Swedish Biomethane Roadmap

Jonas Ammenberg

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LINKÖPING UNIVERSITY

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- advancing resource-efficient biogas solutions -

A transdisciplinary competence center where co-production of knowledge is generated by 21 different biogas actors and ten research groups at Linköping University and Swedish University of Agricultural Sciences, Sweden

http://www.biogasresearchcenter.se/

Swedish Energy Agency | LINKÖPING UNIVERSITY | SLU Swedish University of Agricultural Sciences … *and 21 participating organisations* | Biogas Research Center

Research areas

Societal research

Focus on how the development of biogas solutions is influenced by public/private actors and institutional conditions.

Systems research

Focus on structured, qualitative analyses as well as quantitative methods for handling of critical factors and uncertainty handling for improving economic and environmental performance of biogas solutions

Process and technology research

Focus on improving profitability in existing biogas production and making new substrates available for biogas production through developing intervention based on characterization of undigested substrate.

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Swedish biogas history

- 1930s→: WWTPs
  - Initially focus on waste treatment (volume reduction, hygienization, stabilization).
  - Initially used for heating or flared
  - Municipalities key actors
- 1970s →: manufacturing industry
  - E.g. sugar and pulp & paper industry
- 1970s →: agriculture, farm-scale
- 1980s →: landfills
  - Very small amounts of organic material landfilled since 2005 due to legislation
- 1990s →: co-digestion plants
  - Source separated food waste, slaughterhouse waste, etc.
  - Municipalities key actors
- Off-grid market to a large extent; some local or regional grids

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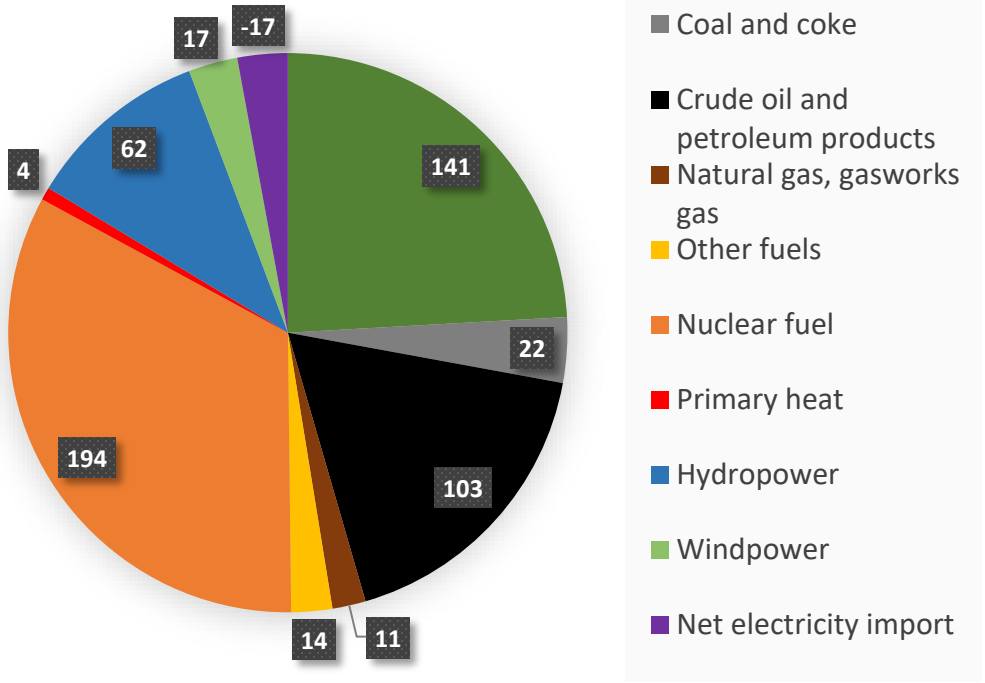
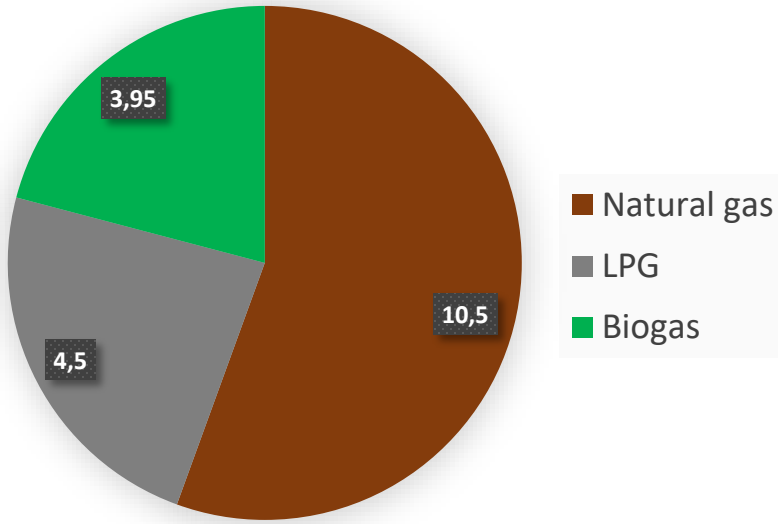
Energy supply & deliveries of energy gases, 2019

Energy supply 2018: 552 TWh



Source: Swedish Energy Agency, 2020.

