Low-Carbon and Climate-Resilient Pathway for Uzbekistan's Chemical and Fertiliser Industry

Low-Carbon Pathway for Navoiyazot

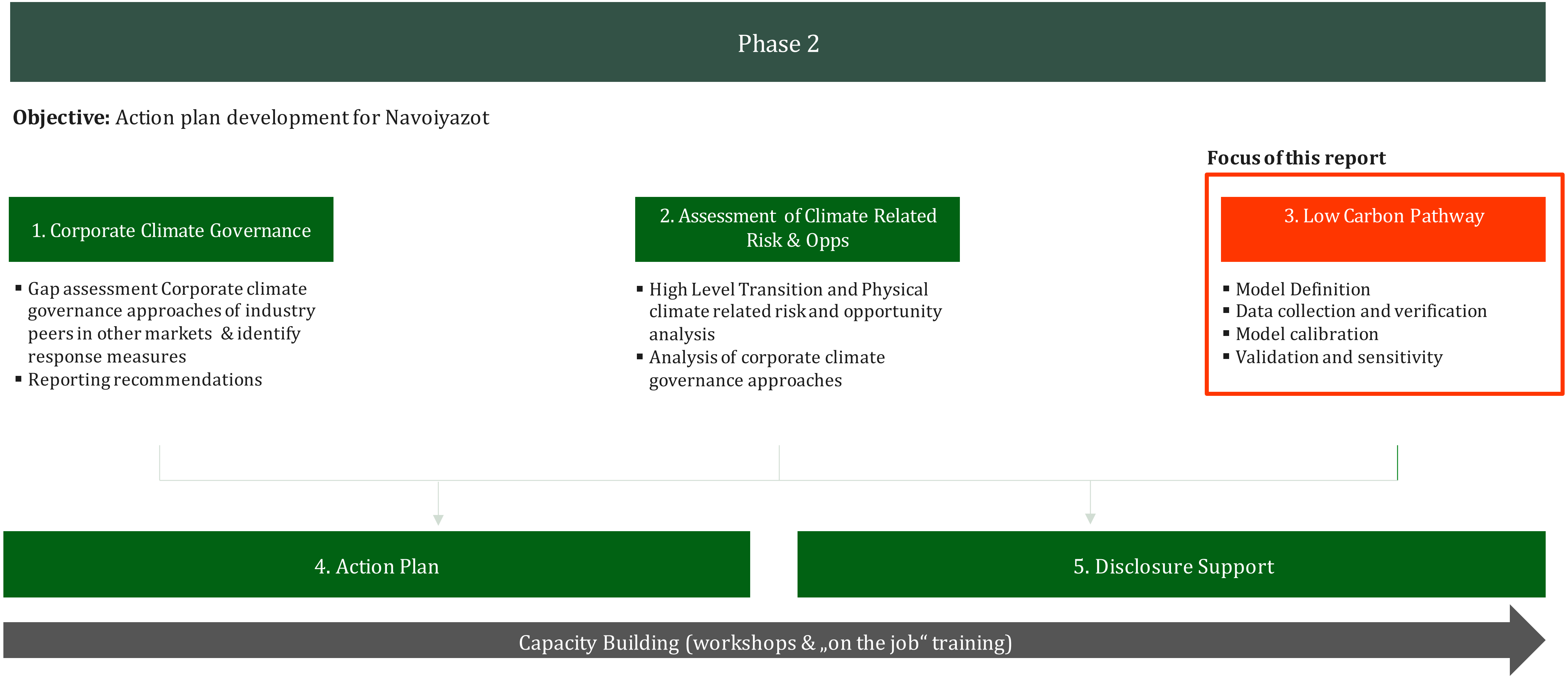
November 2023

Sustainability is our business

Introduction

1. Introduction
2. Assumptions
3. Abatement technology selection
4. Results - LCP Reference scenario
5. Sensitivity Analysis
6. Conclusions
7. Appendix

The low carbon pathway helps identify the least cost technologies to decarbonize Navoiyazot…



Phase 2

Objective: Action plan development for Navoiyazot

Focus of this report

1. Corporate Climate Governance

- Gap assessment Corporate climate governance approaches of industry peers in other markets & identify response measures
- Reporting recommendations

2. Assessment of Climate Related Risk & Opps

- High Level Transition and Physical climate related risk and opportunity analysis
- Analysis of corporate climate governance approaches

3. Low Carbon Pathway

- Model Definition
- Data collection and verification
- Model calibration
- Validation and sensitivity

4. Action Plan

5. Disclosure Support

Capacity Building (workshops & „on the job“ training)

… and when these could be implemented between today and 2050 to achieve emissions reductions

- Modelling the **low carbon pathway (“LCP”)**
  - helps to identify specific solutions to address climate impacts
  - indicates potential sources of finance to implement the decarbonisation vision
  - outlines a timeline for implementing these actions and what the decarbonisation direction should be
- The LCP identifies the **least cost** combination of **various mitigation measures** – technologies, investments, policies – that achieve the decarbonisation objectives set
- The proposed LCP will detail the contribution of each technology to decarbonisation at any given time
- The output of the LCP modelling is a pathway that shows which technologies and investments will be **required at what point in time** to achieve the Navoiyazot emissions reduction target

