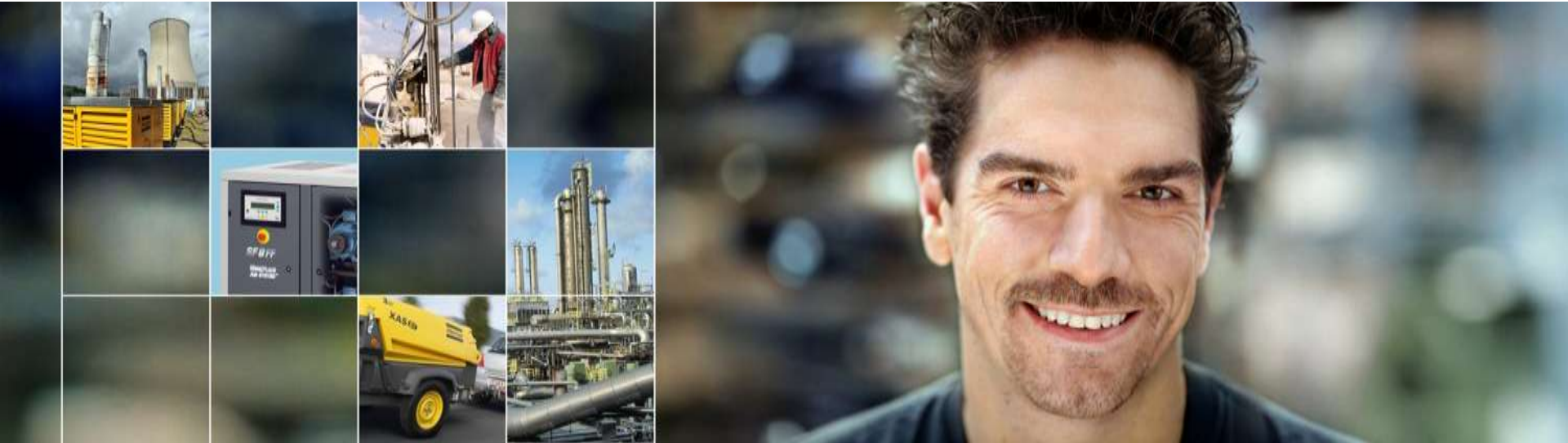


From Waste To Wheels Biogas Creating The Future



ExCo67 Workshop

May 10, 2011

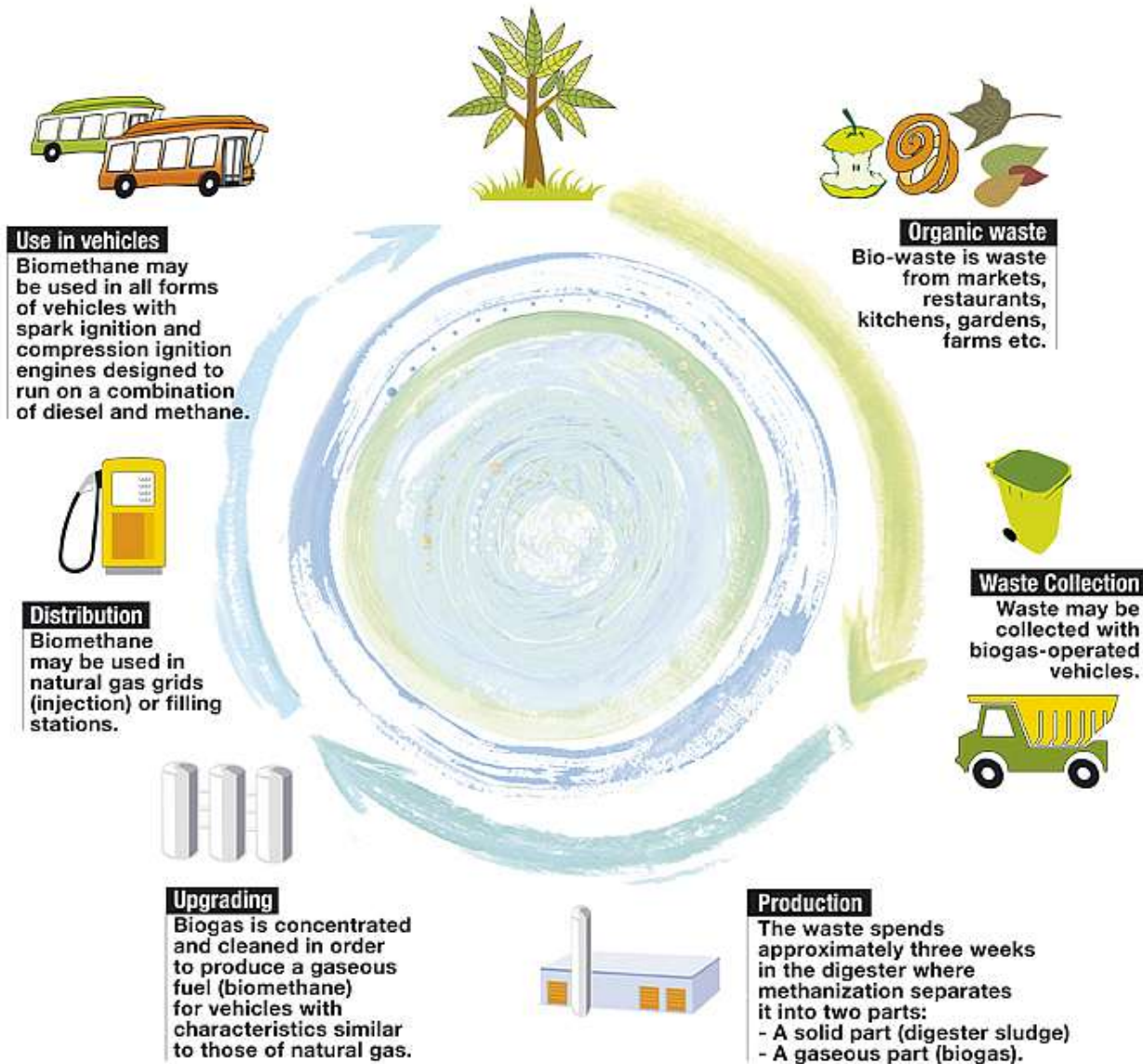
Sustainable Productivity



From waste to clean fuel

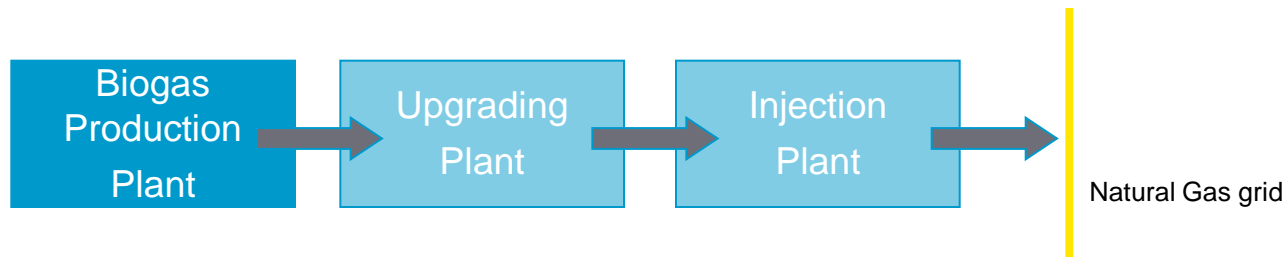
- Climate concerns and dwindling fossil fuel resources are driving an increasing demand for renewable energy solutions.
- Many countries have passed legislation to increase the use of renewable energy sources.
- Some examples of renewable energy technologies:
 - solar energy
 - windpower
 - biogas and biomethane
- Biomethane offers a unique opportunity to integrate waste management solutions with the production and use of a clean burning, low carbon, fuel which can also be used as a nonfossil renewable vehicle fuel.