Use of energy gases 2019: 18,9 TWh



Source: Statistics from the Swedish Gas Association, 2019

25% fossil energy

Low share/levels of gas

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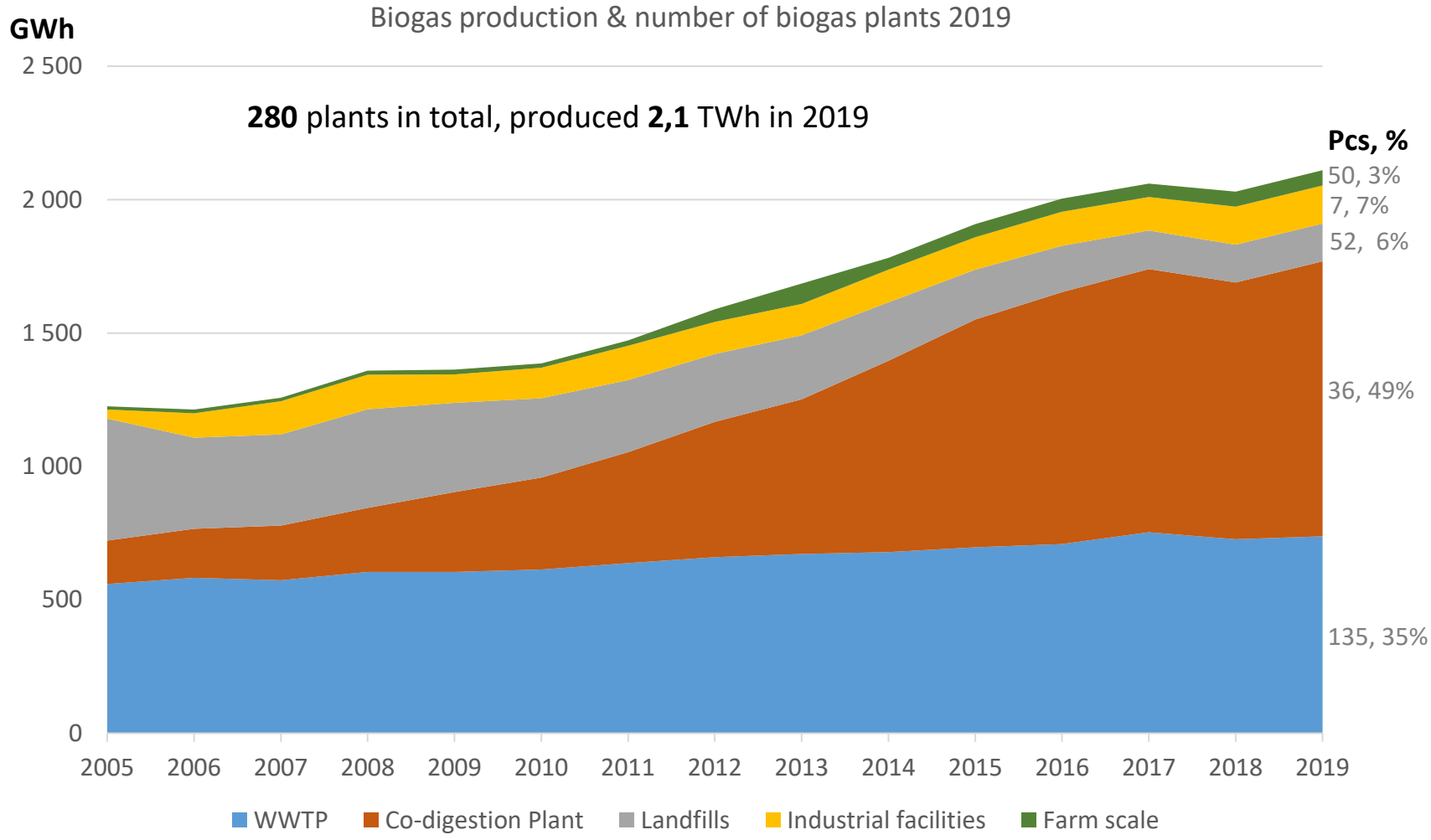
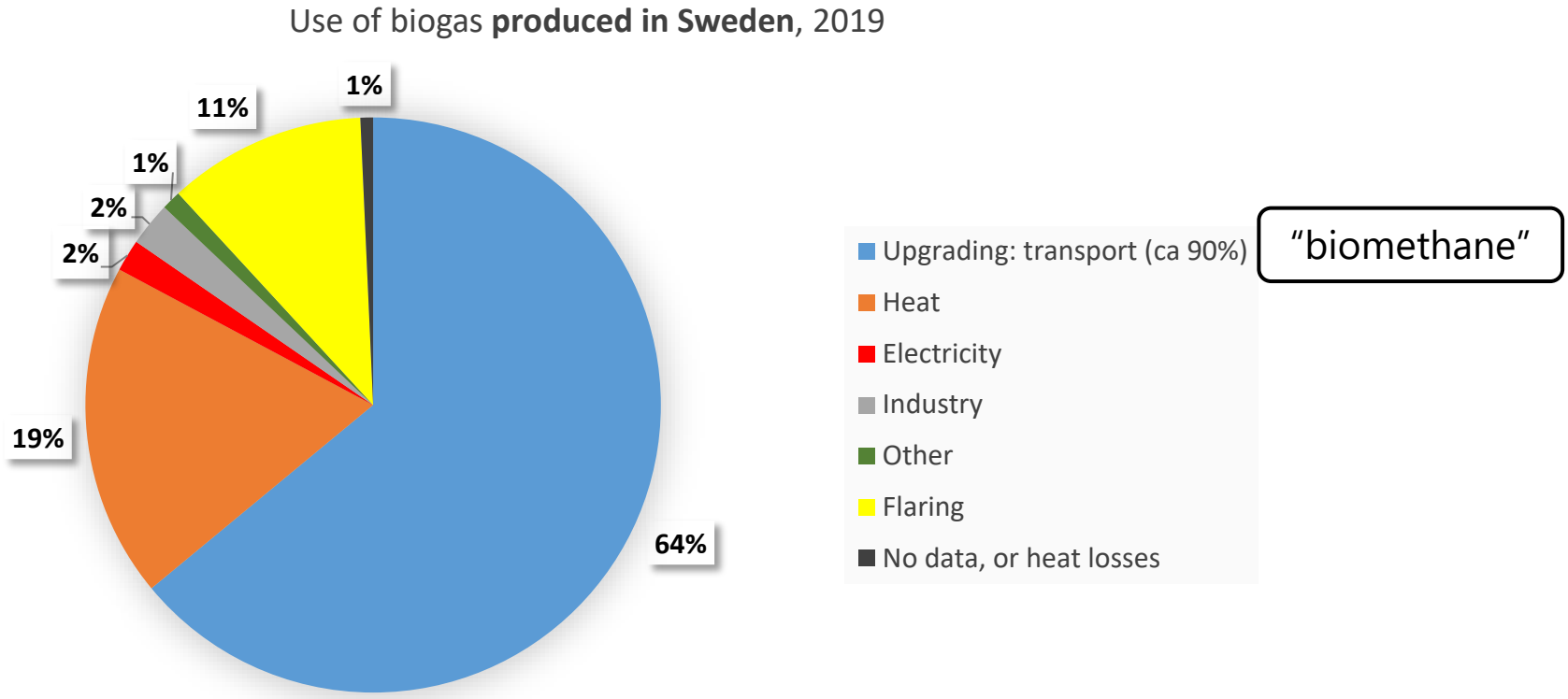
Production of biogas, 2019



