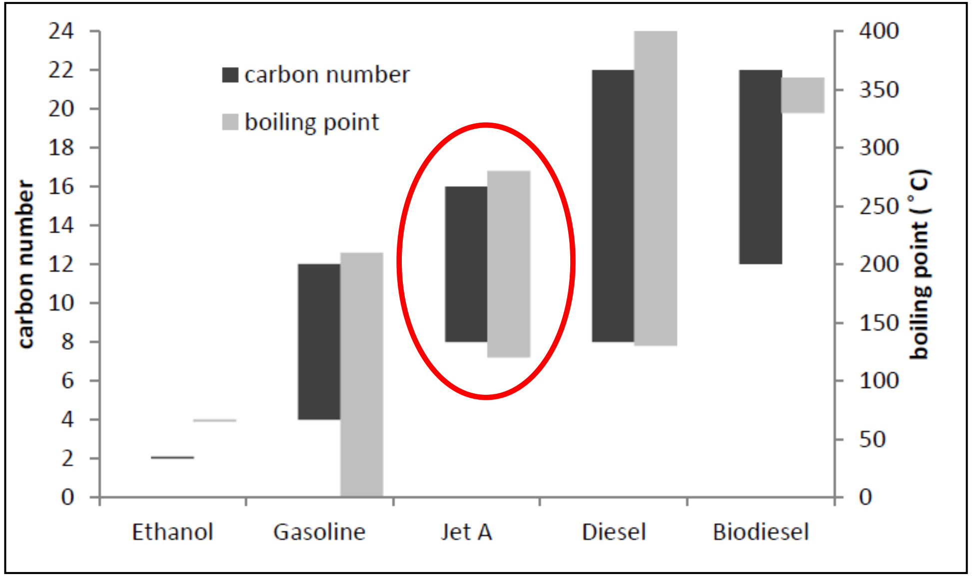
Key features of fuels and biofuels



Effect of oxygen content on the energy density of liquid fuels



Carbon number and boiling point range of commercial transportation fuels

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Source: IEA Bioenergy Task 39, 2014