Renewable Energy Solutions



Biogas production is a natural process

- Biogas is produced by the degradation of organic matter in the absence of oxygen (anaerobic digestion).
- This degradation, also referred to as methanization, occurs in natural areas like swamps or in controlled areas like landfill containing organic waste.
- Methanization can be artificially controlled by fermenting sewage sludge, organic waste from households, food industry, restaurants, gardens etc.. (anaerobic digestion).
- This raw biogas comprises mainly of methane and carbon dioxide, but also contains small amounts of hydrogen sulfide (H₂S) and ammonia



Efficiency and ecology

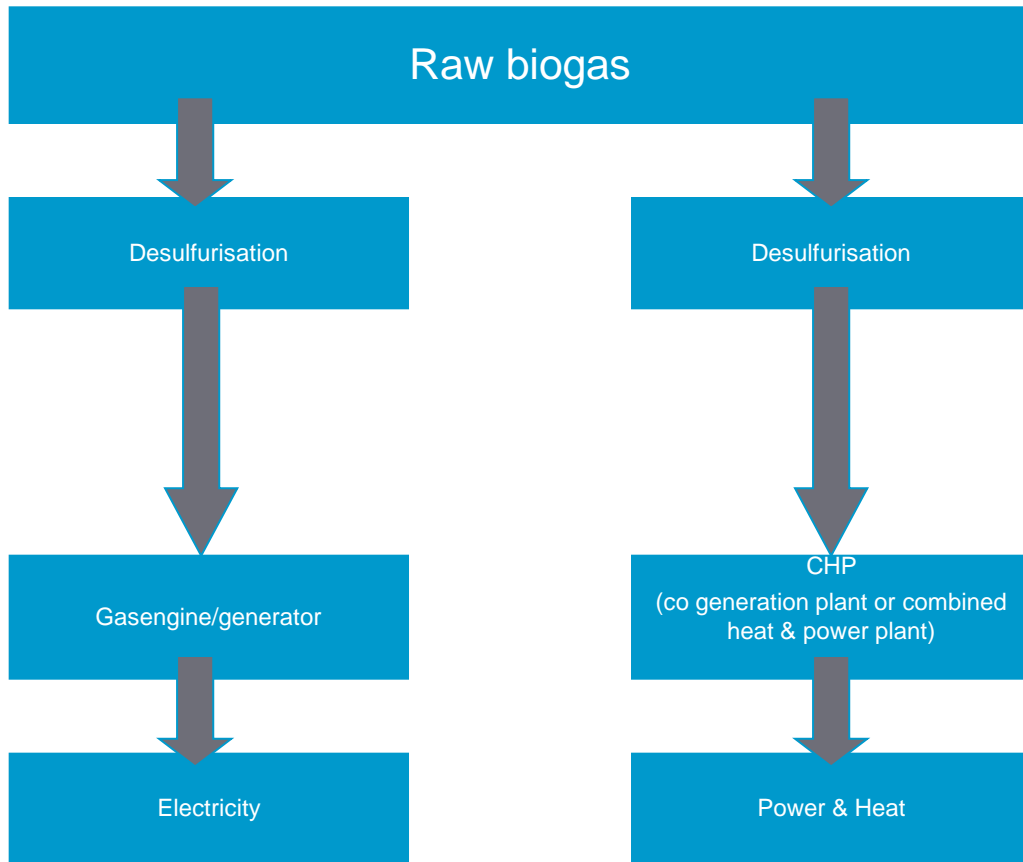
Efficient reduction of greenhouse gases

- The environmental aspects are unquestionable, since it is not a fossil fuel and therefore it does not add greenhouse gases to the atmosphere.
- The use of landfill for biogas production can even lead to a reduction of CO₂ emissions as methane leaks to the atmosphere are prevented (methane has a 23 times greater greenhouse gas effect than CO₂)

Pure facts

- The energy content of 1 m³ of raw biogas (with 65% methane content) is equivalent to approximately 6.5 kWh.
- One liter of oil contains approximately 10 kWh.
- Which means that about 1.5 m³ of raw biogas is needed to replace one liter of oil.

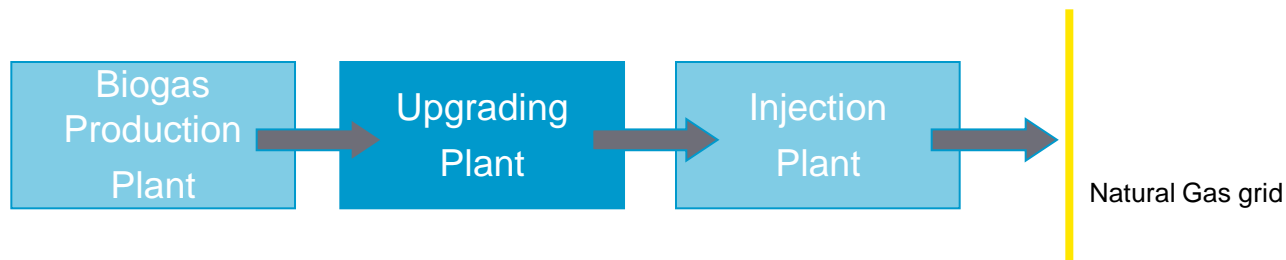
Use of biogas



- In the majority of cases biogas was only used for electricity production.
- The production of heat which represents some two thirds of biogas energy output, remained unused in many cases due to lack of viable heat-related applications in or near site areas

From raw biogas to biomethane

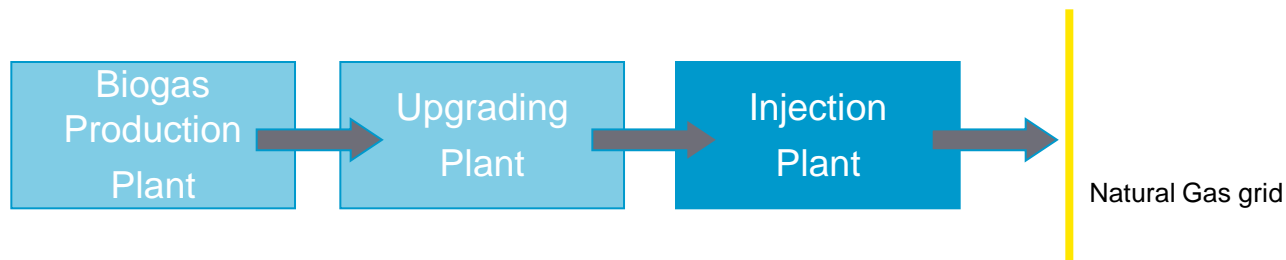
- The raw biogas can be upgraded to natural gas quality by separating the hydrogen sulfide (H₂S) water and carbon dioxide (CO₂)
- The upgrading can be done via water scrubbing, amine washing, PSA (pressure swing adsorption) or cryogenic processes.
- This upgraded biogas has per m³ an energy content of approx. 10 kWh, which is equivalent to one liter of oil.