Source: Swedish Energy Agency & Swedish Gas Association

In addition: about 1,8 TWh/y (netto) imported from Denmark & some other countries

Use of biogas, 2019



About 1.3 TWh/y upgraded from 68 upgrading plants, of which about 0,5 TWh was grid injected. About 0.8 TWh used locally or trucked to filling stations.

About 30% of the **imported** gas was used as vehicle fuel in 2018 (ca 500 GWh of 1,6 TWh)

Source: Swedish Energy Agency, Swedish Gas Association & Klackenberg, 2021

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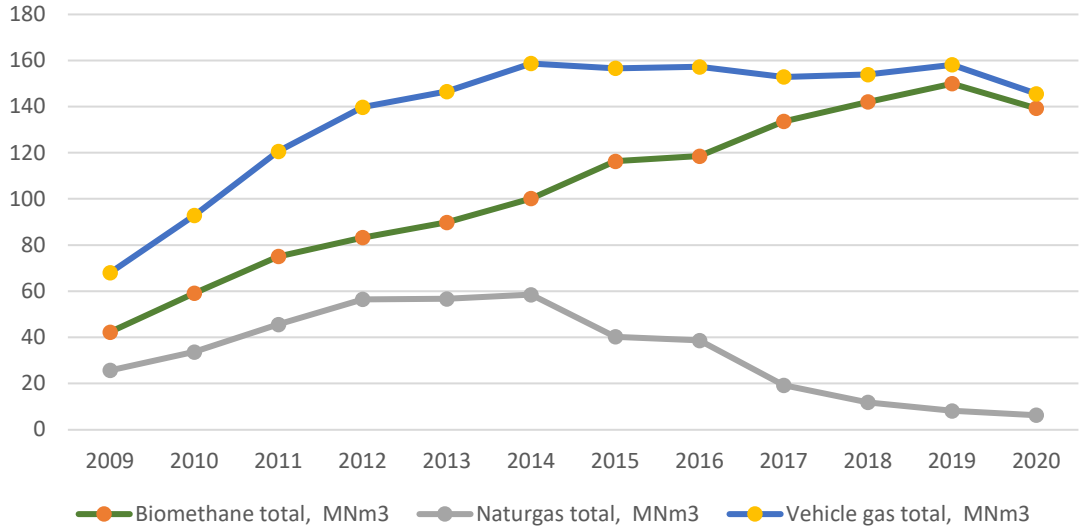
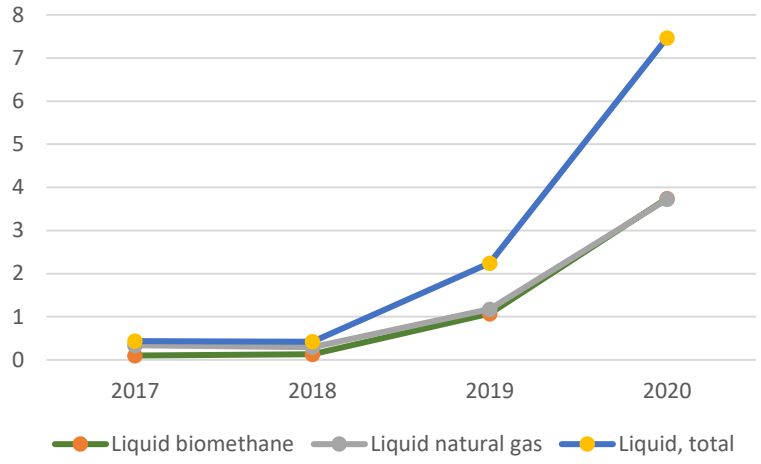
Development regarding gas as vehicle fuel

