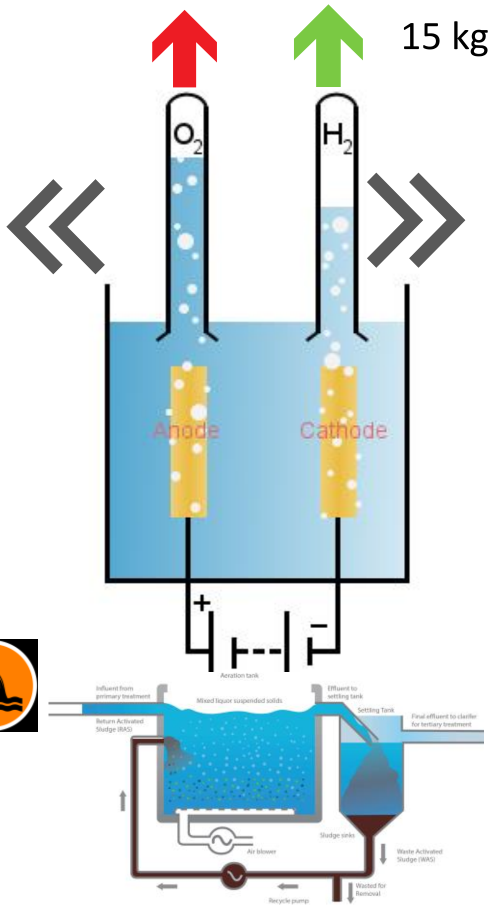
O_3 Systems Technology BV.

O3 SYSTEMS
WATER | AIR | SOIL | ENERGY

Value increasing and Energy reduction "green" Hydrogen production with Ozone.

15 kg H_2 uur 326 WWTP's

- Zuurstof
- Beluchting met O_2
- Desinfectie LO_3
- Enegie opslaan LO_3
- Verwijderen Xeno verb Hormonen medicijnen etc
- To > 100 Ozone Consumer Markets
- Stikstof binden Kunstmest ! $LN_2 + LO_3 \rightarrow NOx$



- Waterstof
- Proteinen Manufacturing
- Energie opslaan LH_2 Transport Electra
- Mengen met CH_4
- Transport 500.000 cars op H2
- Buildingblock Chem Industry

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H2 Plus process ™

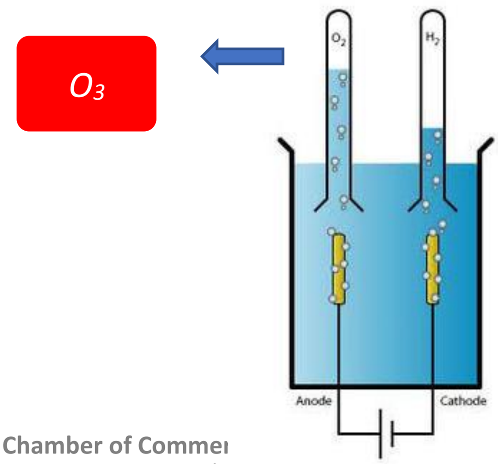
Sequential production of hydrogen and ozone in existing water Electrolyser

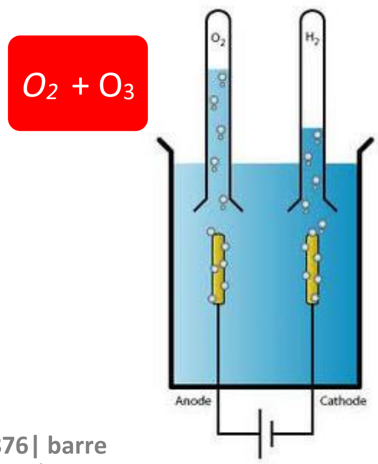
If the oxygen released in the production of hydrogen water electrolysis is used and converted into ozone, this (Thermodynamic) results in a saving and reduction in the hydrogen price of about **20%.** This ozone can also be used directly in the many current applications already present (sewage treatment plants, paper mills, etc.) and future applications in industry. This allows "new" or improved oxidative processes to be done and stimulated. This will make a further contribution to the energy and CO_2reduction in the Netherlands. In this way, a new commercial product and technical knowledge will also bring economic benefits and contribute to the reduction of the global CO_2 problem. By reducing the cost of, among other things, the "green" hydrogen, the hydrogen economy will be able to make a big leap forward.