Biomethane every where

Can be used independently of its production location

- Compressed, stored in tanks and transported to point of use, or..
- Biomethane can also be fed into the natural gas grid.
- An injection plant is required, consisting of, gas analyzer, calorific value adjustment, compressor and flow meter
- The gas can be used anywhere else in electricity production, heating or petrochemical sectors.
- Or as renewable environmental friendly vehicle fuel.



A clean alternative

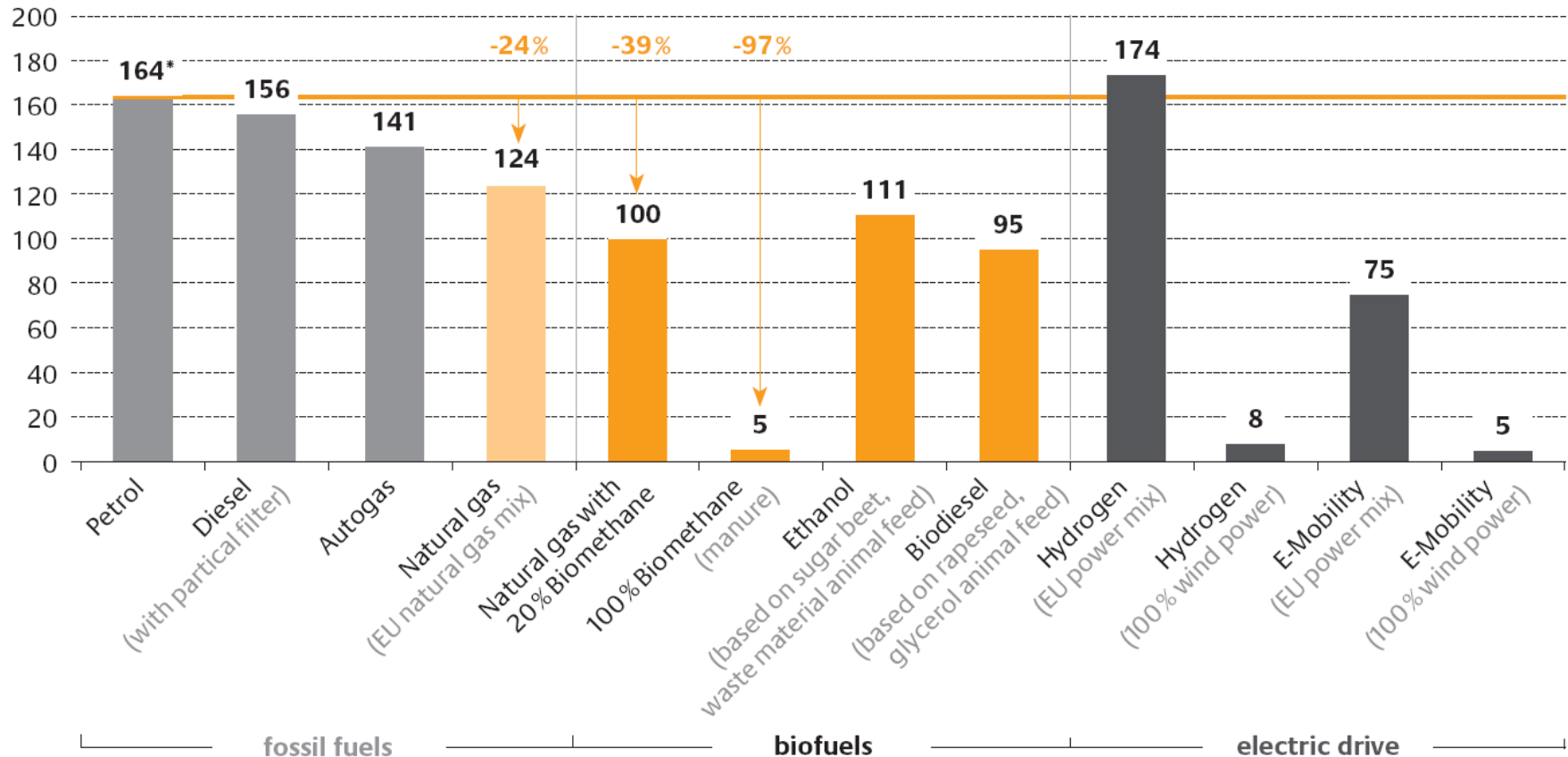
Biomethane the clean alternative to petrol and diesel

- Human activities, in particular transport, are partially responsible for the problems associated with the greenhouse effect and therefore global warming.
- Carbon dioxide CO₂ is a main contributor to greenhouse gases
- Fossil fuel combustion (petrol, diesel, kerosine, gas...) emits annually more than three billion tons of CO₂ into the atmosphere.
- Vehicle gas fuel (biomethane, natural gas or mixture of both) can replace traditional vehicle fuels.
- Switching from petrol and diesel to vehicle gas can reduce CO₂ emissions by up to 30% for natural gas to about 95% for biomethane
- The most environmentally harmful compounds (particles, non methane hydrocarbons) are absent when biomethane is used.
- For example, using biomethane as a fuel in buses leads to a reduction of 80% in particles, 80% in sulfur compounds and 70% in nitrogen oxide, as compared to diesel buses.



Clear reduction of CO2 footprint

WTW GHG emissions in g CO₂ eq./ km



* reference vehicle: gasoline engine (induction engine), consumption 7 l per 100 km