Deliveries of gas as vechicle fuel, 2009-2020 (MNm^3)

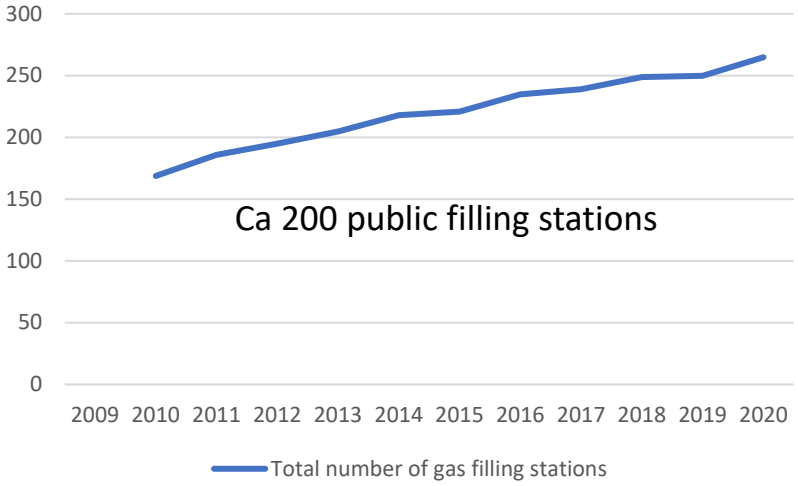


Deliveries of liquied gas as vechicle fuel, 2017-2020 (MNm^3)



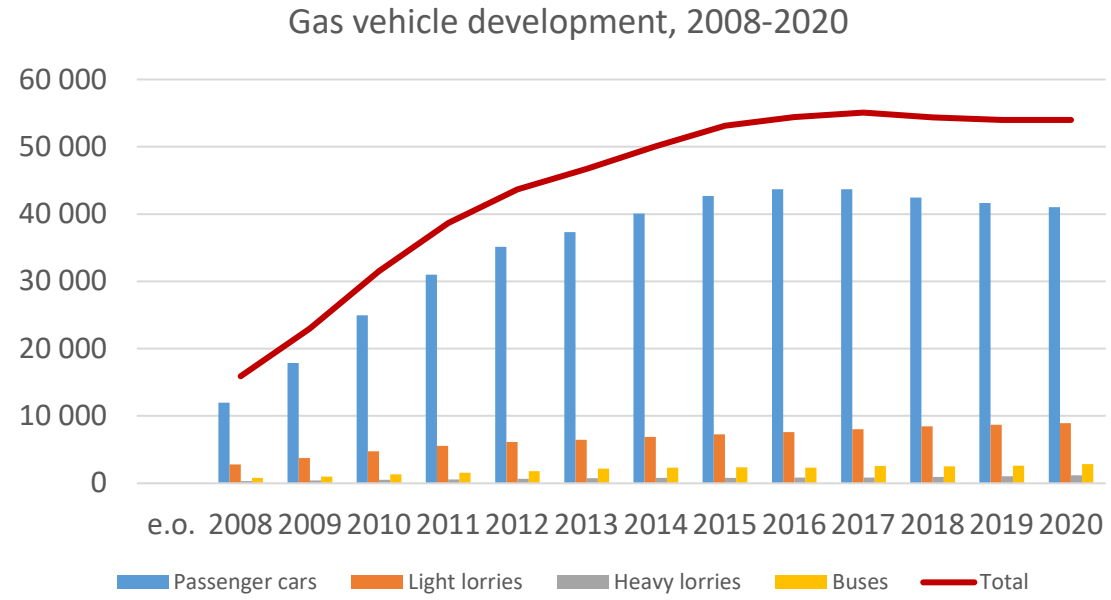
- Liquified biomethane (LBG, or bio-LNG) has entered the market (vehicles & fuels)
- News for 2020: 1 491 GWh vehicle gas, including 75 GWh liquified fuel (>95% biomethane).