H2 Plus additional process ™

Simultaneous production of hydrogen and ozone in one water Electrolyser

By simultaneously producing hydrogen and ozone in one water-Electrolyser, the hydrogen price can be reduced by about **25%,** because the total energy demand for the production of hydrogen and ozone goes down. As a result, commercial products are made available at both poles (c athode and anode), with a commercial value of both around 8-10 euros/kilograms. For this, the existing Electrolyser needs to be adjusted or a new electrolysis concept will arise. The literature and laboratory tests of O3 systems show that it can be done and on a lab scale with a significant reduction in overall energy demand/ need. In this way, both the hydrogen and the oxygen economy are stimulated, both are circular and have renewable sources and environmentally friendly and harmless end products.





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Transport & Applications

LO_x (LO_2 and LO_3)

By (temporarily) converting oxygen into ozone, 50% more oxygen can be stored in an M^{3}. Also, the storage conditions are much more suitable and safer than the current "oxygen" storage conditions (minus 186 °C).

In order to be able to transport ozone "safely in liquid form (LO3), the following conditions are required. 30 bar and minus 30 °C. O3 systems will demonstrate that LO3 is also stored at 20 gr C and 105 bar !This ozone fluid has also already enclosed its "evaporation energy/ heat" and it would also be possible to use the ozone, if needed, in more than 100 **types of!!!** existing ozone consumers, for example. as – combined cleaning and disinfectant with only oxygen as the final product and no harmful by-products . It is possible to use the ozone fluid (LO3) both ozone, oxygen as heat source. All this contributes to the reduction of transport, air water emissions, new safer and cheaper processes and practices and even health risks (reduction of Xenobiological and halogenated aggressive reaction products and reduction or elimination of emissions from conventional cleaning methods, means and systems

Business Cases Hydrogen and Ozone

Business Case 2

The Dutch flat Energy oxygen reservoir for wastewater. Also a ideal electric shock absorber for 1 GW of power.

We talk about energy and power in this business case!
We use the following data:
The Netherlands contains 326 wastewater treatment plants, (300 for our calculation model). Of which about two thirds are mainly located a few tens of kilometers from the sea coast! And borders. This data offers the following unique (polder) possibility's.

Power

To switch approximately 1 GW of the electric power Joule/sec on and off.
The process of wastewater treatment hardly suffers from this because the microflora can easily go a few seconds, minutes even up to 15 minutes or more without oxygen in the wastewater treatment plant.
These unique slow systems act as if they are the entrance and Exit from the electric highway. By combining this data and in this way these processes we have approximately 300 "pushpin points" to buffer 1 GW electrically Each location accounts for 1 GW / 300 = 3 MW. The expensive Electric highway does not have to be extended to the Alps in Switserland or Norway. But only a few 10 kilometers need to be extended with adapted entrances and exits.

Energy

The second very attractive. Is the energy supply and storage possible at these 300 locations because we are able to buffer or return the energy in modular 40 ft gas containers 24/7 via energy stored in GASES. That is the idea of Werner von Siemens as Storing energy in GAS molecules hydrogen, oxygen and ozone
This can be done in reinforced PLASTIC tanks type 4 CNG Tanks up to 200 bar
In those 40 Ft containers one can also make safer and efficient store more certainly about eight times smaller storage based on.b a volume compared to the conventional battery.