Overview of the steps to taken to develop the LCP

Collect Navoiyazot plant data

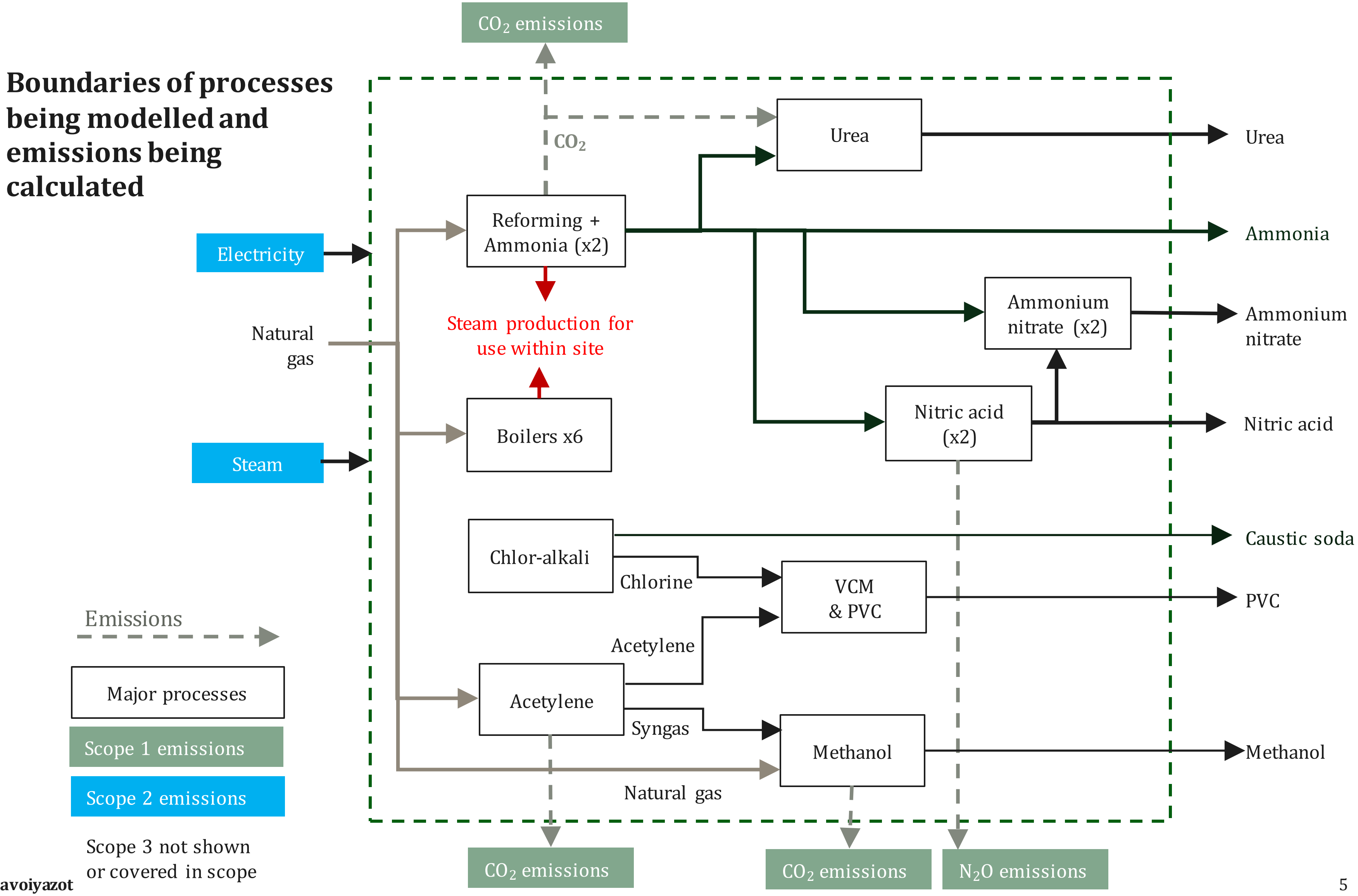
Develop “baseline“ emissions scenario

Model scenarios based on agreed target

Develop LCP

Navoiyazot is an integrated fertiliser and chemical plant based on natural gas/C1 chemistries

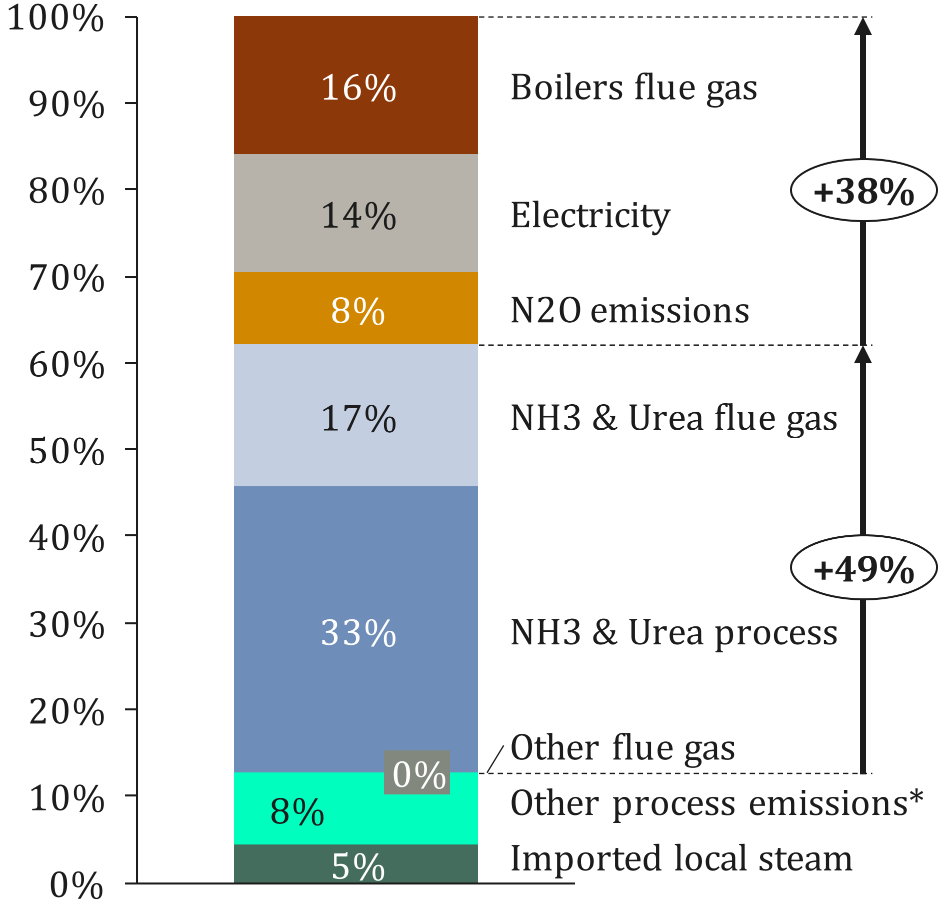
- Navoiyazot's configuration, simplified mass and energy balance, and resulting Scope 1 and 2 CO_2 emissions have been developed based on information provided by UKS
- The plant utilises natural gas for feedstock, fuel (e.g. in reformers) and for six boilers.
- The largest units (product volumes, feedstock, energy and emissions) are the reforming, ammonia and urea trains
- Scope 1 and 2 GHG emissions are primarily CO_2 and some N_2O from the nitric acid plants.



The NH_3 units are the source of the main emissions from Navoiyazot

- The NH_3 and Urea units are by far the largest emissions contributors of the Navoiyazot plant
- A third of NH_3 process CO_2 emissions are **captured in Urea** (becoming Scope 3 emissions) – not shown on the chart
- **Electricity** purchased from the Navoi power plant accounts for **14%** of total emissions
- Flue gas emissions from the **boilers** contribute **16%** of total emissions
- N_2O equivalent CO_2 emissions represent **8%** of the total emissions
- The **Acetylene/VCM/PVC/Methanol** units cumulatively contribute only **8%** of total emissions
- **Imported steam** from the Navoi power plant accounts for about **5%** of the Navoiyazot plant emissions

CO_2 equivalent emissions of the Navoiyazot plant in 2022



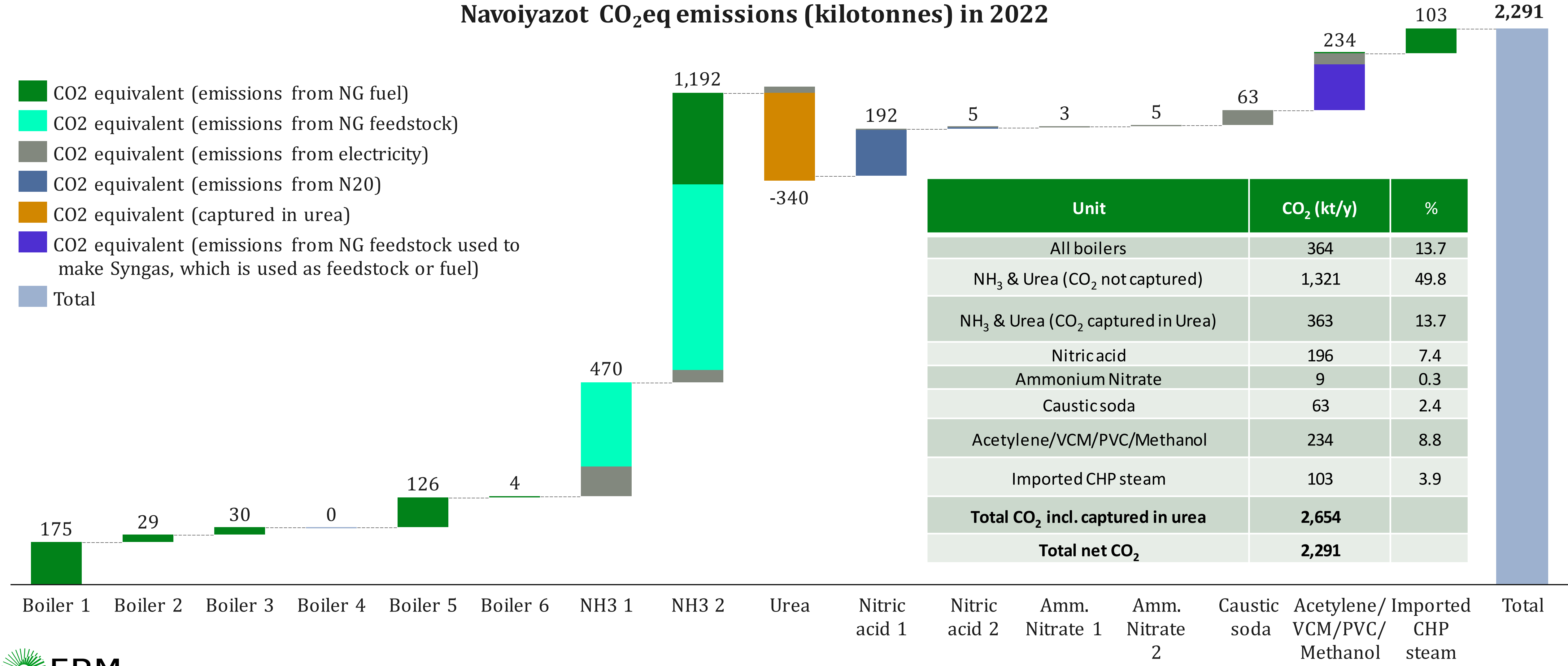
Total Navoiyazot plant emissions in 2022:
2,291kt/y of CO_2eq