Public transportation

Picture from Nov.1998, China



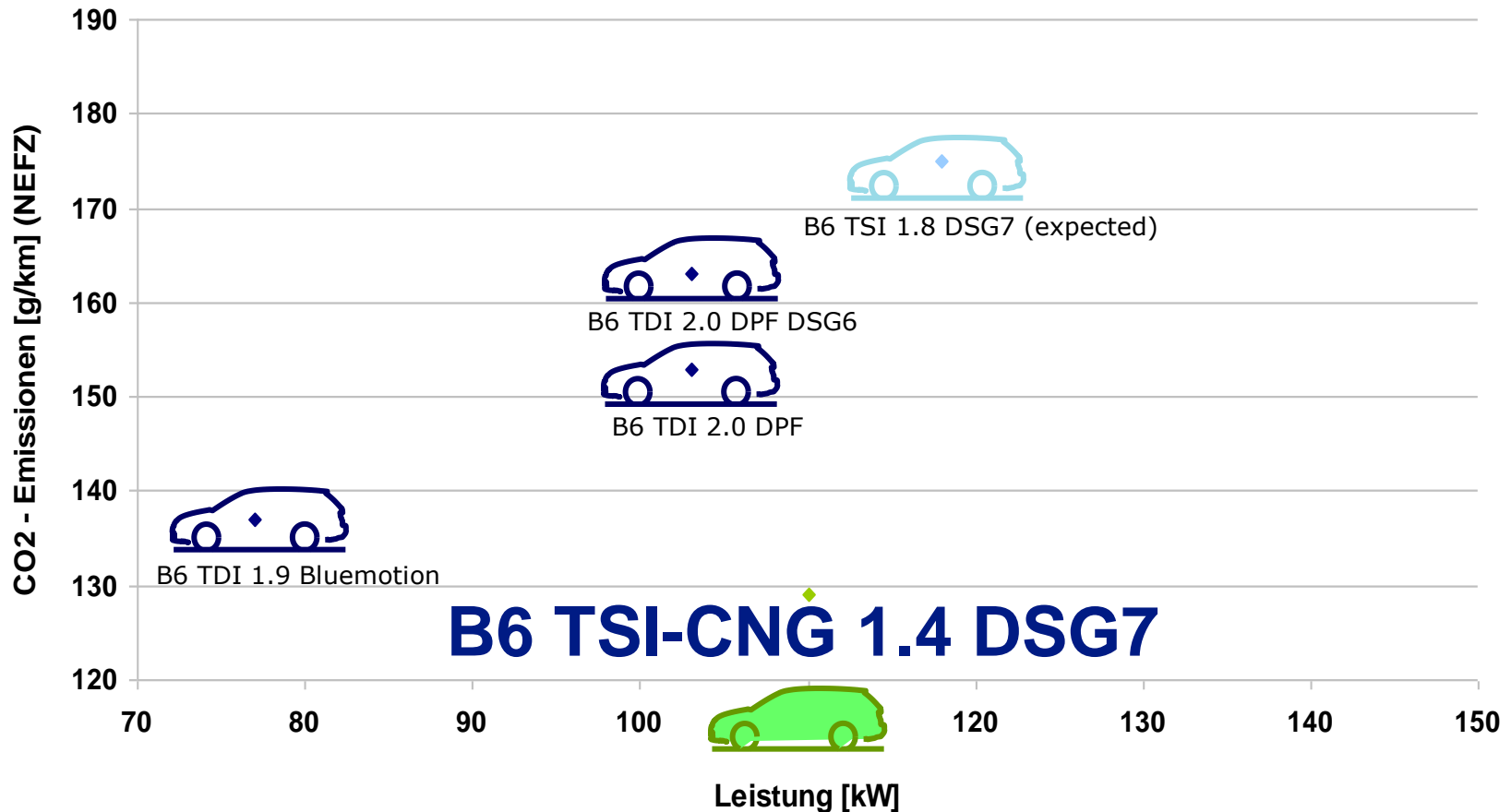
Atlas Copco

VW-Scirocco



CO2 Emissions

VW Passat - Different Engine/fuel Options



On biomethane = carbon neutral





Efficient Cars - Passat TSI EcoFuel

VW Passat 1.4 TSI EcoFuel Trendline

Viertürige Stufenhecklimousine der
Mittelklasse (110 kW / 150 PS)

Nun ist es soweit: der Passat TSI EcoFuel erreicht als erstes Auto die vollen fünf Sterne beim ADAC EcoTest. Das Erdgas-Auto bietet sehr geringe Schadstoffemissionen und zusätzlich einen geringen CO₂-Ausstoß. Der Erdgasverbrauch fällt mit durchschnittlich 4,9 l/g recht günstig für eine große Limousine aus. Die Reichweite ist mit etwa 425 km durchaus praxistauglich. Geld des Gas mal aus (21 l/g Tank), kann auch mit dem 31 l Benzintank weitergefahren werden. Vom Gasantrieb bekommt der Kunde kaum etwas mit, in beiden Betriebsarten beschleunigt der kleine 1,4-l-TSI-Motor mit Kompressor und Turbo den Passat flott, die Tanks verbergen sich unter Kofferraumboden und Rücksitzbank. Der große Kofferraum bleibt also bestehen. Das umweltfreundliche Angebot startet bei knapp 30.000 Euro - dafür bekommt man ein absolut praxistaugliches und ungewohnt flottes Erdgasauto.

Karosserievarianten: Limousine und Kombi **Konkurrenten:** mit Erdgas keine

+ erstes 5-Sterne-Auto im ADAC EcoTest, sehr gute Verarbeitung, sehr großer Kofferraum, viel Platz im Innenraum, funktionelle Bedienung, bequeme, körpergerechte Sitze, sichere Straßenlage, starker, sehr lauffruhiger Motor, niedriger Verbrauch, günstig im Unterhalt

- hinten schlechte Sicht



ADAC-URTEIL



Stand: April 2009
Text: M. Kuhnert

The Passat Ecofuel is the first and only car on the European market to achieve 5 stars in the ADAC-Eco-Test - better than a Toyota Prius. EVs have to aim to be as good in CO₂ and practicality terms

VW Caddy Eco-fuel

- Best selling CNG van in Germany, launched mid 2006
 - Built to run on CNG rather than a petrol conversion
 - Right hand drive is type approved for sale in UK
 - Also available at Caddy Maxi Car – 7 seats
 - We are working with a number of companies who make home refuelling devices that can fill with CNG overnight
 - Good financial savings, good eco outcome



EEV emissions – very low NOX and particulates.
Carbon neutral on biomethane

MB Sprinter NGT

- Mercedes Benz
 - Sprinter CNG in UK in Q2 2009
 - First time MB have designed a CNG Sprinter from 'first principles' (rather than petrol conversion):
 - Very low emissions
 - 25% less CO2 than petrol on grid gas
 - Carbon neutral on bio-methane
 - Also has petrol tank
 - Total range of 1100 km
 - Ideal for supermarket home delivery, quiet, clean, long range, fast refuelling



No Congestion Charge
Carbon neutral on biomethane

MB Econic - Tractor

- Distribution logistics
 - EEV emissions and 20% lower CO2 than diesel
 - Drive at night into cities as very quiet
 - On bio-methane, carbon neutral
- MB bringing to UK in right hand drive form
- What a great idea for supermarkets



Ideal for inner city deliveries
and loads of <36 tonne
This truck loves biomethane

Econic Refuse truck

- Refuse Trucks
 - MB Econic (see below in Malmo, running on bio-methane)
 - Also Lille



Initially on fossil CNG but migrating to CBM as ADs are developed. It has to make sense!