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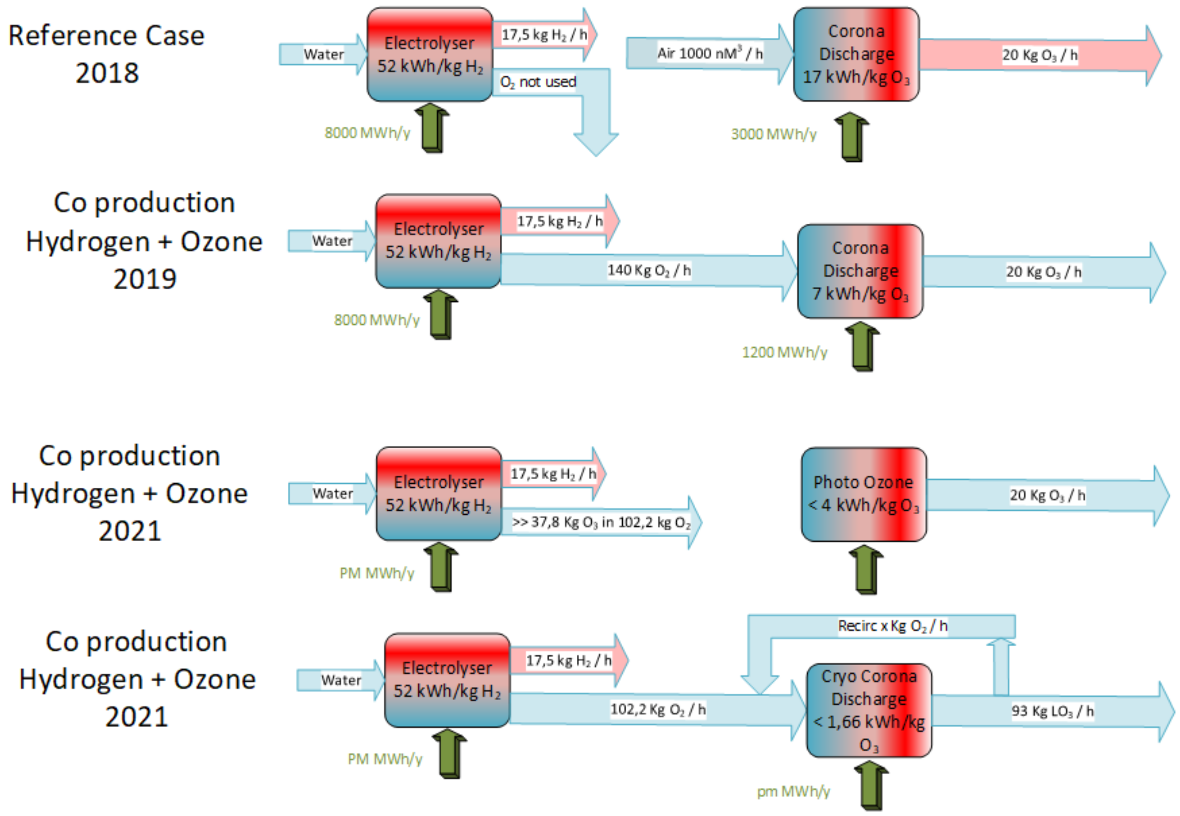
The 3 molecule storage system (Siemens battery) is much safer and more robust and operates more securely than ordinary batteries.

Due to the logical link with wastewater, you can use an existing Infrastructure simple and cheaper and modular 1 GW Power of energy and power are collected, adsorbed, or returned.
There is no comparable sector where this can be applied so quickly and . The bonus for WWTP's this itself saves 50 % energy! The WWTP sector consumes about 8 % of total energy consumption in the NETHERLANDS.
The trade in liquid ozone #LO3 is estimated to approximately 1.9 billion euro's per year.

Outlook Simultaneous Hydrogen and LO_3 Production .



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The Kick-off of the Oxygen Economy!

Potential ozone in relation to the "hydrogen" economy and production.
In the treatment of (domestic) waste water.

The Netherlands owns 321 domestic wastewater treatment plants that are already at the strategic intersections of our infrastructure. The current energy consumption of the water boards (NL total) is 90MWe = that is about 8% NL total energy consumption, of which 4 pro mille, total for oxygen/air injection.
Consumption of e.g. 1 mg ozone /l wastewater compared.b to medicine and hormone residues would result in a total ozone consumption of 5500 kg/day and "cleaner" wastewater, more purification capacity, 30 – 40 % less sludge and more better conversion to biogas!

If all water boards make hydrogen/ozone themselves using "standard" Electrolyser (729 MWe)(total installed power 275 MWh), this results in ....
• At 50% of the available wastewater market, savings of 480GWhe (50% savings on electricity costs of wastewater sector).
• Also directly 6.3% efficiency improvement of the hydrogen economy with only oxygen use! This would result in a national energy saving of 5.8% !!!!

Yield (€) hydrogen and liquid ozone as a commercial product and storage of energy aside.
If the oxygen is used via ozone, this will improve the hydrogen economy by 50% efficiency and save NL energy
Hydrogen should preferably be consumed immediately. In a WWTP, H2 can also be used as a raw material for the preparation of proteins. Attractive and economical combinations with Power2ammonia technology are also possible at wastewater treatment. The hydrogen of the Electrolyser can also be used to make approximately 4000 tons to 300 €/tonne of local fertilizers for approximately 1.25 million euros per year per site. It would also allow hydrogen-powered transport equipment to load/refuel 500.000 hydrogen cars.
When oxygen is charged / converted with electricity by means of a so-called ozone generator DBD, liquid ozone is created under pressure and low temperature (chemically, the oxygen molecule changes from O2 to O3:an additional oxygen atom is added to the O_2 molecule by the electric charge). The electricity stored in this way can then be released by combustion, with O_3 being converted back to O_2. Ozone can be efficiently stored in liquid form under lower overpressure and lower temperature. These benefits far outweigh the lower energy density (kJ/kg) of liquid ozone compared to hydrogen gas.