* Products include Acetylene, VCM, PVC and Methanol

Natural gas used as feedstock in the SMRs is the largest source of emissions

Natural gas used as fuel also has considerable emissions contribution

Navoiyazot CO_2eq emissions (kilotonnes) in 2022



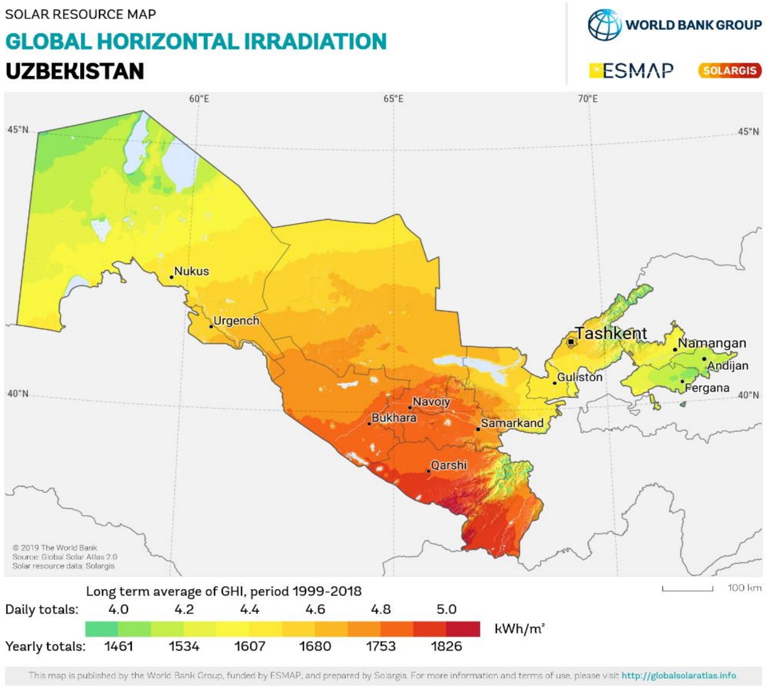
Unit	CO_2 (kt/y)	%
All boilers	364	13.7
NH_3 & Urea (CO_2 not captured)	1,321	49.8
NH_3 & Urea (CO_2 captured in Urea)	363	13.7
Nitric acid	196	7.4
Ammonium Nitrate	9	0.3
Caustic soda	63	2.4
Acetylene/VCM/PVC/Methanol	234	8.8
Imported CHP steam	103	3.9
Total CO_2 incl. captured in urea	**2,654**	
Total net CO_2	**2,291**	

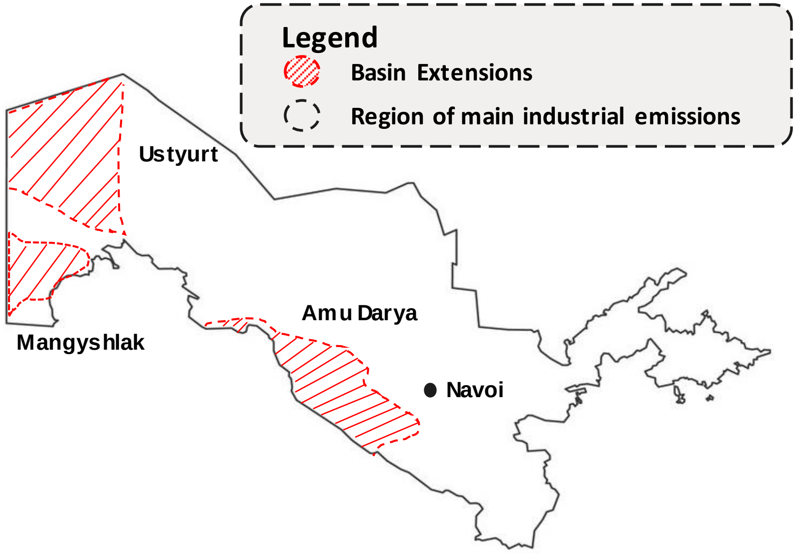
Assumptions

The technologies analysed in the LCP utilise Uzbekistan's resources

Uzbekistan's most notable energy resources relevant to Navoiyazot are solar and natural gas

- Uzbekistan benefits from **high solar irradiation** which has led to **large scale projects**. The 100-megawatt (MW) Masdar solar plant located in the Navoi region was inaugurated in August 2021. There is a pipeline of solar energy projects planned.
- Also notable are its uranium reserves (7th for reserves although this is less relevant to Navoi's LCP) and geothermal potential, although the viability of its utilisation is not well understood.
- The country has the 11th most **natural gas reserves** globally. Where natural gas is continued to be used in the LCP this will need to be paired with **carbon sequestration**. Large basins are extending into Uzbekistan from neighbouring countries, with the **Amu Darya basin** being relatively close to the Navoiyazot plant.
  - The basins in the northern part of the country are better-understood, while the Amu Darya basin has **not been explored**.
  - Potential reservoirs (depleted oil & gas fields) need to be identified and assessed to ensure that they are suitable for permanent CO_2 storage.
  - Exploration, assessment, infrastructure and policy are needed, which can severely delay CCS deployment.





A range of abatement technologies have been assessed in the LCP reference scenario (1/2)

Only the carbon capture and utilisation technology option is included in the baseline

Abatement technology assumptions

Technology	Description	CO_2e reduction % vs reference	CapEx	OpEx *	Scenario inclusion	Notes/sources
Carbon capture and utilisation (CCU)	Production of technical gas (CO_2), used in industries such as healthcare, agriculture, food	-78kta (Scope 1 to Scope 3)	$16 million	n/a	Baseline and LCP reference	Source: UKS. Implementation period: 2022 – 2025. The project is planned to be implemented by creating a joint venture with the Air Products company (USA) with the share participation of Air Products - 60% and Navoiyazot JSC - 40%.
Carbon Capture and Storage (CCS)	Technology capturing CO_2, then transporting and storing it to mitigate its impact.	95 %	Ame $221/t CO_2 *No CAPEX if >95% concentration*	$10/t CO_2 +Transport and storage tariff: $75/t	LCP reference	Storage capacity appears to be close to Navoi in the southern and western part of the country[1].
Electrolysis	Electrolysis of water to produce carbon-free hydrogen from renewable sources.		$790/kW	$24/kWh	LCP reference	Depends on the availability of renewable energies and water scarcity. *Reference capacity: 100MW*
Electric boilers	Use of renewable electricity for the generation of steam	100 %	$102/kW	$2/MWh	LCP reference	Electric boilers will use renewable electricity to provide low carbon steam. Also used to replace purchased steam

* OpEx excluding fuel use

A range of abatement technologies have been assessed in the LCP reference scenario (2/2)