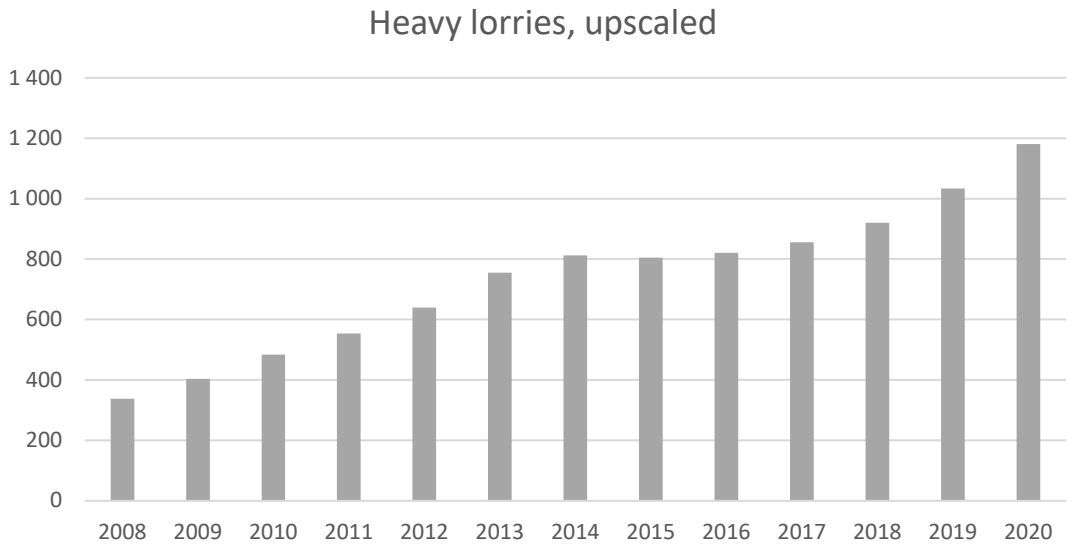
Total number of gas filling stations



Source: Statistics Sweden (SCB), Swedish Gas Association

Development regarding gas vehicles





- Ca 54 000 gas vehicles:
  - ✓ 41 000 pass. cars
  - ✓ 9 000 light lorries
  - ✓ 2 800 buses
  - ✓ 1200 heavy lorries
- A shift in focus to electric vehicles (EV):
  - ✓ Policy best for (EV), but ok for gas
  - ✓ Fewer good gas pass. vehicle models
  - ✓ Promising regarding HDV and liquified biomethane
- A large share of second-hand gas vehicles sold to Finland & the Czech republic

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Sources: Statistics Sweden (SCB) & Transport Analysis

Digestate management

- About 2.8 Mtonnes of digestate in 2019:
  - 86% as biofertilizer in agriculture, certified quality

- 100 % as biofertilizer from co-digestion plants and farm-scale plants (SPCR120)

- 41 % as biofertilizer from WWTPs (Revaq)

Source: Swedish Energy Agency & Swedish Gas Association

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Development

Some selected examples

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Development

- From public to private actors (large scale international companies)
  - Transformation into markets
- Several biogas production plants recently built, soon to be ready, or planned (waiting for policy to be implemented, budgeted, etc.)
  - Mainly large scale, focus on liquefaction. For example:
    - ✓ *Stora Enso* and *Gasum* in Nymölla – biogas at a paper mill, 75-90 GWh/y liquid biomethane per year
    - ✓ Farmers and *Scandinavian biogas* in Mönsterås, manure, 120 GWh/y liquid biomethane per year
  - Biomethane to marine transports (ferries/ships)
  - Improved industrial performance: *SSAB* looking for 2 TWh/year to make fossil free steel

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Policy development important

- A lot is ongoing on the EU level

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Biogas solutions have been invisible in EU relevant strategies

- One brief reference as a method for treating animal waste in the Waste Directive (2008 + update)
- Not mentioned in the Circular Economy Action Plan (2018)
- Encouraged in Bioeconomy Strategy (2018, updated), but only briefly addressed (mentioned 5 times)

Based on work by professor Stefan Anderberg, Linköping University, BRC

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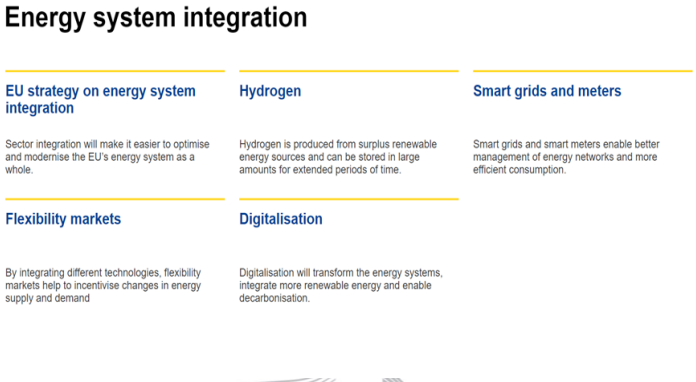
Change with the Green Deal and three new strategies in 2020, where biogas solutions are central (and mentioned)

Based on work by professor Stefan Anderberg, Linköping University, BRC

- Environmental challenges, focus on climate neutrality (2050), protection of natural capital. Well-being, health
- More sustainable/circular economy, energy security, sustainal mobility, etc.

- Realising the biobased economy in farming
- Advanced biorefineries - cascading



- A more circular and energy-efficient energy system, rural systems
- Utilize potentials related to wastewater, biological waste, residues from agriculture, forestry, food industry, etc., for bioenergy production including biogas
- Waste to energy supported, biogas among the more sustainable approaches, support renewable, low-carbon fuels. Hydrogen …
- Design of competitive gas markets

- EU to lead regarding methane emission reductions in all relevant sectors, synergies of biogas production are particularly stressed
- Proposed to support rural areas and farming communities in developing biogas production from agricultural waste, manure

EU policy barriers to biogas

- The taxonomy for green investments and norms regarding CO_2 emissions from vehicles
  - Gas vehicles assumed to use natural gas!

  → Vehicle producers going for EVs (and hydrogen)

- Is it so, and in that case:
  Why is black electricity and black hydrogen green,
  and green gas black???

