N2kWh

FROM POLLUTANT TO POWER

CONTACT INFORMATION

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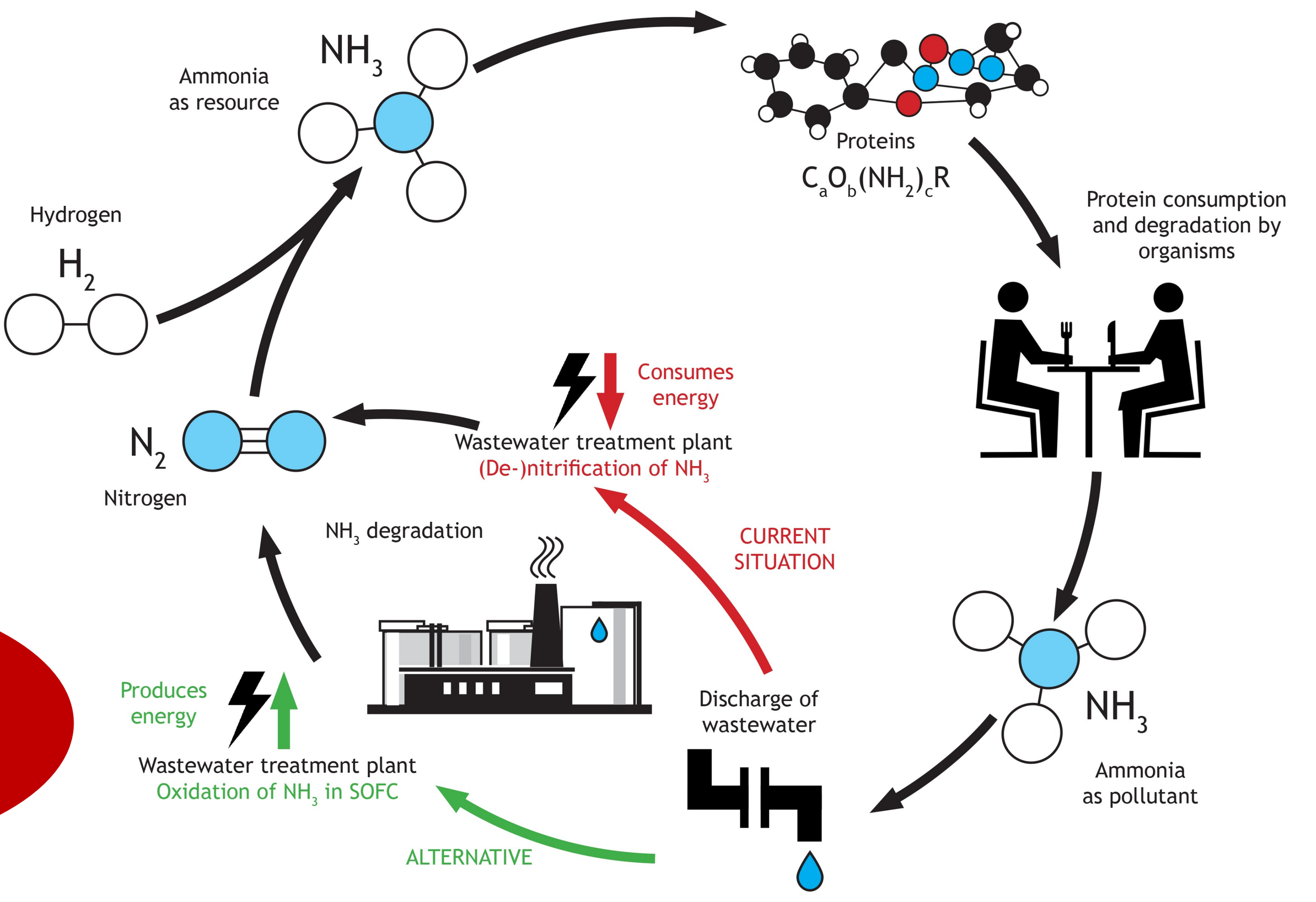
INTRODUCTION TO RESEARCH

PROBLEM DESCRIPTION

Ammonia (NH_3) is world's second most produced chemical and is a vital resource for protein production. NH_3 becomes present in residual (waste) water streams, for example after protein degradation by organisms, and is considered a pollutant for aqueous environments, because it potentially leads to algae blooming.