Abatement technology assumptions

Technology	Description	CO_2e reduction % vs reference	CapEx	OpEx *	Scenario inclusion	Notes/sources
Methane pyrolysis	Thermal decomposition of methane into hydrogen and solid carbon.	50-70 %	$314 /$kW_{NG\ feedstock}$	$3.45 /$MWh_{NG}$ feedstock	LCP reference	Costs greatly vary depending on the design configuration used. Air-fired methane design has been used for costing and mass and energy[1].
Low carbon electricity	Use of low carbon electricity sources, such as solar	100 %	n/a (assumed purchased electricity)	Electricity cost only ($27/MWh 2023)	LCP reference	Uzbekistan government focussing on increasing the share of renewable electricity in the power mix to more than 25% by 2030[2]. This highlights the increasing availability of renewable electricity in Uzbekistan.
Electrified acetylene & hydrogen production unit	This technology uses an electric plasma reactor to convert natural gas to acetylene and H_2	75 %	$222 million	Consistent with current acetylene process	LCP reference	High cost in comparison to the partial oxidation of natural gas and lower TRL. Far higher conversion efficiency to acetylene, and lower syngas production.
Electrified SMR	Electric SMR uses electricity to raise temperature rather than natural gas	100 %	$771/$kW_{NG}$ feedstock	$3.45 /$MWh_{NG}$ feedstock	LCP reference	Lower TRL technology assumed available from the early 2030s. Provides 100% decarbonisation of SMR fuel when using renewable electricity.
N_2O abatement	SCR technology for the destruction of N_2O	90%	$1.80/$tCO_2e$ lifetime costs		LCP reference	Assisted funding from GIZ has been assumed, reducing the costs to the plant by 50%

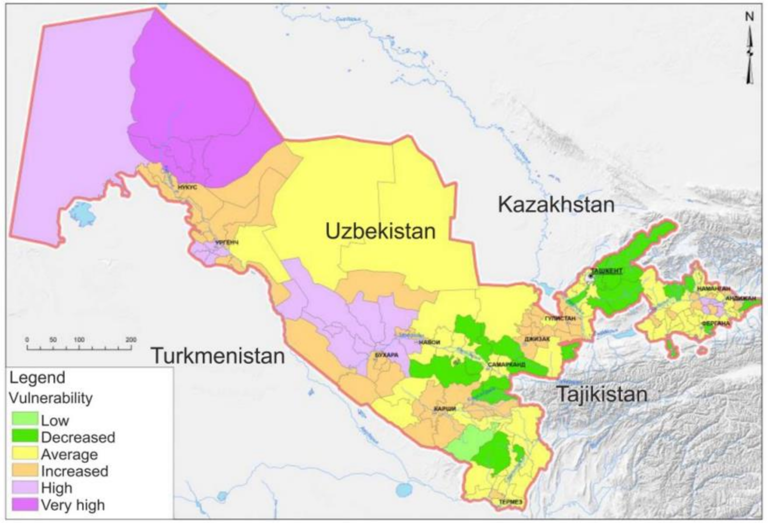
* OpEx excluding fuel use

Technology readiness level (TRL) is an indicator of the technical and commercial maturity of a technology

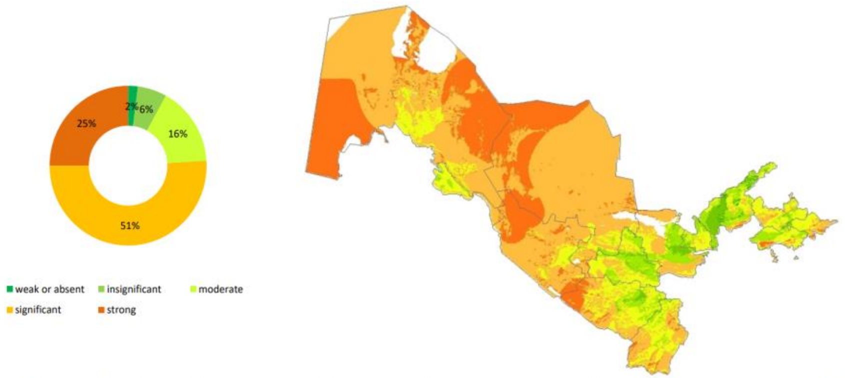
Uzbekistan is water stressed and some abatement technologies may worsen this

- Agriculture is the main consumer of water in Uzbekistan currently (more than 90% of consumption) and water demand is expected to increase further.
- Water resources in Uzbekistan are **scarce** and several regions of the country are susceptive to desertification and **drought**.
- It is estimated that water availability in the country will decrease further in the following years.
- Some emissions abatement options (e.g. electrolysis for green hydrogen) require significant amounts of water, which can contribute to the country's water stress.
- Although beneficial for CO_2eq emissions reduction, **electrolysis** can be significantly more **water-demanding** in comparison to steam methane reforming per kg of H_2 produced.

Technology	Water consumption (kg_{H2O}/kg_{H2})	
	Only SMR	+ Carbon capture
SMR	**6**	**+ 0.1 – 14.5***
Electrolysis	**15 – 20**	



Vulnerability of agriculture and water resources to climate change



Map of the territory's susceptibility to desertification and drought.

* The water consumption of a CCS technology heavily depends on the cooling technology. A closed-loop cooling technology using a cooling tower is expected to be at the higher end of the range.

Some technology options have been excluded due to constraints

Cotton stalks for bioenergy are excluded whereas cotton stalks for bio-based products should be considered by Navoiyazot

- Uzbekistan is one of the **largest cotton producers** in the world. For 65 percent of the country's rural population the main source for biomass energy is cotton-plant stems, production of which accounts for 2–3 million tonnes per year. The cotton stalks are mostly used for cooking and space heating. There is also a **trend** on the utilization of cotton stalks moving towards shredding and **mulching** into the soil
- If cotton stalks are used for bioenergy at industrial scale by Navoiyazot, they could divert these cotton stalks from residential use and mulching, causing negative social and environmental consequences. In addition, mulching and local use of cotton stalks releases less carbon than transportation and industrial bioenergy use. For these reasons, **cotton stalks** for **bioenergy** are **excluded**.
- It is technically possible to use **cotton stalks** for **bio-based products**, such as particle boards, combining with resins (e.g. urea formaldehyde resins made from urea and methanol). Bio-based products applications are more attractive as the carbon is "locked up" in the products for a longer period (e.g. in buildings) and then when disposed could be then used for bioenergy (i.e. the concept of cascading uses of biomass). This is not covered in the scope of the LCP but could be considered by UKS.

Some technology options have been excluded due to constraints

Biogas feedstocks appear to be limited close to Navoiyazot

- Biogas feedstocks need to be located within a limited radius (~30km) of the anaerobic digestion plant to support a viable economic model. Biogas feedstocks include manure, wet agricultural residues and the organic fraction of municipal solid waste. These are all thought to be **limited suitable feedstocks** in Navoi but further local biomass assessments conducted by a local team should be conducted to assess this.
- The Navoi region has an arid climate and vast deserts (shown right). The southern part is used for intensive irrigation farming, utilizing the limited water resources of the lower Zarafshan River and via the Amu-Bukhara Channel of the middle reaches of the Amu Darya.