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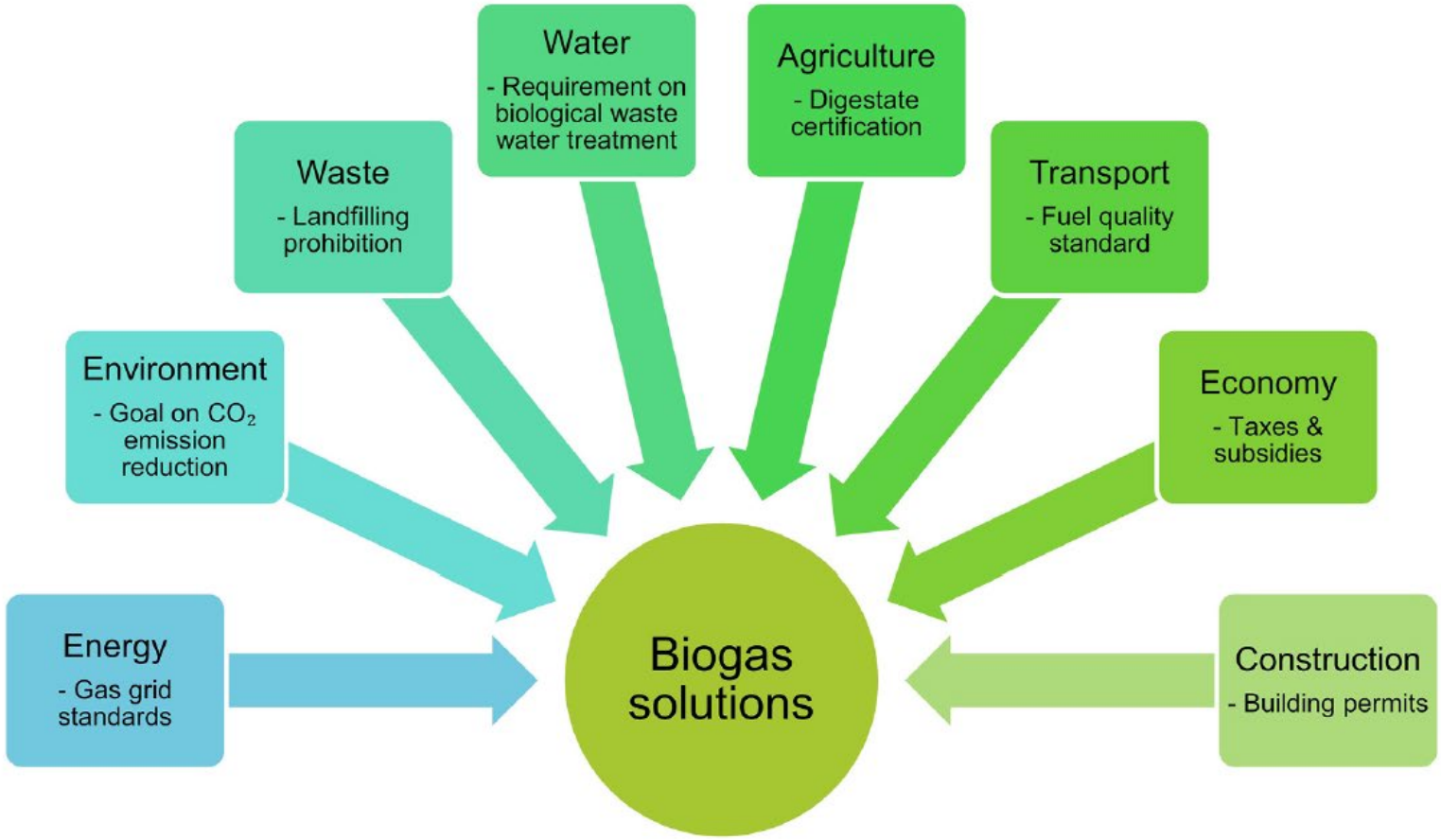
The institutional conditions for biogas



Source: Gustafsson and Anderberg, 2021
New article from BRC

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Policy

- Examples of long-term climate and energy goals:
  - **Climate** neutral energy sector 2045, with at least 85 % GHG emission reduction in Sweden. From 2045 negative emissions.
  - 100 % **renewable electricity** production 2040
  - 63 % GHG emission reduction in non-EU ETS sector in 2030 and 75 % 2040 compared to 1990
  - 70 % GHG emission reduction in domestic **transport** (excl. aviation) 2030 compared to 2010. Climate neutral 2045

- Examples of **financial support** systems:
  - High CO_2 tax and energy tax on fossil energy and **tax exemption** for renewables
    - ✓ E.g. CO_2 tax and energy tax exemption for biomethane for transportation
  - Production **support for manure**-based biogas; ~ € 0.043/kWh
  - 40% reduction of income tax for use of company gas vehicles
  - Norway and Sweden have a joint electricity certificate market

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Policy

- Relatively new policy:
  - Bonus-malus (cars with low CO_2 emissions get a bonus, while cars with high CO_2 emissions get a punitive tax. EV highest bonus)
  - Municipal environmental zones – gas vehicles allowed in the most restricted zones (zone 3)
  - Quota obligation for biofuels in gasoline and diesel from July 1st, 2018

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Policy – future

- Enquiry into market conditions for the Swedish biogas sector; ***More biogas! For a sustainable Sweden***:
  - 676 pages!
  - Investigation of the most suitable long-term policies for biogas and biomethane after 2020
  - New legal texts suggested → hoping for a rapid implementation
  - Focus on the production side