To this extend, NH_3 must be removed from residual water streams, before the water is discharged. Current methods applied in waste water treatment plants (WWTP), consume significant amount of energy: aeration (to facilitate (de-)nitrification) accounts for approximately 50-70% of the total energy usage of a WWTP[2].



PARADIGM SHIFT

When the NH_3 can be recovered as fuel from residual water stream, energy can be produced in stead of used in order to remove NH_3. This might lead to a paradigm shift:

from pollutant to power.

Used elec. energy[2]:
3.1 kWh/kg-NH_3

[1]Environmental Dynamics International (2011). *Aeration Efficiency Guide*

[2]Beck, M. B., & Speers, A. (2006). *2nd IWA Leading-Edge on Sustainability in Water-Limited Environments*: IWA Publishing.

NH_3 IN SOFC

SOFC

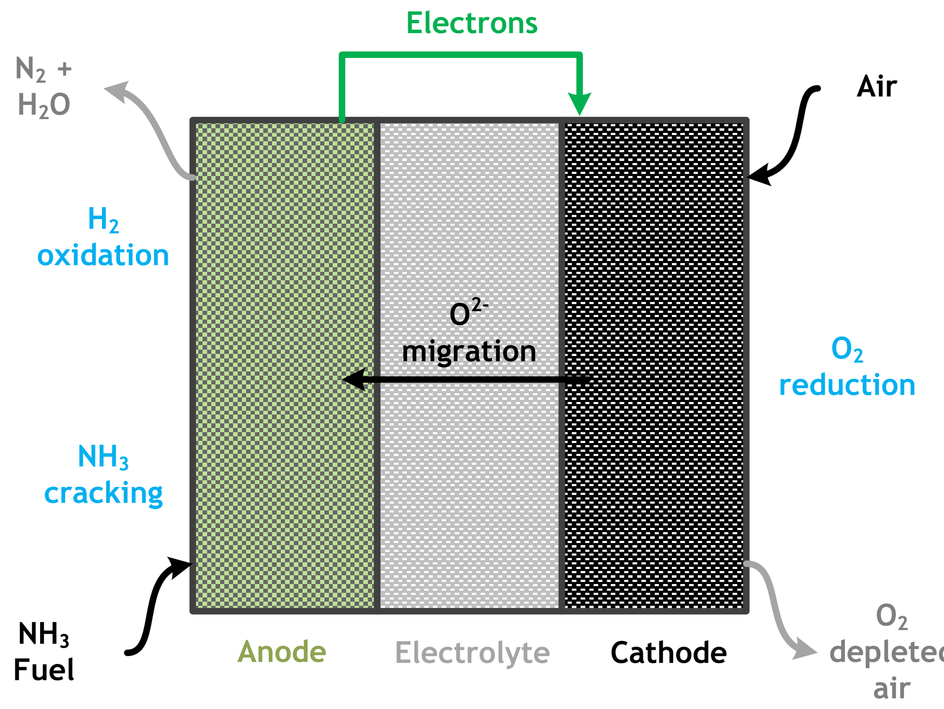
A Solid Oxide Fuel Cell (SOFC) is a specific type of fuel, made of solid ceramic materials. In a SOFC, H_2 is oxidized by O_2, resulting in a current of electrons, which can be utilized as electrical energy. Additionally, the residual released energy can partially be utilized as thermal energy.

The electrical efficiency of a SOFC is 50%, whereas the total energy efficiency can reach up to 85-90%, in case of thermal energy utilization[3].

Because a SOFC operates at temperatures of T = 600 – 800 [°C], NH_3 can be cracked internally into H_2, making it possible to use NH_3 directly as a fuel.

[3]Larminie, J., & Dicks, A. (2003). *Fuel Cell Systems Explained*. Southern Gate, Chichester: John Wiley & Sons Ltd.