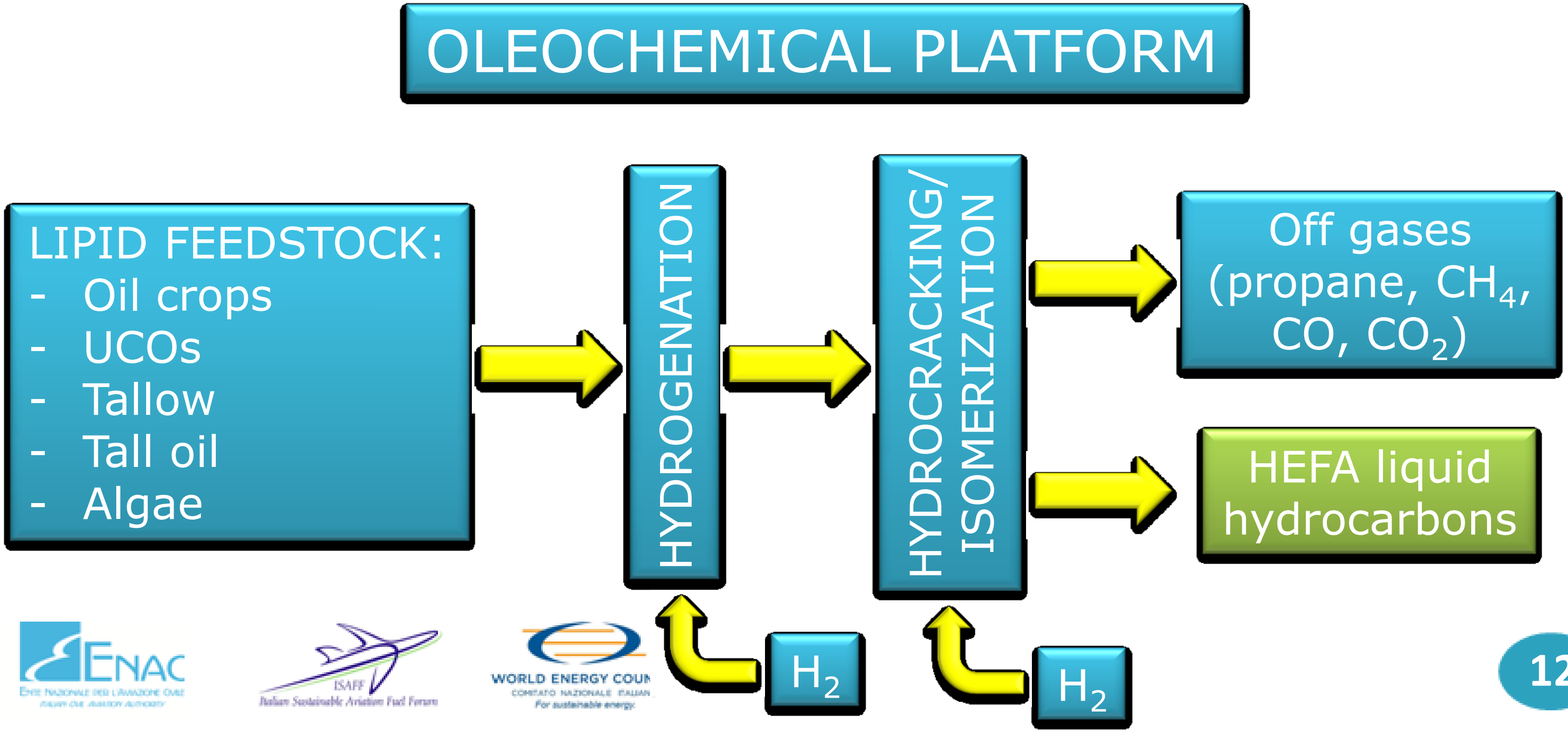
Drop-in biofuels

- To replace jet fuel, we need for a new generation of “drop-in” biofuels, namely:

“Liquid bio-hydrocarbons that are functionally equivalent to petroleum fuels and are fully compatible with existing petroleum infrastructure”

Source: IEA Bioenergy Task 39, 2014

Drop-in biofuels production pathways



Production capacity of HEFA drop-in biofuels

Company	Feedstock	Facilities	Capacity (t/year)
Neste Oil	Palm oil	3	1,973,000
Diamond Green Diesel	Tallow	1	428,000
Emerald Biofuels	Tallow	1	268,000
Dynamic Fuels	Tallow	1	236,000
Conoco Phillips	Soy oil	1	43,000
Sun Pine	Tall oil	1	83,000
World Total		8	3,031,000

Source: IEA Bioenergy Task 39, 2014

Neste Oil Corporation HEFA biofuels plant in Singapore, 2010

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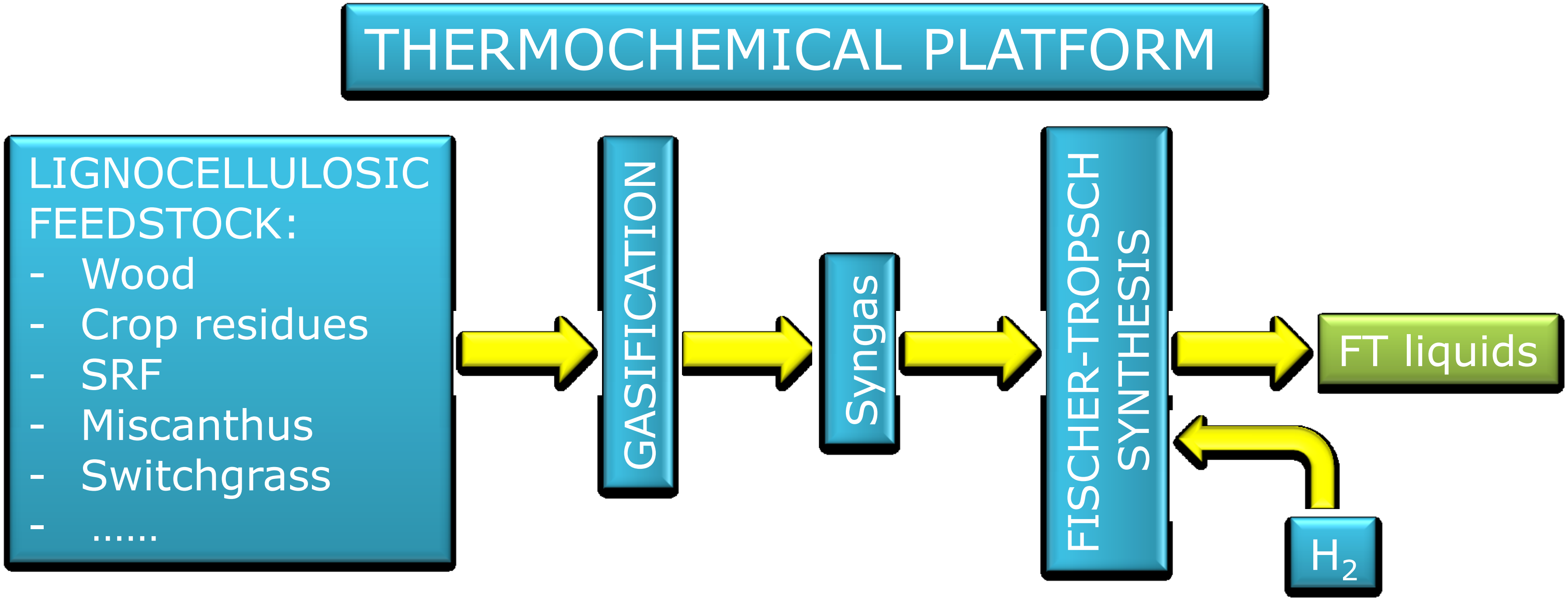
World Total		8	3,031,0