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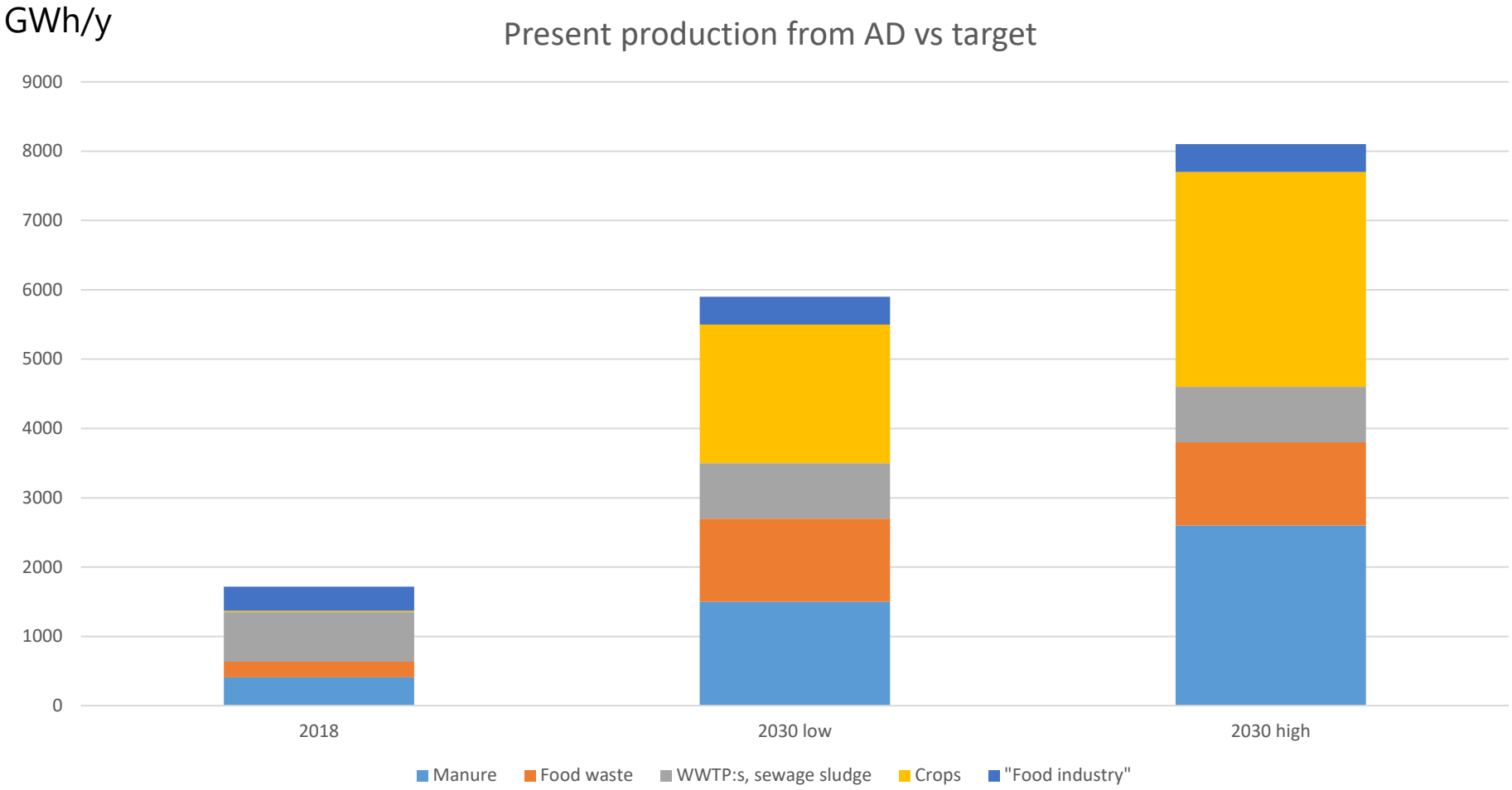
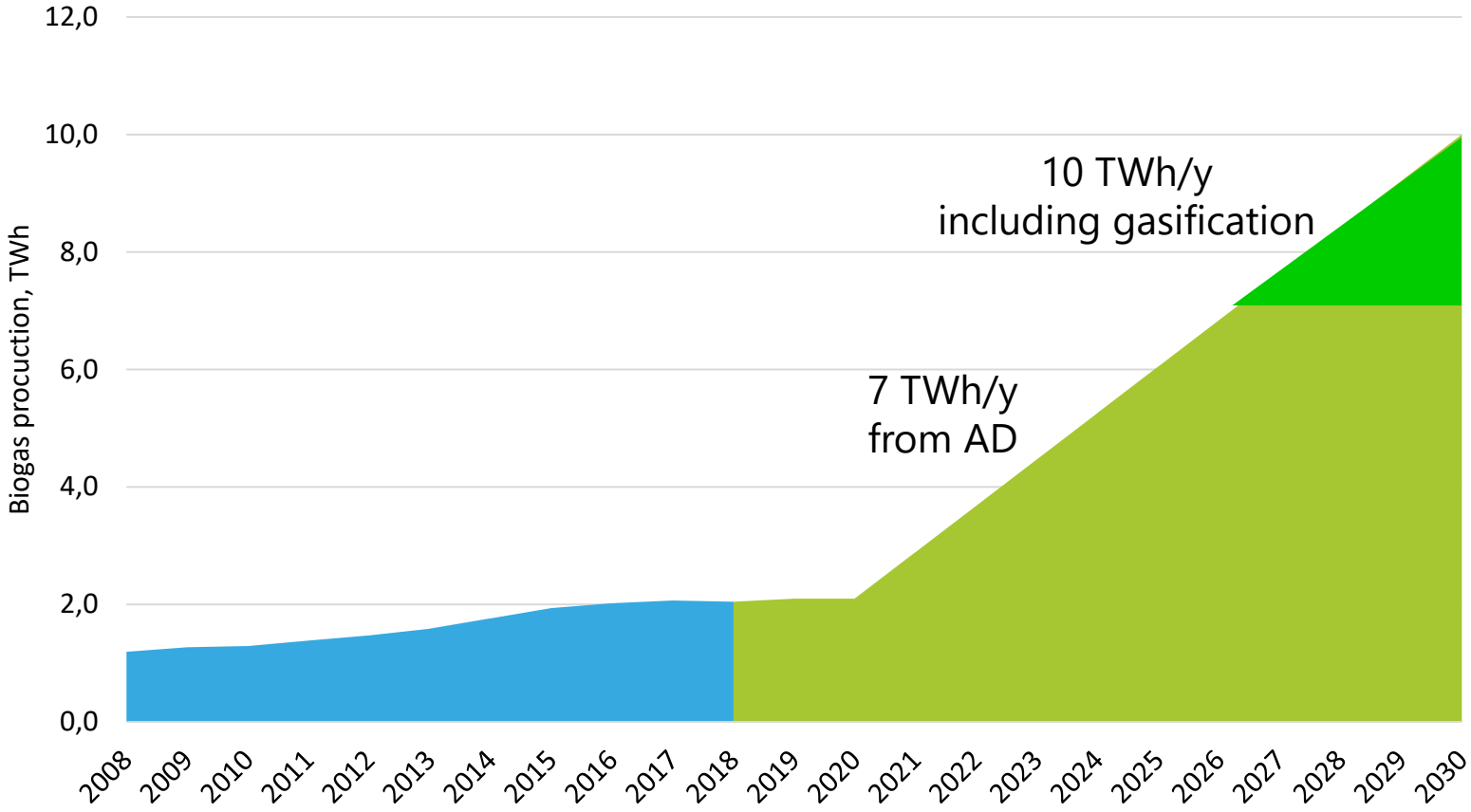
Production target