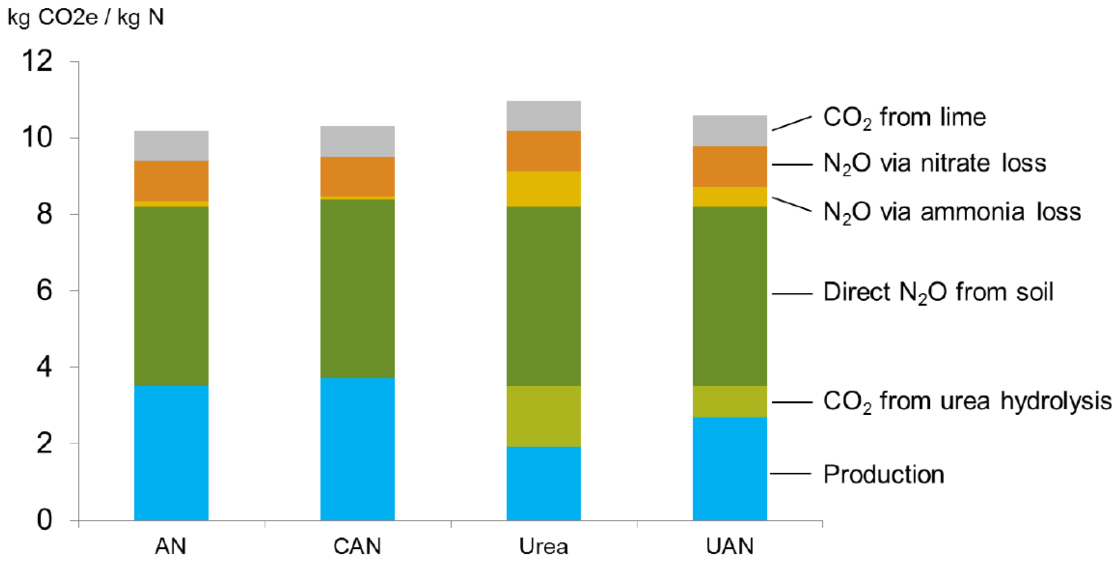
Potential biomass collection radii around Navoiyazot

Producing more urea-based fertilisers reduces production emissions but increases downstream use emissions…

…making decarbonisation more challenging as production emissions have more options to decarbonise

- One option to decrease production related emissions would be to produce more urea from captured CO_2 and ammonia, but this won't reduce lifecycle emissions
- Urea has lower emissions in production than some other fertilisers, including AN, but the CO_2 captured in this product during production is released when urea is applied (CO_2 from urea hydrolysis).
- In addition, more N_2O is emitted by urea during the nitrification process compared to ammonium nitrate (AN). In contrast, AN uses nitric acid and this can result in high N_2O emissions during production as previously discussed.
- In addition, there is precedence in EU Emissions Trading Scheme (ETS) policy for ammonia-based fertilisers for the company who generates the CO_2 to bear the responsibility. The ammonia producer must count the CO_2 when it is used for urea.

Carbon footprint of N fertiliser production and use based on default emission factors



Abatement technology selection

A discounted cash flow (DCF) model is used and considers seven abatement technologies

- The **mass and energy balances** and **emissions** of **Navoiyazot to** produce a baseline “business as usual” scenario of emissions to 2050, reflective of the industry evolution under existing policies
- The model takes account of natural gas used as fuel and feedstock as well as electricity purchased from the grid
- The model calculates emissions savings and develops cost profiles for the abatement technologies
- The model **compares the net present value (NPV) of the abatement technologies** to 2050, using a discount rate of 10%, to **arrive at the least cost mix of technologies to abate emissions** to meet the emissions reductions target. The WACC for UKS is based on a 70:30 debt:equity ratio, 17.5% for equity, SOFR+3% for debt with SOFR at 5.3% and a corporate tax rate of 15%.
- An **emissions reduction target** of 25% reduction by 2030 and 96% reduction by 2050. This is aligned with the reductions in direct emissions needed to meet the **IEA Ammonia Technology Roadmap Net Zero Emissions** by 2050 Scenario

Different LCP assumptions are modelled to enable the discussion on key parameters like RE price and water intensity of abatement options

- The “**Baseline**” scenario only includes the planned CCU project but **no other abatement technologies**.
- The “**LCP reference Scenario**” models the emissions reduction potential of **several abatement options**.

Scenario	Description
Baseline	The baseline consists of the current technologies operating until 2050 without any low carbon abatement option, except the carbon capture and utilisation project, which has reached FID. No capacity adjustments or new product lines are considered in the baseline, the product mix and volume remains as it was in 2022. The baseline provides the “counterfactual” to the LCP scenario with cost inputs as found in the following slide.
LCP reference Scenario	The LCP reference scenario consists of the abatement technologies found to be the least cost options for decarbonisation of emissions contained in the baseline up to 2050. The impact of water stress on technology availability is not considered. Costs assumed are as in the following slide.

- A “**Lower cost sensitivity**” scenario in the table below is modelled with **considerably lower RE** and **green H_2 prices**.
- Price inputs are based on large planned RE projects in Uzbekistan.

Sensitivity		Description
Lower cost sensitivity	Renewable electricity price	Lower prices for renewable electricity may be available than the price given in the LCP reference. Navoiy Solar PV Park supplies power at $27/MWh for a period of 25 years[4]. 18 USD/MWh has been awarded in Uzbekistan start up in Sherabad district, Surkhandarya region with planned start up 2024. It is assumed that the renewable electricity price starts at $27/MWh in 2023 and reduces to 18 USD/MWh by 2030.
	H_2 price	The lower H_2 price is a calculated using the lower renewable electricity price above within a H_2 pricing model. The price starts at 87 $/MWh in 2023 and reduces to 51 $/MWh by 2050.

Uzbekistan has low-cost natural gas and solar

The baseline/LCP reference case assume a constant natural gas price

Cost and price inputs

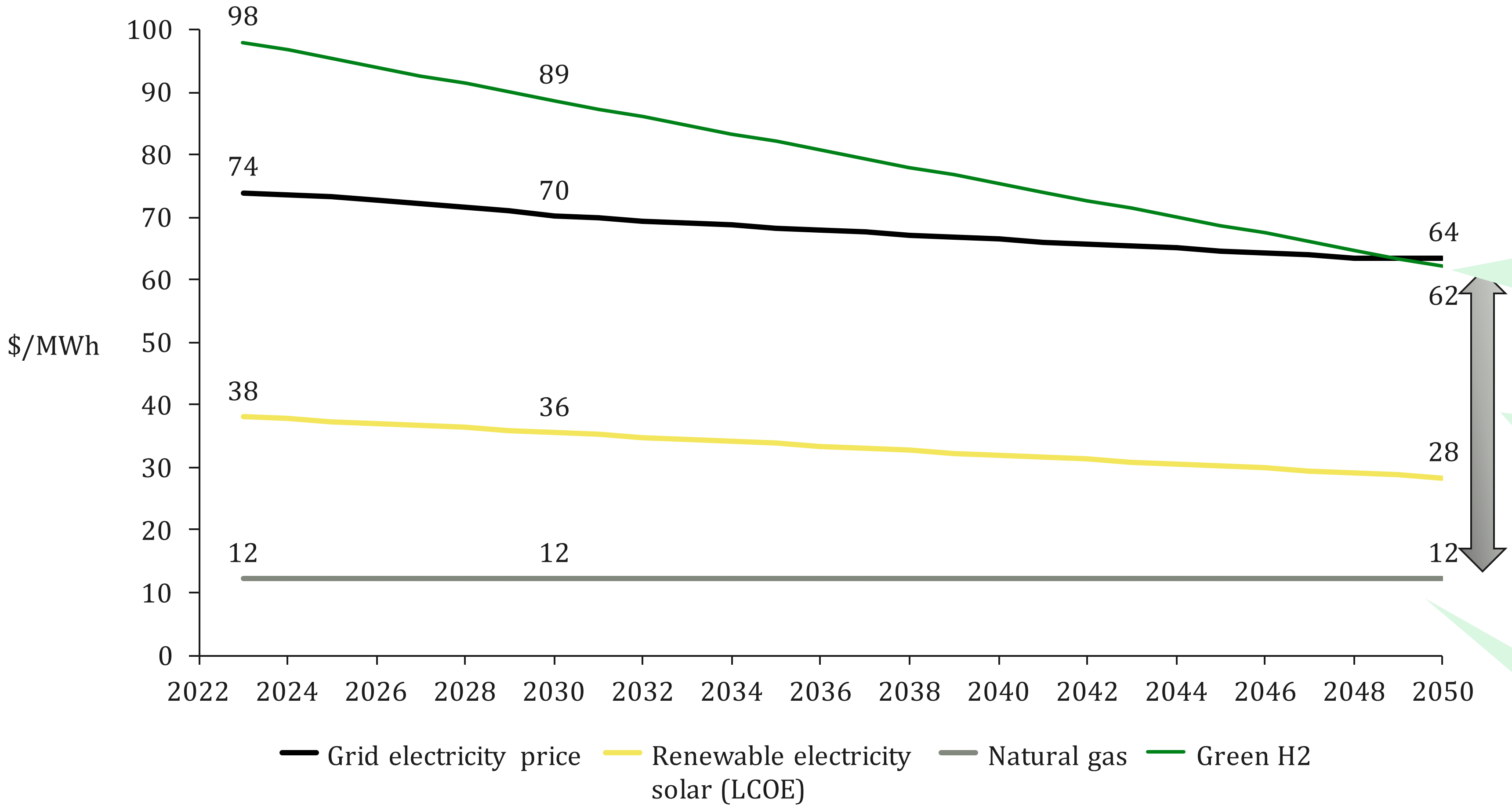
Input	Unit	Baseline/LCP		Notes/sources
		2023	2050	
Natural gas	USD/MMBtu	3.6	3.6	Based on 1,500,000 soums per 1000 m^3.* We have assumed that the gas price remains constant to 2050 in the baseline and LCP due to limited information about potential changes in price and/or market liberalization published.
Grid electricity	USD/MWh	74	64	Based on 900 soums per kWh.* Grid mixture includes 87.8% Natural gas, 7.5% Hydro, 4% Coal and 0.7% Oil. Renewable Energy share in the Uzbekistan energy mix is expected to reach 20% by 2025 and 25% by 2030[3].
Navoi power plant electricity	USD/MWh	74	74	Based on 900 soums per kWh.* Constant to 2050 as the natural gas price remains constant. All of the electricity consumed at Navoiyazot is from the local combined heat & power plant.
Renewable electricity (solar)	USD/MWh	38	28	The EBRD has provided LCOE projections, including transmission fees, for the years 2030 and 2040. Renewable energy price projections were derived through linear extrapolation.
Green Hydrogen	USD/MWh	98	62	LCOH projections have been provided by the EBRD for the years 2030 and 2040. Green H_2 price projections were derived through linear extrapolation.
Imported steam (Navoi power plant)	USD/MWh	31	31	Steam price calculated using an internal ERM model. Constant to 2050 as the natural gas price remains constant.