Iveco EuroCargo and Stralis



Dennis Eagle Dual Fuel RCV



Fossil CNG

Substitution Rate %	CO2 reduction%
50%	13.7%
55%	15.1%
60%	16.4%
65%	17.8%
70%	19.2%
75%	20.6%



Vehicle can still run on diesel – good savings on ‘fossil CNG’ – more than 50% CO2 reduction on CBM

From concept to reality – in just three years



Volvo Trucks
Environmental Affairs
14 2010-01-13



In summary – methane gas + diesel

- More methane gas available than crude oil
- Increased biogas production
- High fuel efficiency
- Over 50% greater operational range compared to traditional gas engines
- Suitable for long-haul applications with LNG
- 80% greenhouse gases reduction potential



Volvo Trucks
Environmental Affairs
15 2010-01-13



Atlas Copco

Biomethane an energy efficient renewable fuel

- A German* study has shown that a biomethane fueled car runs 3 times the distance of a car fueled with bio-diesel produced from 1 hectare of land. The distance is 50% longer when compared to ethanol.
- EUROCAR/JRC/CONCAWE'S well-to wheel analyses indicates that methane based hybride engines provide greater energy efficiency then gasoline and diesel engines

*FNR(Fachagentur Nachwachsende Rohstoffe) and BEE (Bundesverbandes Erneuerbare Energie)

Autonomy with BioFuels

from the annual earning of a hectare cultivable acreage

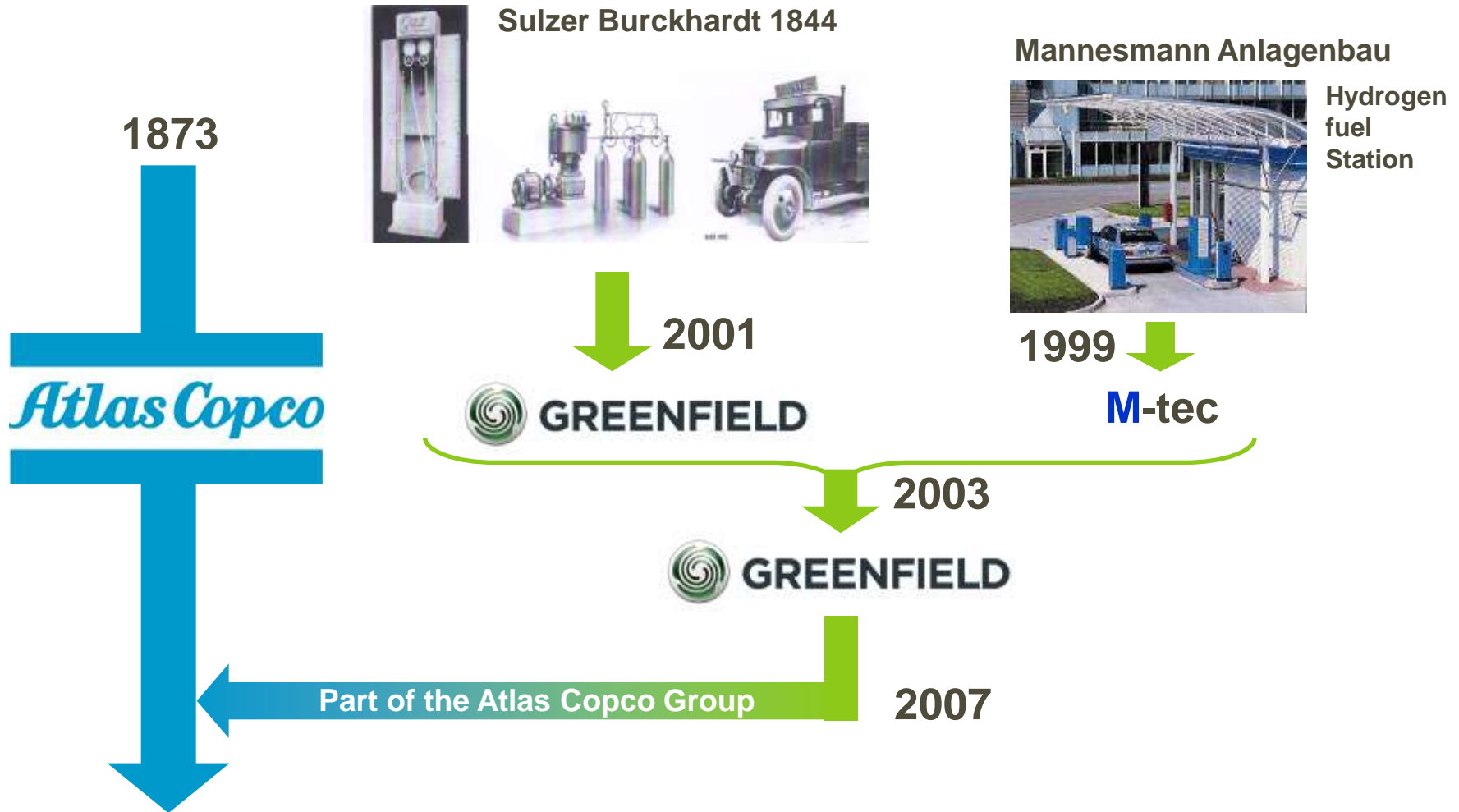
(with a consumption of 5 Liter / 100 km)



Source: Fachagentur für nachwachsende Rohstoffe e.V.



GREENFIELD's History



GREENFIELD - A strong brand in an strong group



GREENFIELD



DYNAPAC



Satisfied Customers...