Source: IEA Bioenergy Task 39, 2014

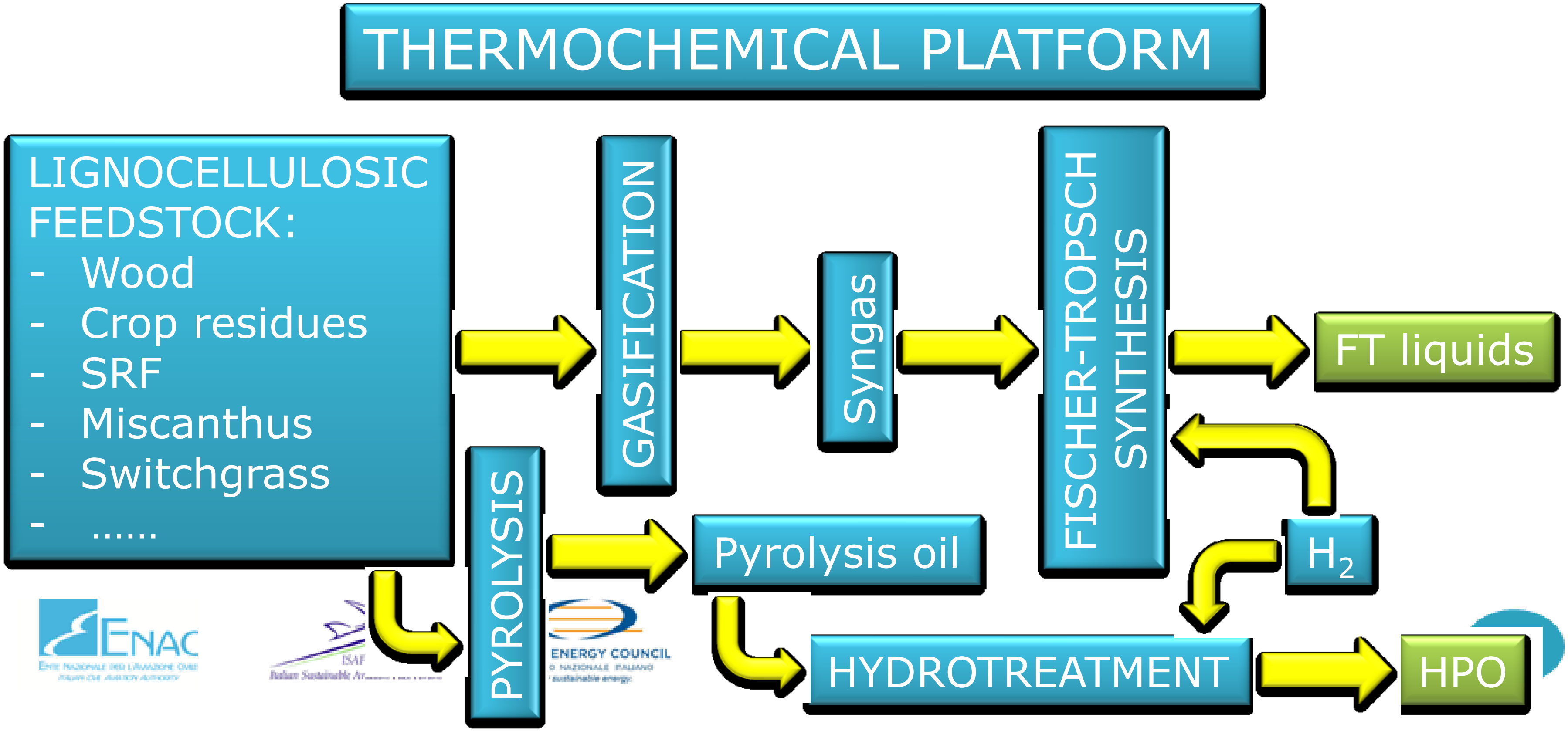
Corresponding to about 3.8 Mt of lipid feedstock