* Converted using exchange rate 1 soum to 0.0000819 USD1.

** Conversion of m^3 of natural gas to MMBtu using 0.3MMBTU/1000m^3.[2]

Renewable electricity and green H_2 prices are expected to decrease towards 2050

Energy price assumptions used in baseline and LCP reference scenario



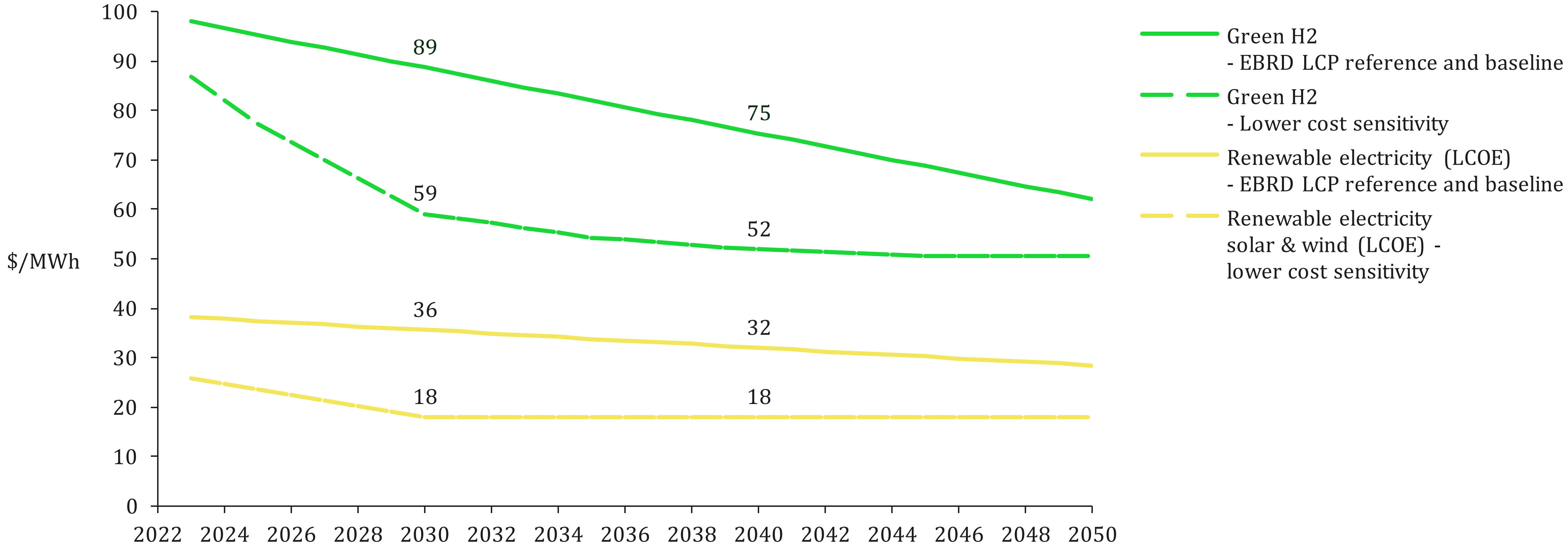
With an increasing renewables penetration in the grid, and a decreasing RE price, the overall grid price is expected to decrease[1]

The price of green H_2 (~2$/kg in 2050) remains significantly higher than natural gas.
The natural gas gap with renewable electricity is much smaller.

The low price of natural gas makes it challenging for renewable options to be competitive.

Alternative sources suggest lower renewable electricity and hydrogen costs

Alternative renewable electricity and hydrogen price assumptions



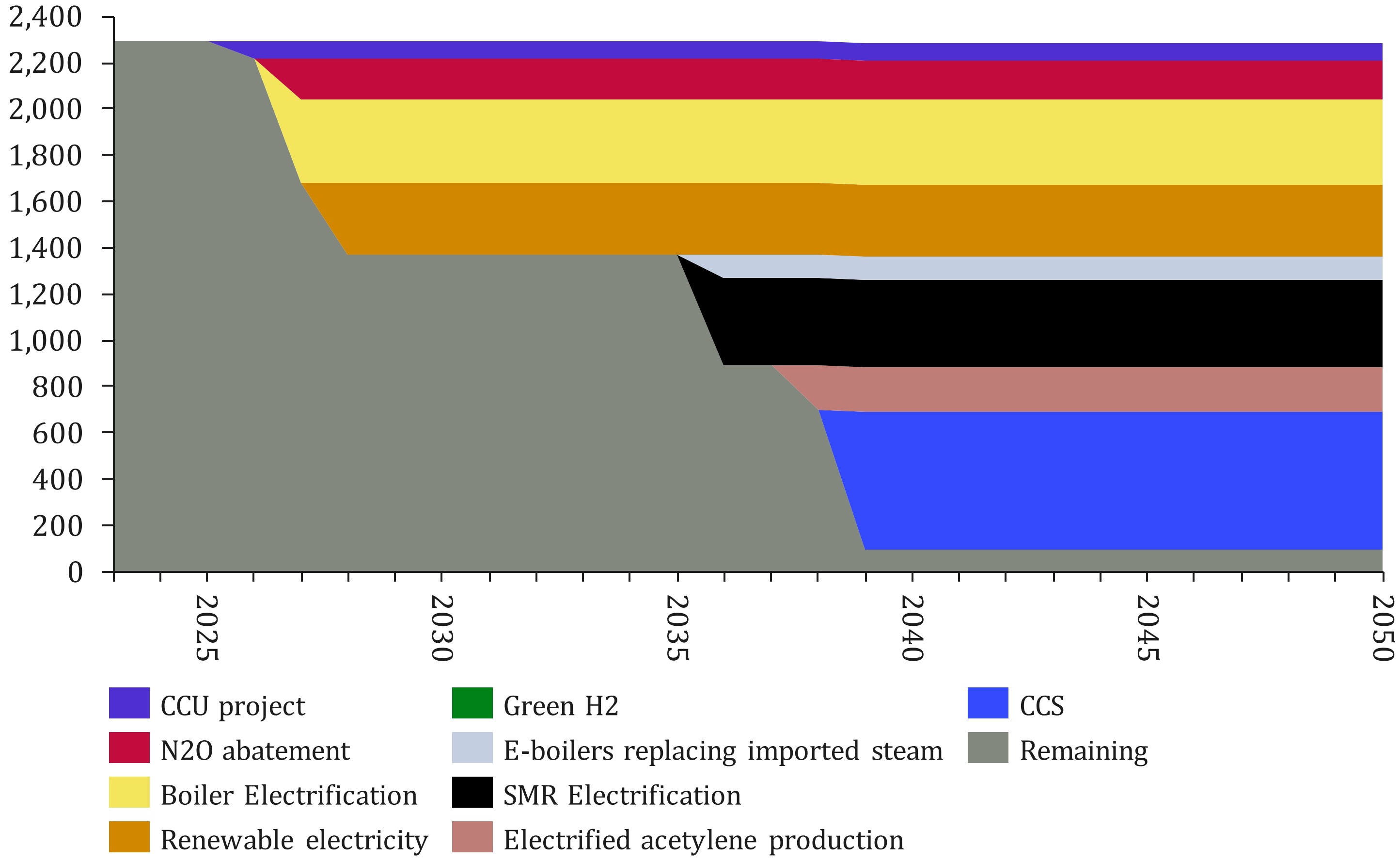
- Higher costs provided by the EBRD in Uzbekistan. However, large planned projects might provide cheaper RE.[1]
- Cheaper RE will lower the price of green H_2.
- Lower cost sensitivity prices might not represent a LCOE that includes transmission fees.