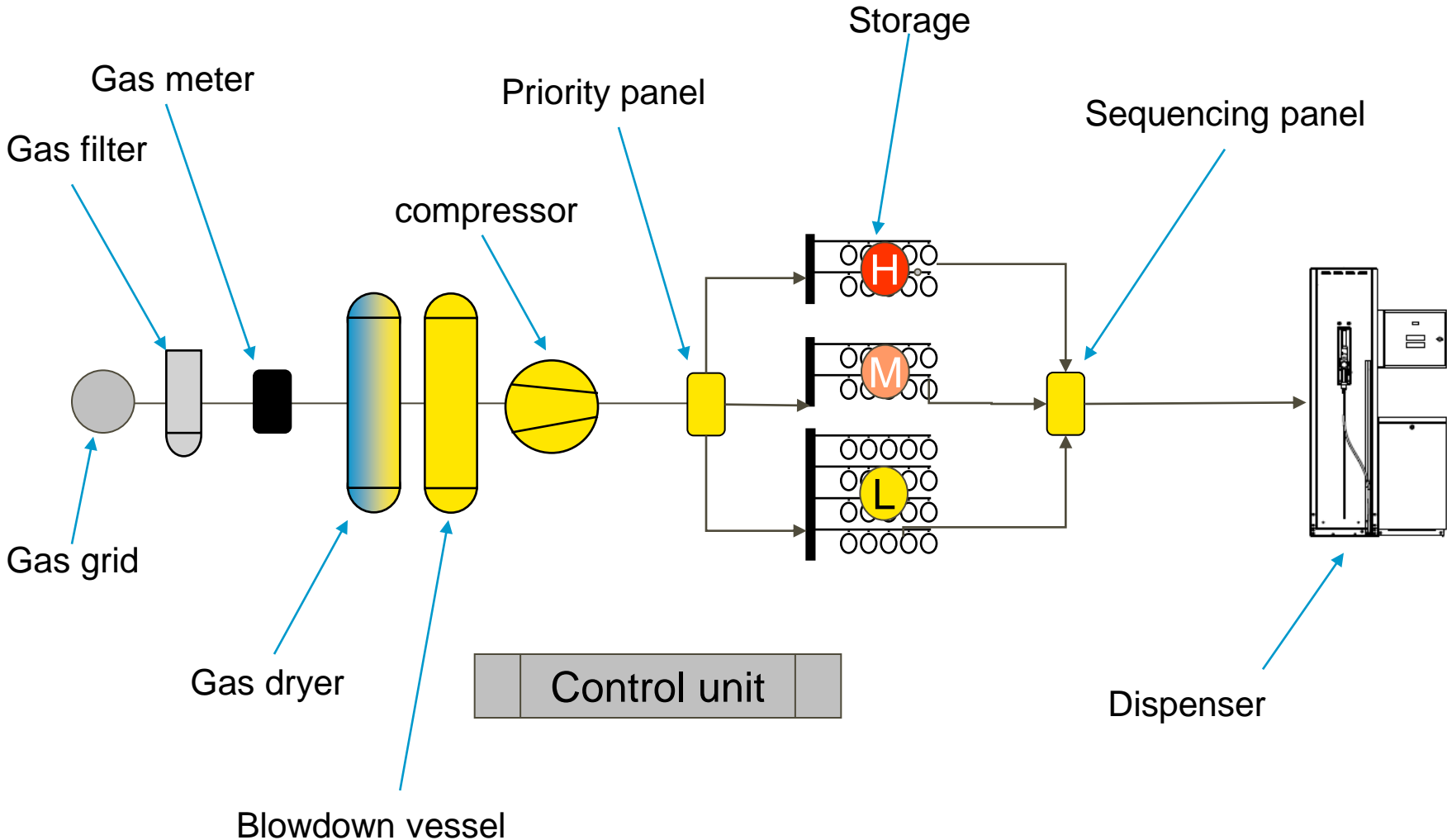


Key Figures

- Alternative Fuels Refuelling Solutions references
 - More than 1'800 installed stations
 - Where of 490 in Europe
 - In more than 40 different countries worldwide
 - First Application in 1927

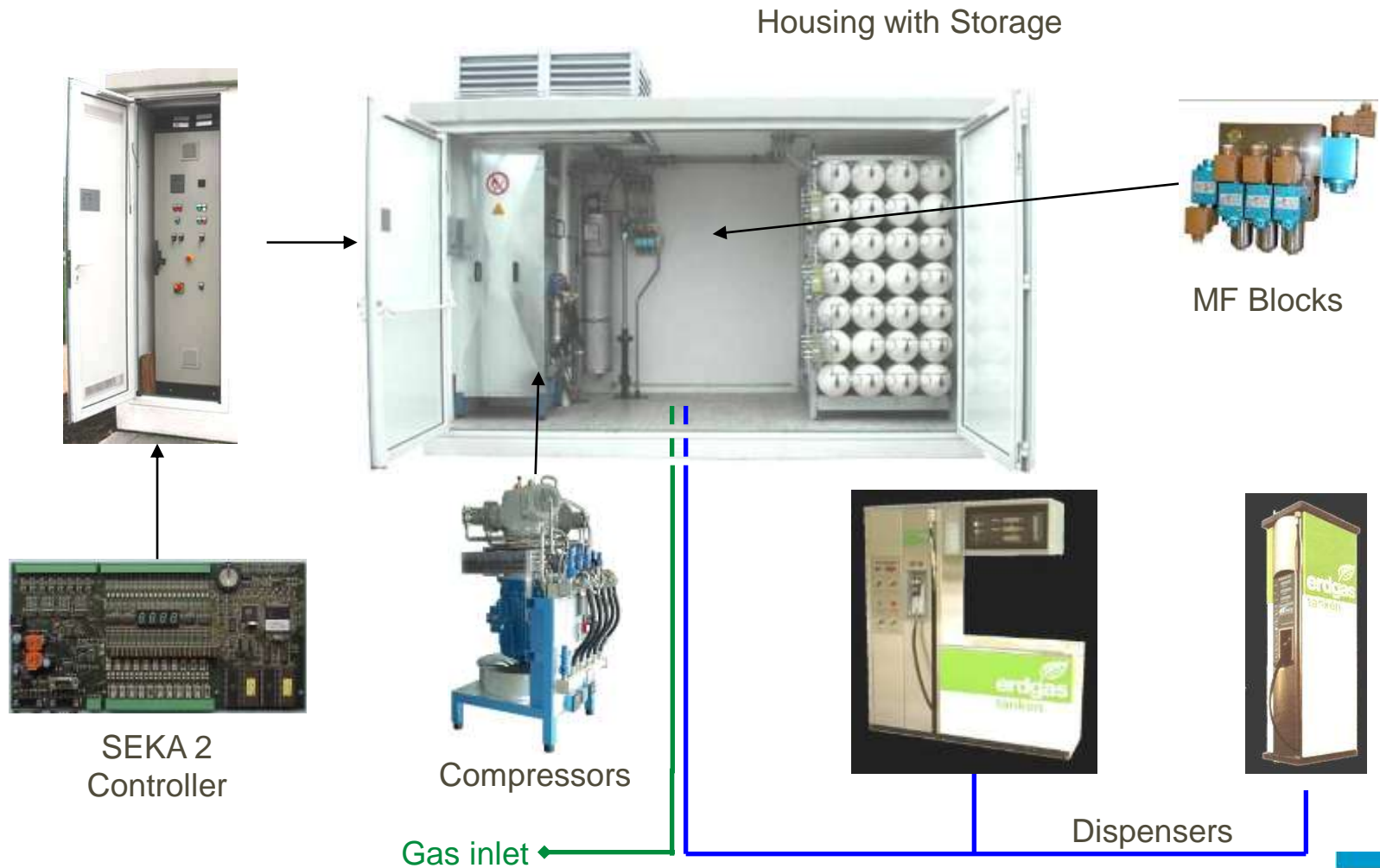
CNG-Station - basic layout

FAST - FILL



NGV Application

GreenField – the One-Stop Resource for NGV stations



Example of application:

S100 Single

Suction pressure: up to 40 bara

Delivery rate: 80–210 Nm³/h

Electric motor: 30/37 kW

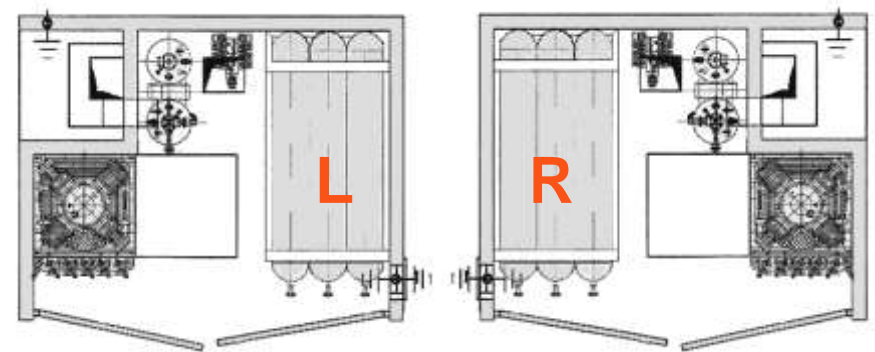
Max. pressure: > 300 bar

Gas storage: Max. of 21 gas tanks,

Total capacity: 1,7 m³

Pressure: Adjustable from 250–300 bar

Sound levels: 65 ± 3 db(A) 1m



Capacity: 50 – 100 cars/day (12h)