Electrical energy production



Thermal energy production

NH_3 AS FUEL

Available elec. energy:
3.7 kWh/kg-NH_3

Cathode reaction

O_2 reduction:	$^1/_2\, O_2 + 2e^-$	–>	O^{2-}

Anode reactions

NH_3 cracking:	NH_3	–>	$^1/_2\, N_2 + {}^3/_2\, H_2$

Complete NH_3 cracking at T > 450 [°C], in the presence of a nickel catalyst

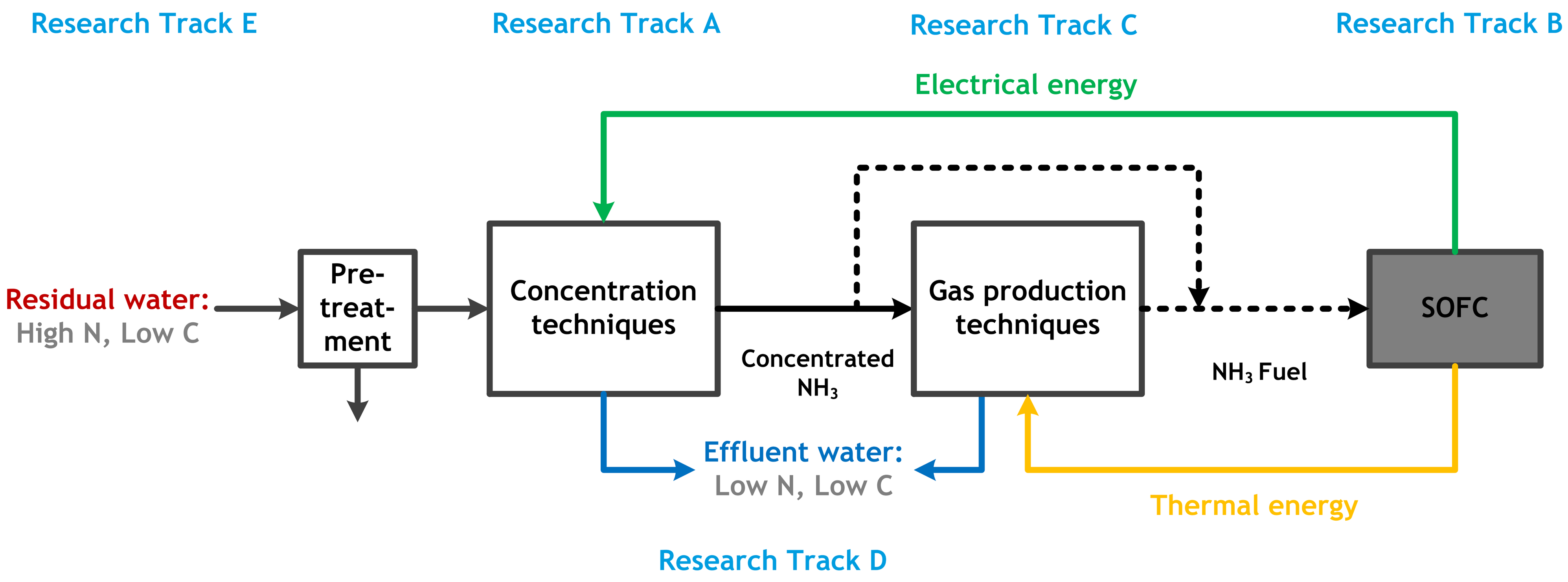
H_2 oxidation:	$H_2 + O^{2-}$	–>	$H_2O + 2e^-$

Overall reaction

NH_3 oxidation:	$NH_3 + {}^3/_4\, O_2$	–>	$^3/_2\, H_2O + {}^1/_2\, N_2$
	Reactants		Products (exhaust)

N2kWh RESEARCH

RESEARCH PLAN



RESEARCH STEPS

- Research Track A: Selection of most suitable technique to concentrate NH_3
- Research Track B: Evaluation of SOFC performance on the produced NH_3 fuel
- Research Track C: Selection of most suitable technique produce gaseous NH_3
- Research Track D: Development of a mass and energy balance tool, in order to evaluate various scenarios
- Research Track E: Implementation of the system and determine the required pre-treatment for various residual water streams

RESEARCH OBJECTIVE

Development of an energy producing system to remove NH_3 from high N, low C residual (waste) water streams using a SOFC: the energy that is required to produce the fuel should be lower than the energy produced from the fuel.

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