Neste Oil Corporation HEFA biofuels plant in Singapore, 2010

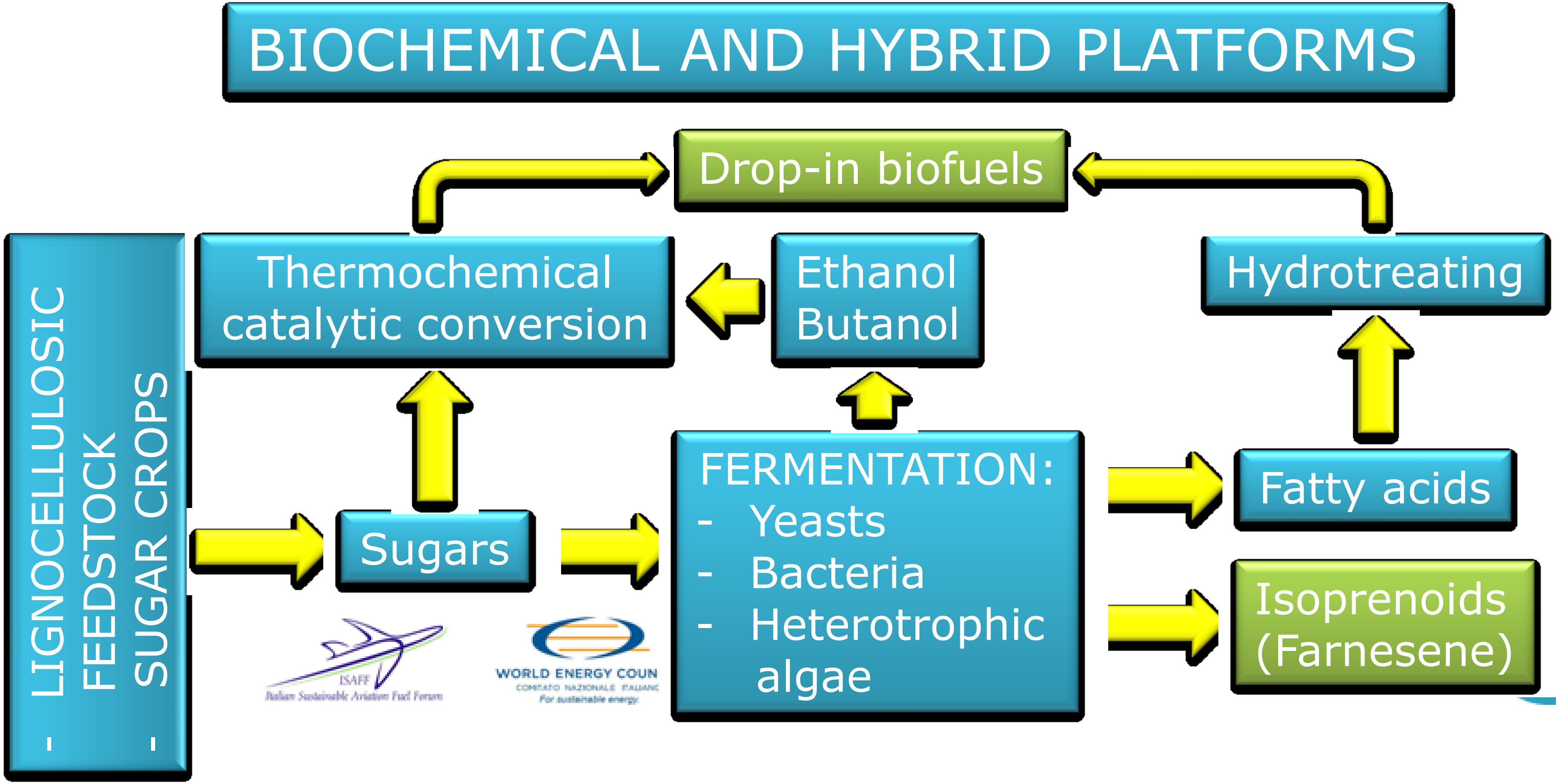
Drop-in biofuels production pathways



Drop-in biofuels production pathways



Drop-in biofuels production pathways



Feedstock availability in Italy

- Two possible pathways taken into account:
- HEFA biofuels production from lipid feedstock (developed technology, industrial facilities already operating)
- Fischer Tropsch liquids (BTL) production from lignocellulosic feedstock (technology near to the market deployment, at pilot/demonstration plant stage)

Feedstock for HEFA biofuels

- Raw materials currently available in Italy:
  - Used cooking oils (UCOs) and tallow / inedible fats from slaughter houses
  - Conventional oil crops (rapeseed, sunflower, soybean)
- Possible future feedstock
  - Non-food oil crops (Abyssinian mustard, castor-oil plant, tobacco, cardoon …)

UCOs production and availability

- Estimated UCOs production: 280,000 t/year
  - 20% from restaurants
  - 30% from food industry
  - 50% from domestic cooking