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'Green extracted' ozone can also be used as a raw material by industry (e.g. in paper mills, household wastewater treatment plants, iron foundries and the chemical industry).
If this "large-scale" use of hydrogen/ ozone were also done, for example, for the paper sector and other "large" users/ ozone consumers ,this would make a significant part of energy generation and ENERGY STORAGE!!! of the Netherlands can be covered, and a significat contribution to the hydrogen economy and supply to the hydrogen (gas) pipeline network or hydrogen means of transport are provided.

- • This would result in a hundredfold improvement compared to the above domestic wastewater cleaning case / calculation

In the very short term, 'green extracted' ozone can make diesel engines from ships and "heavy" trucks more economical and much cleaner, by adding ozone just before the existing catalyst. There will no longer be soot particles in the exhaust and the engine will become 10 to 15% more economical. This can also be applied to diesel passenger cars. All this would boost the hydrogen economy and provide enormous energy savings and additional raw material (ozone). Due to the synergy of the hydrogen economy with the oxygen economy, the Paris objectives can be achieved with greater comfort with the Netherlands as the guide country and market leader.

- • The **T**echnology **r**eadiness **l**evels TRL level is equal to or greater than 8 !
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Ratio Hydrogen Ammonia & Ozone

Characteristics	**Hydrogen**	**comments**	Ammonia	Ozone	ratio
					O_3 & H_2
Boiling point (1 013 hPa = 1 atm)	- 252 °C (20 K)	methane: -161 °C (112 K)	- 33 °C (240 K)	- 112 °C (161 K)	
Boiling point (xx bar)			27 °C 10 bar	- 34 °C & 30 bar	
Critical point (bar & °C)	- 239 °C & 13 bar	- 82,6 °C & 46 bar	132 °C & 113 bar	- 12 °C & 56 bar	
6					ratio
Density gas H_2 (0 °C, 1 atm)	**0,090** kg /Nm^3	H_2 14 times lighter as air	0,80 kg /Nm^3	2,14 kg /Nm^3	24
Density liquid H_2	70,8 g /l [at -245°]	benzine: 720 g /l [0 °C]	769 g /l [at 15 bar]	979 g /l [at - 34 °C]	13
9					
Energy content gas H_2 (OVW)*	120 MJ /kg	methane: 50 MJ /kg	18,7 MJ /kg	3,0 MJ /kg	**0,025**
(0 °C, 1 atm)	33,3 kWh /kg			0,8 kWh /kg	
	10,8 MJ /Nm^3	methane: 36 MJ /Nm^3	**15,0** MJ /Nm^3	6,4 MJ /Nm^3	**0,59**
	3 kWh /Nm^3		4,1 kWh /Nm^3	1,8 kWh /Nm^3	
Idem as **gas** & **200 bar** & ambient as vol	**2,2** MJ /l compres.		see below	**1,3** MJ /l compres.	**0,59**
15					
Energy content liquid H_2 (OVW)*	8,5 MJ /l frigid	benzine: **33** MJ /l ambien	**14,4** MJ /l [at 15 bar	**2,9** MJ /l frigid	**0,33**
	120 MJ /kg	benzine: 46 MJ /kg	18,7 MJ /kg	**3,0** MJ /kg	
	2,36 kWh /l				
19					
Flammability limits in air (25 °C, 1 atm)	4 – 77 vol %	methane: 5,3 – 15,0 vol %			
Detonation in air (25 °C, 1 atm)	15 – 59 vol %	methane: 6,3 – 13,5 vol %			
Auto ignition fire point	560 °C	methane: 537 °C	651 °C		
Ignition energy	0,02 mJ	methane: 0,29 mJ			
Conclusion: 1. Expressed as gas volume so at any equal pressure like 1 or even 200 bar, hydrogen gas is still at least one and a half times more energetic as ozone gas					
2. Expressed also as volume, ozone **liquid** for instance at minus 34 °C & 30 bar is almost one and a half more energetic as hydrogen **gas** even at 200 bar H_2					
https://de.wikibooks.org/wiki/Tabellensammlung_Chemie/_Dichte_gasförmiger_Stoffe					