7 TWh/y 2030 from anaerobic digestion



Production target perspective



Source: Marcus Gustafsson

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Main support suggested

Package I:

- Continued production support for manure-based biogas: ~ € 0.040 per kWh
- Upgrading support: ~ € 0.020–0.030 per kWh
- Liquefaction support: ~ € 0.010–0.015 per kWh

Upgrading - biomethane for transport & industry!

Package II:

- Beneficial financial instruments (loans, guarantees)
- Some kind of production support (other energy gases/technologies, i.e. not AD)?

- Ten years support period

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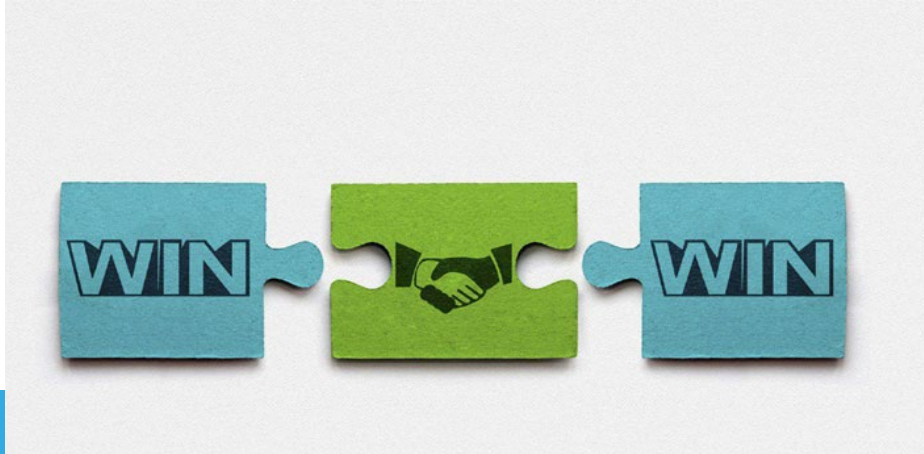
Socio-economically beneficial

- Support package I → reduced CO_2 emissions corresponding to 4% of Sweden's total emissions

- The socio-economic benefits are greater than the costs, just based on these climate impacts
  - Positive even if no other biogas related benefits included; such as lowered emissions of particles, reduced noise levels, nutrient recycling, reduced eutrophication, improved waste management, improved energy security, etc.



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Sustainability assessment of buses available on the Swedish market

-Results from Dahlgren and Ammenberg, 2021

Note: Sweden has a large share of renewable electricity

Table 15. Overview of the assessment results.

	Diesel	HVO	FAME	Ethanol	Natural Gas	Biomethane	Electricity
Technical maturity	VG ***	VG ***	VG ***	G ***	VG ***	VG ***	S ***
Daily operational availability	VG ***	VG ***	VG ***	VG ***	S - ***	VG S - ***	VG VP - ***
Total cost of ownership	P - **	VG VP - **	VG S - *	VG VP - *	P VP - **	G VP - **	G VP - *
Need for investment in infrastructure	If there is no existing infrastructure, all alternatives require significant investments (i.e., Very Poor). In real cases, the specific needed infrastructure investments can be estimated and compared in a more meaningful way.						
Cost stability	VP - *	P VP - **	VP - **	S VP - **	S P - *	S P - *	S P - *
Non-renewable primary energy efficiency	VP **	G - **	VG VP - **	S VP **	VP **	S - **	VG VP - **
Greenhouse gas emission savings	VP **	S - **	VG P - **	VG VP - **	S VP - **	P VG **	VG **
Air pollution	P - *	S P - *	S P - *	S S *	G *	G *	G ***
Noise	S - *	VG S - *	VG S - *	VG S - *	VG S - *	VG S - *	VG VG ***
Local/regional impact on land and aquatic environments	VP ***	VP **	P **	P **	VP ***	G **	VP **
Energy security	VP ***	VP ***	VP ***	S ***	S *	S ***	VP *
Sociotechnical system services	S ***	S ***	S ***	S ***	S ***	VG ***	VP - ***

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Jonas Ammenberg, PhD
Associate Professor (Docent)

Environmental Technology and Management
Biogas Research Center
jonas.ammenberg@liu.se

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