Footprint: only 2.8 m x 2.2m



Example of application:

S100 DUO

Suction pressure: up to 40 bara

Delivery rate: 160 – 420 Nm³/h

Electric motor: 2x 30/37 kW

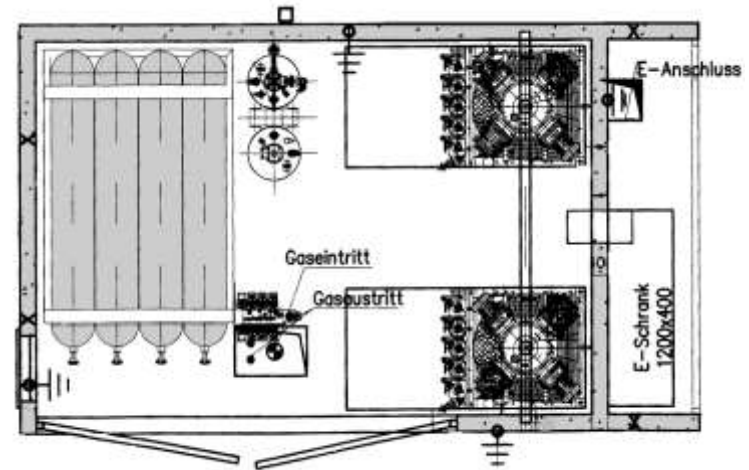
Max. pressure: > 300 bar

Gas storage: 21/28...49*) gas tanks,

Total capacity: 1,7/2,2...3,9 m³

Pressure: Adjustable from 250–300 bar

Sound levels: 65 ± 3 db(A) 1m



Capacity: 100 – 200 cars/day

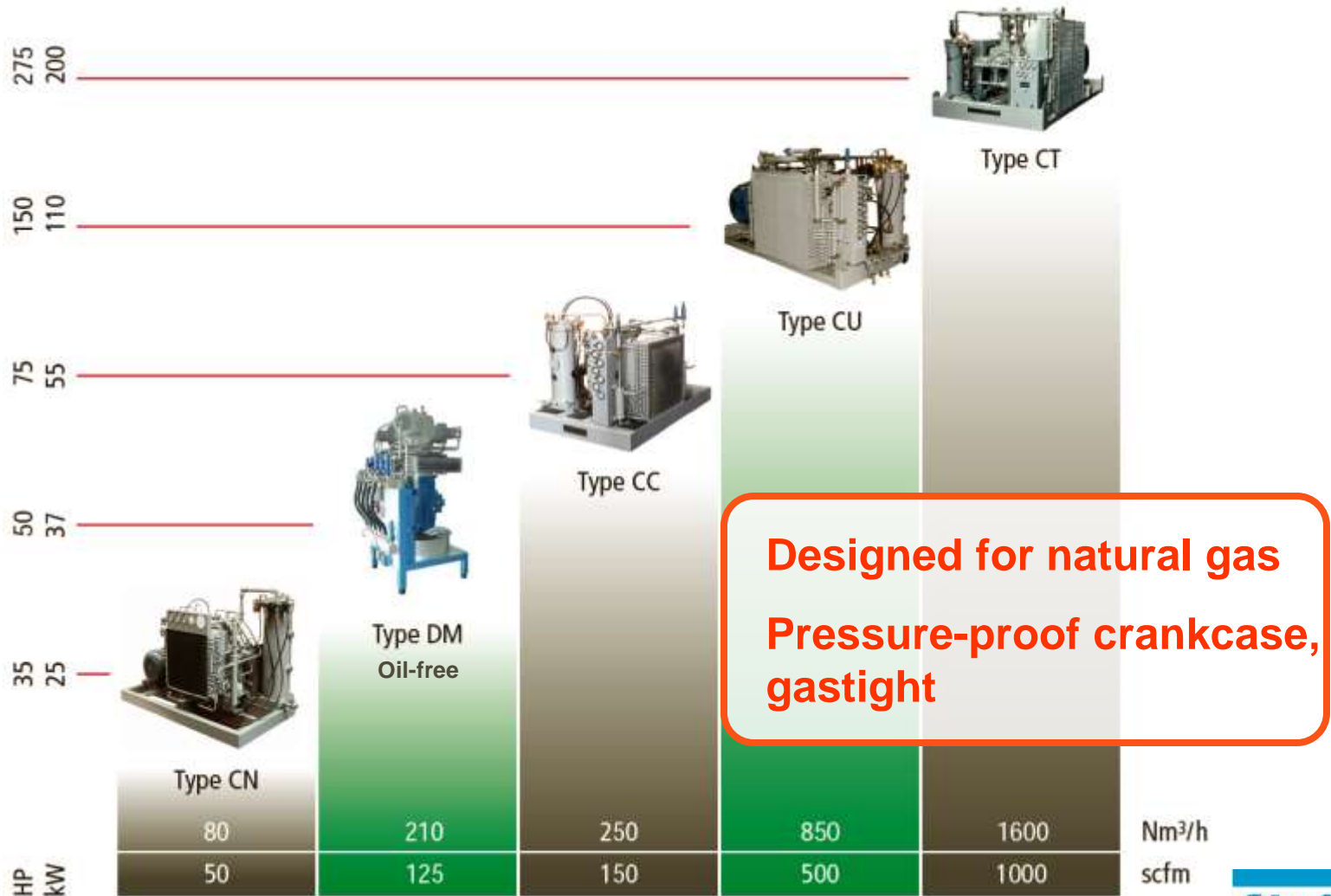
Footprint: 4,2 (5,4)*) x 2,5m



Products



GREENFIELD CNG-Compressors



Main Features of GREENFIELD Compressors

- Robust, modern, compact design. Easily accessible, packaged compressor unit incorporating own base plate
- Low pressure ratio per stage
- Automatic condensate drain after each stage, gas recycling into the suction line
- Pressure-tight crankcase
- Discharge pressure up to 351 bara (5090 psia) as standard, special applications up to 501 bara (7250 psia)
- All compressors are subjected to a trial run on our test bed
- All compressors are available in air cooled execution.
The CU and CT type compressor is also available with water cooling.
- All compressors can be fully packaged with sound attenuation hood, electrical controls etc.