Results- LCP Reference scenario

1. Introduction
2. Assumptions
3. Abatement technology selection
4. Results - LCP Reference scenario
5. Sensitivity Analysis
6. Conclusions
7. Appendix

The LCP includes several technologies with significant introduction of renewable electricity and carbon capture and storage (CCS)

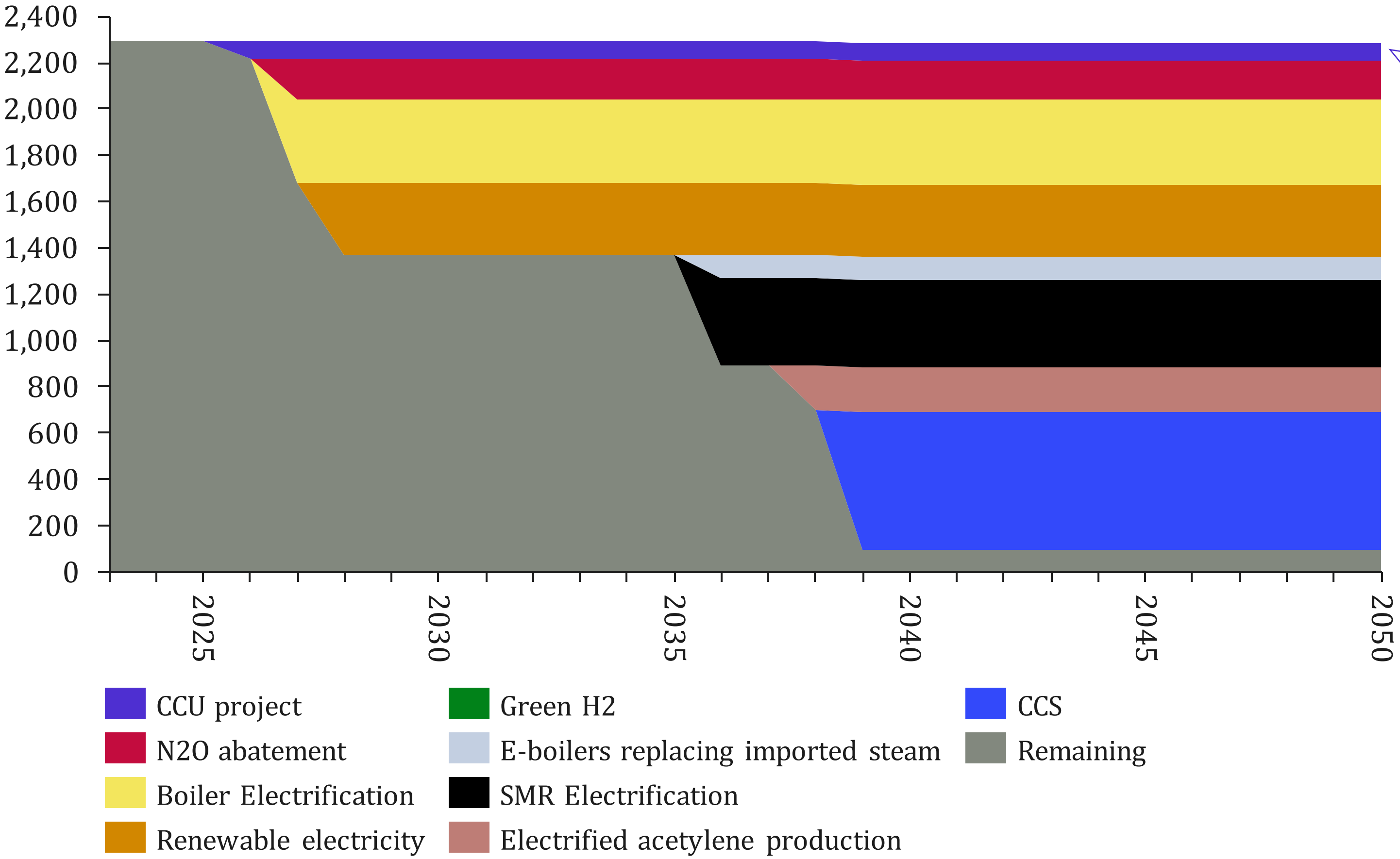
Production emissions reductions by abatement technology (ktCO$_2$ / yr)



- The LCP reference scenario abates **~96% of 2023** plant emissions by **2050**
- The pathway suggests **N$_2$O abatement and boiler electrification** should be **implemented quickly**
- The pathway has a strong reliance on **renewable electricity** and **CCS** to achieve decarbonisation:
  - Renewable electricity for heat and power: 5.6 TWh/yr
    - Equivalent to 9% of 2019 electricity production in Uzbekistan[1]
    - UKS has previously reported 0.4 TWh/yr (7% of the forecast requirement) could be met with onsite solar
    - 2.1TWh/yr of RE (37.5% of the forecast requirement) is planned for the Navoi region.
  - CCS transport & storage infrastructure required for 600 kt CO$_2$/yr
- Significant **infrastructure developments** will be **required** to achieve this LCP, related to renewable energy and CCS

The planned technical gas (CCU) projects abates 3% of plant emissions

Production emissions reductions by abatement technology (ktCO$_2$ / yr)