Bin for collecting UCOs from domestic cooking in Castelfidardo (AN), 2009

Source: CONOE, 2012

UCOs production and availability

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  - 20% from restaurants
  - 30% from food industry
  - 50% from domestic cooking

- **About 100,000 t/year recovered, 50% for biodiesel production**

Bin for collecting UCOs from domestic cooking in Castelfidardo (AN), 2009

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Source: CONOE, 2012

Tallow and inedible fats availability

- No reliable statistical data for tallow, included into the general category “animal derived by-products”

- All the separately recovered tallow is used as “bioliquid” for producing renewable electricity

Jet fuel from waste lipids

- Tallow and other animal fats not available
- UCOs recovery difficult, and several competitive uses (biodiesel, electricity, chemical industry)
- From a theoretical point of view, by recovering and using 50% of Italian UCOs as a feedstock for HEFA biofuels production, it could be possible to produce about 16-18,000 t/year of jet fuel (0.4 - 0.5% of the total consumption)

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Feedstock availability from oil crops

- Statistical data incomplete and outdated

Vegetable oils production and market in Italy (2011) (*)

Crop	Imported oil (t)	Production (t)	Cultivated area (ha)	Area for energy uses (ha)	Estimated oil for energy uses (t)
Rapeseed	214,473	13,200		6,000	1,400
Sunflower	291,381	98,400		14,100	10,500
Soybean	339,776	75,480		9,900	8,100
Total	845,630	187,080	280,000	30,000	20,000

(*) Elaboration on data from Assitol and Italian Ministry of Agriculture - ENAMA Biomass Project, 2013

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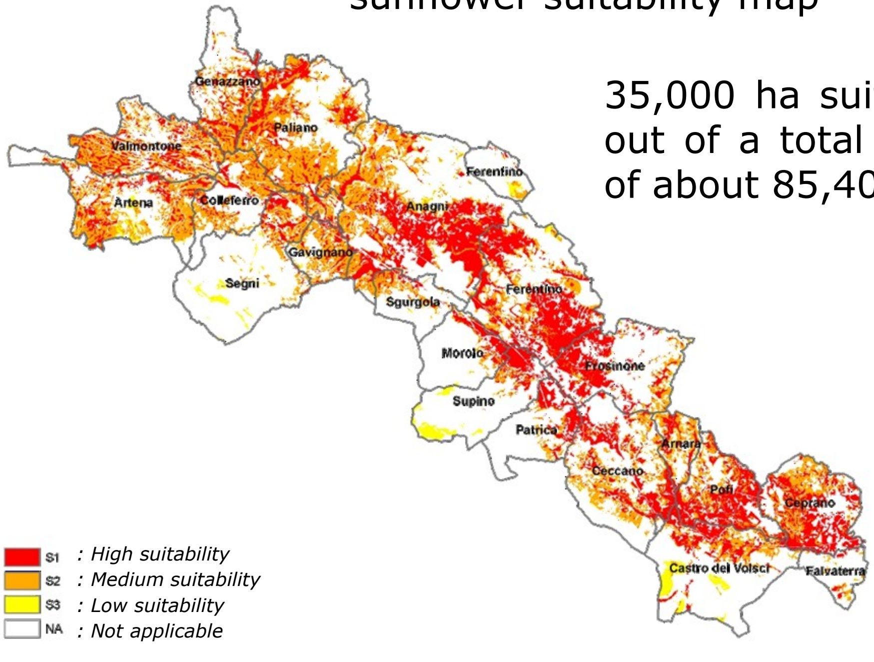
47,000 ha in 2006/2007

(*) Elaboration on data from Assitol and Italian Ministry of Agriculture - ENAMA Biomass Project, 2013

Feedstock availability from oil crops

Possible increasing o
crop area for energ
purposes by usin
marginal, degrade
or polluted land, no
suitable for foo
production

"Valle dei Latini" district: sunflower suitability map



35,000 ha suitable out of a total area of about 85,400 ha

Source: ENEA, 2008

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Feedstock availability from oil crops

- Increasing national production of oil from conventional crops difficult, because of economic reasons (highly variable prices) and request for competitive uses (biodiesel, electricity, chemical industry), but …
- also by increasing tenfold the production of non-food oils, it could be possible to produce only 23-25,000 t/year of jet biofuel (0.6 - 0.7% of the total consumption)

EU biofuels policy developments

- New targets for GHG reduction and RES share in 2030:
  - GHG: from 20% (2020) to 40%
  - RES: from 20% (2020) to ≥ 27%
- Transport is fully integrated in the 2030 GHG reduction and RES targets, but no longer specific targets for transport, as 10% for 2020

Biofuels sustainability legislation revision (ILUC proposal)