Biogas Refueling station

Lille Marquette, Frankreich

Type **S100 - SINGLE** 1 x DM Compressor und 1 x Dispenser Type COMPACT



Tankstelle integriert in die Biogas- Reinigungsanlage

Public CNG-Station, 100% biomethane (virtually)



Gersthofen, Germany

Type **S100 – Duo** 3 x DM compressors and 1 x dispenser type MODULAR

Stand alone – Execution, cars and busses



Public CNG-Station, 50% biomethane (virtually)



Airport München, Germany

Type **S100 – Duo** 1 x DM compressors and 2 x dispenser type MODULAR

Stand alone – Execution, cars and busses



Public CNG-Station, 20% biomethane (virtually)



Führtstenfeldbruck, Germany, stand alone station

Type **S100 – Duo** 1 x DM compressors and 1 x dispenser type MODULAR

Bus CNG-Station, 20% biomethane (virtually)



Augsburg, Germany,

Total installed capacity: 6,700 Nm³/h with 6 dispensers for:
100 buses, 25 refuse trucks and 50 cars and vans daily



Public CNG-Station



Halberstadt, Germany

Type **S750 – Single** 1 x CU compressor and 1 x dispenser type MODULAR

Stand alone – Execution, cars and busses



Dispenser Integration in Petrol Station



OMV – Austria,

Natural Gas filling station

Public Station

Laufen, Schweiz

Typ **S100-DUO** 1 x DM Compressor und 1 x Dispenser Type MODULAR



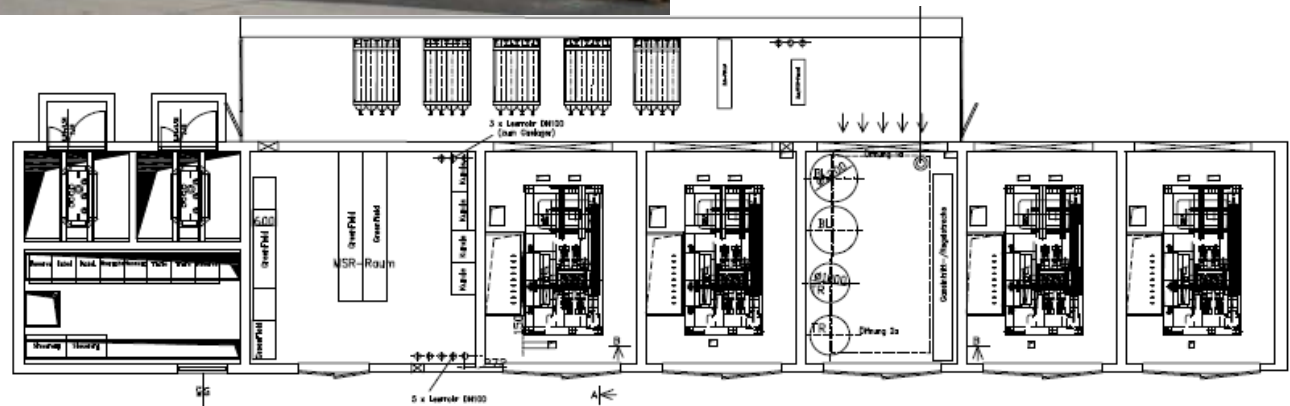
Alternative Fuels Refueling Solutions

Custom Designed Stations

Bus and Public Refuelling Station

Linz, Austria

Type S1500 with 4 x CT compressors and 4 x TOP dispensers



Alternative Fuels Refueling Solutions

Custom Designed Stations

Bus Refuelling Station

Strasbourg, France

Type S/L750 with 2 x CU compressors, 70 slow-fill posts and 1 x MODULAR dispenser



Alternative Fuels Refueling Solutions

GREENFIELD Europe

From	→	TO
Compressors	→	Turn Key Installations
Slow-Fill	→	Fast-Fill
Private	→	Public Stations
50 Nm ³ /h	→	8000 Nm ³ /h
Sweden	→	New Zealand
France	→	Russia

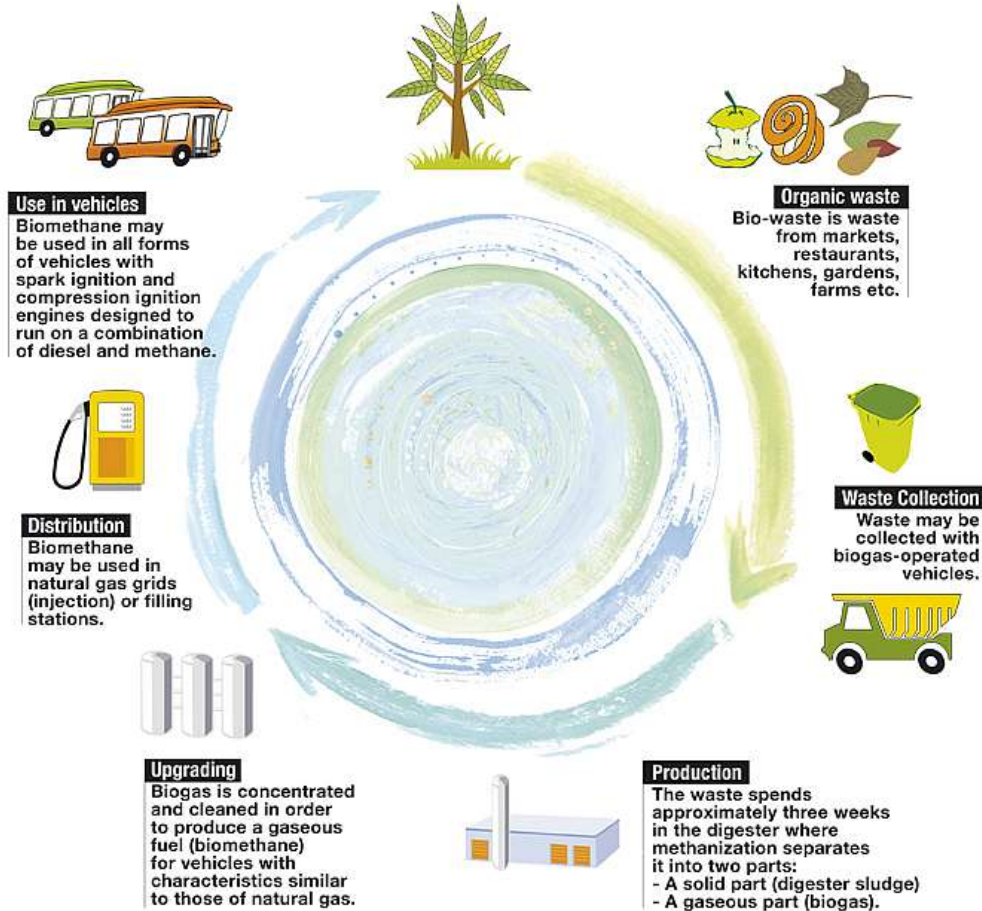
GREENFIELD IS YOUR RELIABLE PARTNER FOR CNG SOLUTIONS

A great potential

Biomethane's role to create clean cities

- The potential raw biogas production in a landfill, receiving all garbage produced in a city with 4-5 million inhabitants, can be typically 40 million m³/year
- Once treated and purified it would become 20 million m³ high quality biomethane, equivalent to natural gas.
- This 20million m³ biomethane is sufficient to fuel some 1000 vehicles, busses or garbage trucks, running on CNG.
- Thus we approach an almost perfect recycling loop

The optimal circle



Does this not sound like a great idea?

To create an energy solution from a waste problem

Atlas Copco group companies
have products to support all levels
of production and distribution of
biomethane



Atlas Copco Group companies have products to:

- dry the biomethane after the upgrading from biogas
- compress the biomethane for injection into the natural gas grid
- compress biomethane in a filling station for biomethane/ naturalgas vehicles

- Brands involved:



**Committed to
sustainable productivity.**





Atlas Copco