European Council's position 13 June 2014	
Cap	**7%** food crop based towards the 10% target for 2020
Sub-targets	Non legally binding sub-target of **0.5%** advanced biofuels (excluded UCO/TME)
Multiple counting	**2x** – non-food cellulosic materials and lignocellulosic materials, including UCO and animal fats **5x** – RES-E in road transport (2,5% now) **2,5x** – RES-E in non-road transport
ILUC factors	ILUC factors to be included **only for reporting** by the Commission, and not for assessing regulatory compliance **December 2017**: review of both, effectiveness of measures and best available science on ILUC factors

EU biofuels policy developments

- In the view of the Commission, food-based biofuels should not receive public support after 2020
- Focus on non-food, low input crops with high GHG saving
- Focus on second and third generation biofuels with low or no ILUC

Possible new feedstock for HEFA biofuels

- Non-food oil crops
  - Abyssinian mustard
  - castor-oil plant
  - tobacco
  - cardoon
- Widespread field trials and some examples of production for industrial uses

Abyssinian mustard (*Brassica carinata* L.) cultivation for biodiesel production in Sicily, 2008

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Estimated land use for producing jet fuel from some non-food oil crops

- Production of 38,000 t/year of jet fuel (1% total consumption) could require:
  - 422,200 ha of agricultural land for Abyssinian mustard
  - 703,700 ha for cardoon
- Very low productivity per hectare, as a direct consequence of the very low oilseed yield (reference values: 2.5 t/ha seed, 30% oil for Abyssinian mustard; 1.5 t/ha seed, 30% oil for cardoon)

Oil vs lignocellulosic crops

- Jet fuel (or any other biofuel) yield from oil crops very low because of:
  - Low production of useful feedstock (max about 2.5 t/ha of seeds, generally < 1 t/ha)
  - Low oil content in the seeds (max about 45-50%, generally ≤ 30%)
- Lignocellulosic crops are most suitable because it is possible to use all the produced biomass (yield ranging from 15 to 30 t/ha or more)

Lignocellulosic feedstock for jet fuel production by FT liquids

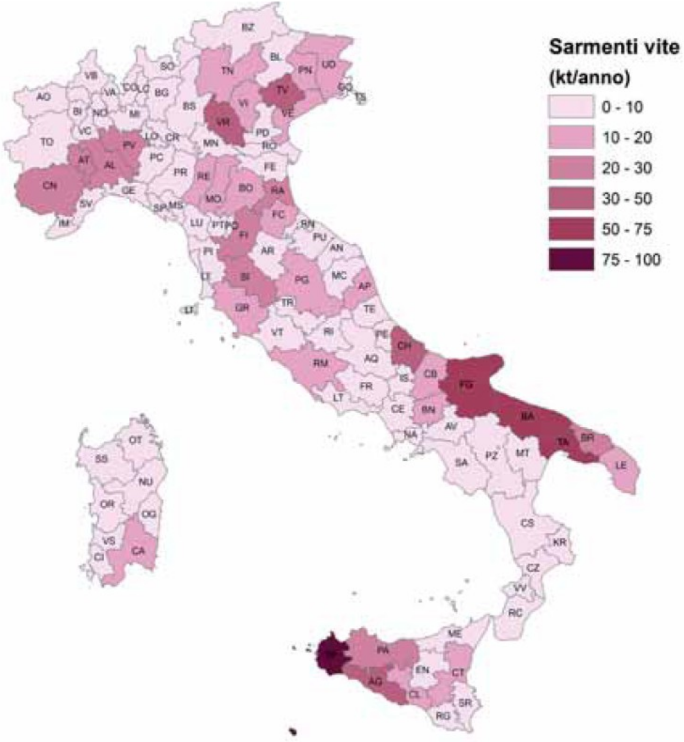
- Lignocellulosic biomass currently available in Italy:
  - Wood and wood residues (SRF, forest maintenance, sawmills and other wood industries)
  - Agricultural residues (pruning, straw, stalks, cobs …)
- Possible future feedstock
  - Lignocellulosic herbaceous crops (sorghum, giant reed, miscanthus, switchgrass, cardoon …)

Availability of lignocellulosic biomass

Biomass source	Estimated suitable amount (Mt/year)
Wood from forestry and/or forest maintenance	2 - 3
Wood from pruning of vine, olive and fruit trees	1.6
Cellulosic residues from herbaceous crops	3.7
Total	7.3 - 8.3

Source: Ministry of Agriculture - ENAMA Biomass Project, 2013

Availability of vine pruning in Italy



Source: Ministry of Agriculture - ENAMA Biomass Project, 2013

Region	Vine pruning (t/year d.m.) (2010)
Piemonte	77,772
Valle d'Aosta	857
Lombardia	35,116
Trentino - A. Adige	20,643
Veneto	109,643
Friuli V.G.	29,364
Liguria	2,965
Emilia - Romagna	87,497
Toscana	89,062
Umbria	20,457
Marche	27,375
Lazio	35,913
Abruzzo	47,224
Molise	10,859
Campania	38,885
Puglia	215,584
Basilicata	10,251
Calabria	18,508
Sicilia	192,037
Sardegna	53,420
Total Italy	**1,123,372**

Availability of lignocellulosic biomass for biofuel production

- Lignocellulosic residues not suitable because of:
  - different chemical composition and properties
  - dispersion on the land (difficulties and costs in collecting and delivering)
  - competitive uses (domestic and district heating, CHP and electricity production)

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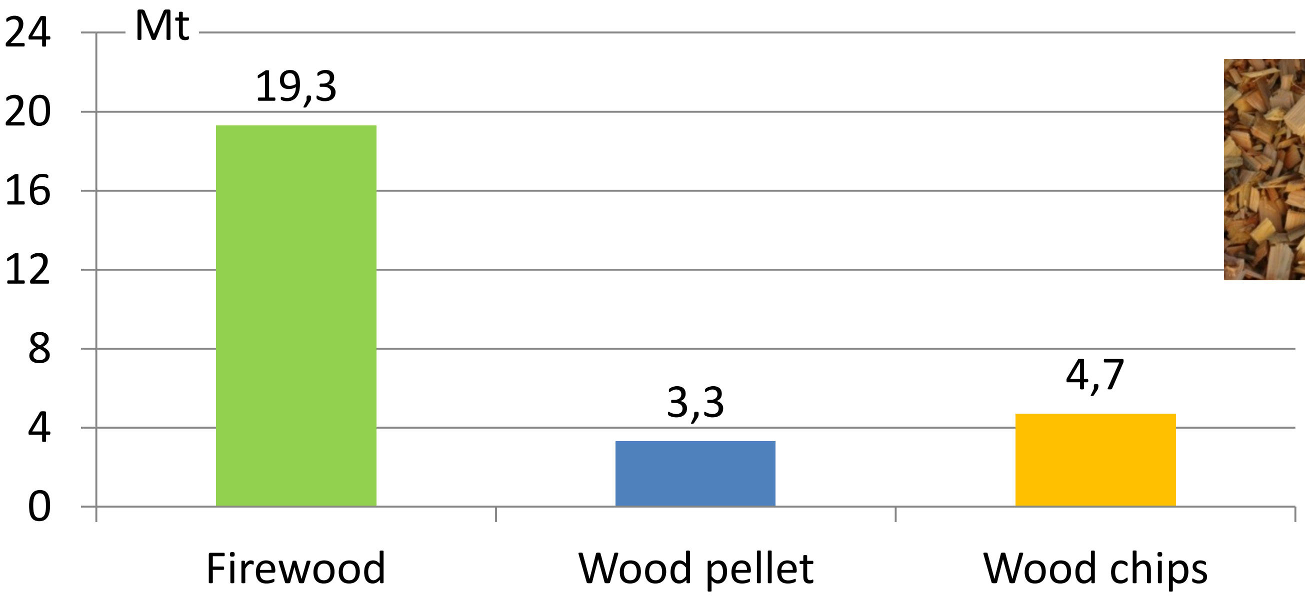
Wood fuel consumption in Italy (2013)



Source: AIEL, 2014

Possible new lignocellulosic feedstock

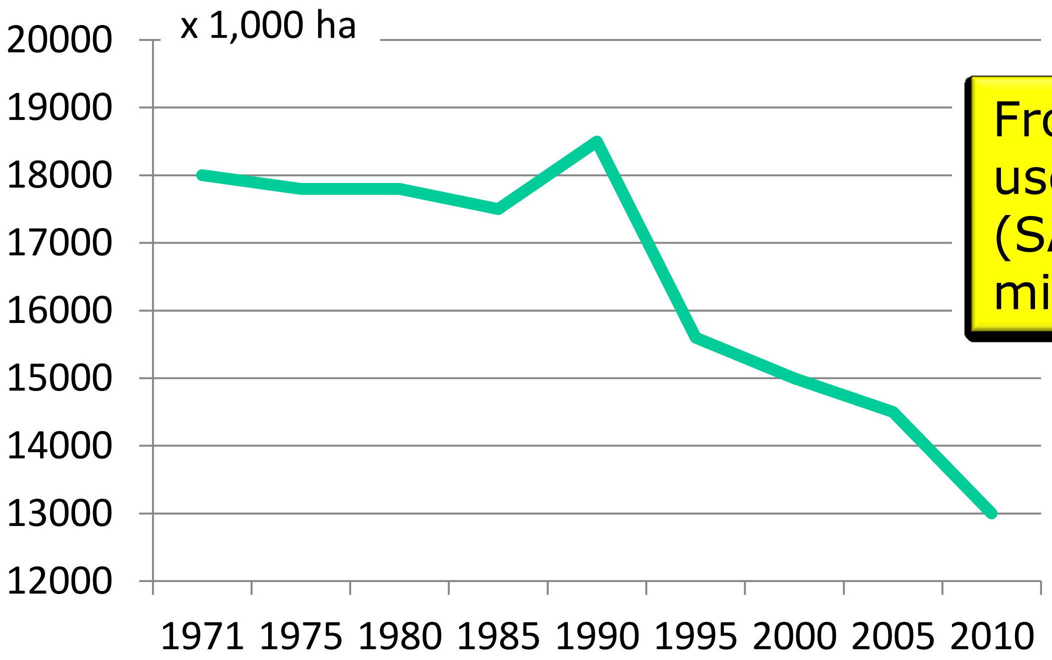
- Annual herbaceous crops:
  - Sorghum, hemp, kenaf, …
- Perennial herbaceous crops:
  - Reed, miscanthus, cardoon, switchgras, …
- Woody crops
  - Poplar, black locust, eucalyptus, willow, paulownia, …

Availability of lignocellulosic feedstock

- Energy crops are the only reasonable way for producing jet fuel (or other biofuels) from lignocellulosic feedstock because of:
  - Quality, certainty of supply, better use of agricultural land (but also possibility to use marginal lands)

- How much land is available for this purpose?

The agricultural land loss in Italy



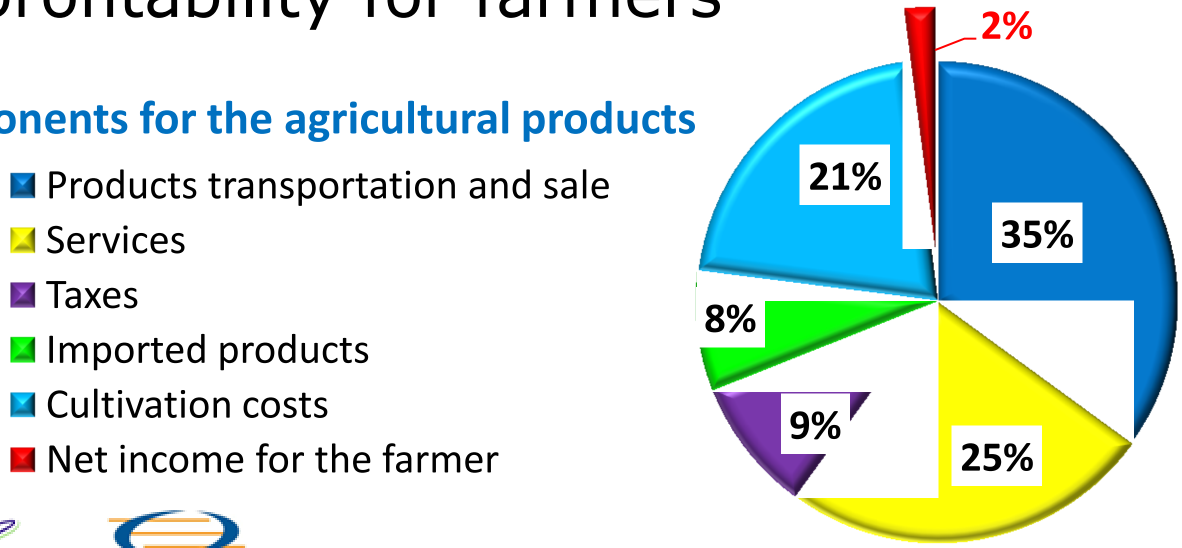
From 1971 to 2010 the used agricultural surface (SAU) was reduced by 5 million hectares (- 28%)

Source: Italian Ministry of Agriculture, 2012

The reasons for the abandonment

- The growth of built-up areas
- The poor profitability for farmers

Main cost components for the agricultural products



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Source: Agrosserva, 2013

Estimated jet fuel production from lignocellulosic feedstock

- Estimated jet fuel production ranging from 0.4 to 1.2 t/ha
- As a consequence of the matter the production of 38,000 t/year (1% of current consumption) could require from 95,000 to 32,000 ha
- Lignocellulosic crops on 500,000 ha (10%) of abandoned agricultural land could replace from 5 to 15% of the present requirements

Conclusions

- In Italy there is land available for replacing a significant amount of the current consumption of jet fuel with biofuel produced from lignocellulosic crops
- It is necessary to establish a strong partnership between farmers and industry, promoting the creation of new sustainable bioenergy chains

Thank you for the attention

Vito Pignatelli
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