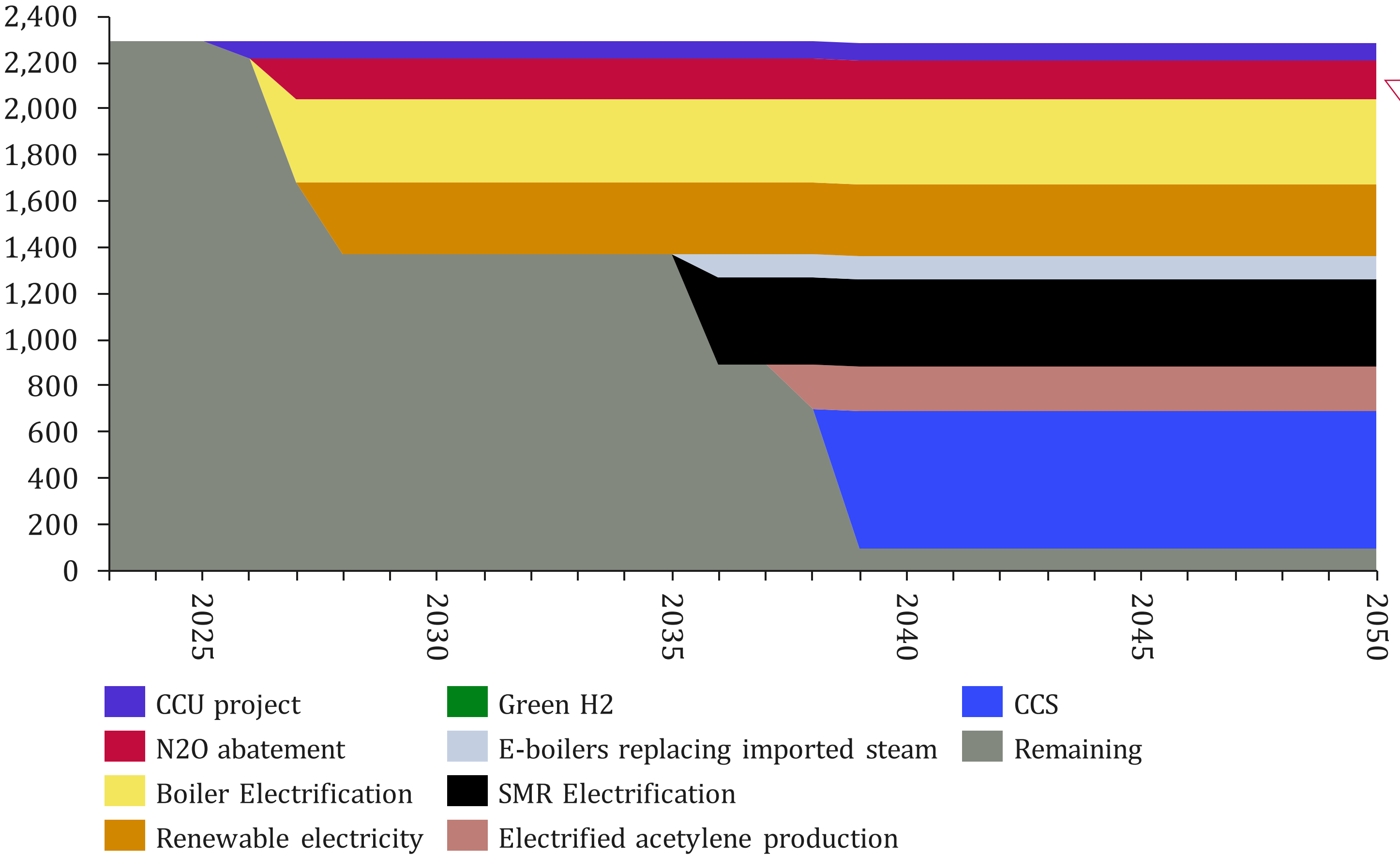


CCU project

- This project saves Scope 1 emission - 78 ktCO$_2$/year of emissions will be taken from the newer NH$_3$ line.
- CO$_2$ used in industries such as healthcare, agriculture and food
- The project is planned to start in 2026
- As part of the baseline, it has no costs attached to it

N_2O destruction technology could readily abate up to 8% of the total CO_2eq emissions of the Navoiyazot plant

Production emissions reductions by abatement technology (ktCO_2 / yr)

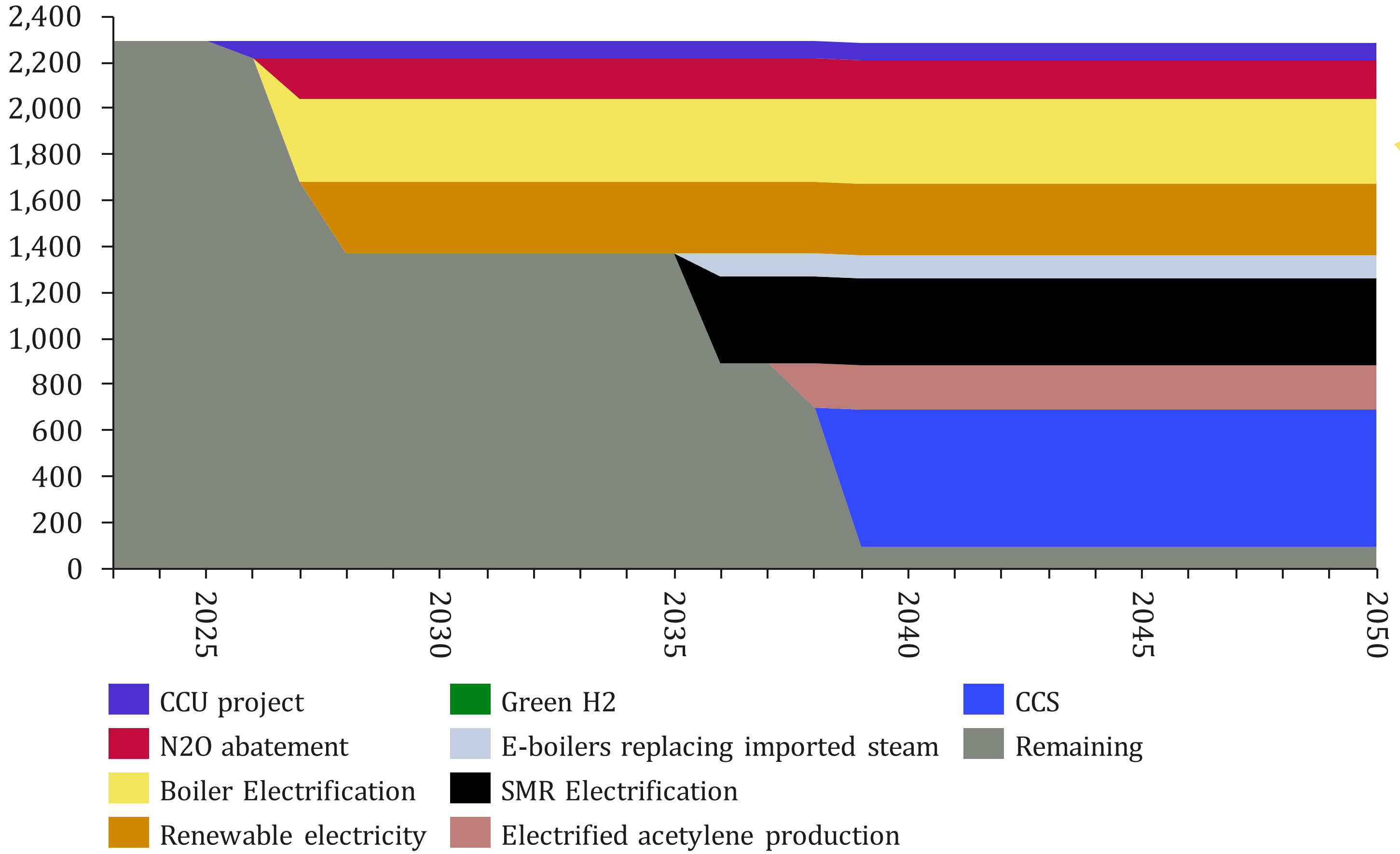


N_2O abatement

- N_2O abatement technologies are technologically and commercially mature
- Only one of the two nitric acid lines currently uses N_2O destruction/abatement technology
- Modern Selective Catalytic Reduction (SCR) technology at the second nitric acid line is modelled to remove 90% of N_2O emissions
- SCR is readily available and assisted funding from GIZ has been assumed in the costing to reduce the costs to the plant by 50%

Boiler electrification can abate a significant amount of CO_2 emissions by replacing natural gas with renewable electricity

Production emissions reductions by abatement technology ($ktCO_2$ / yr)

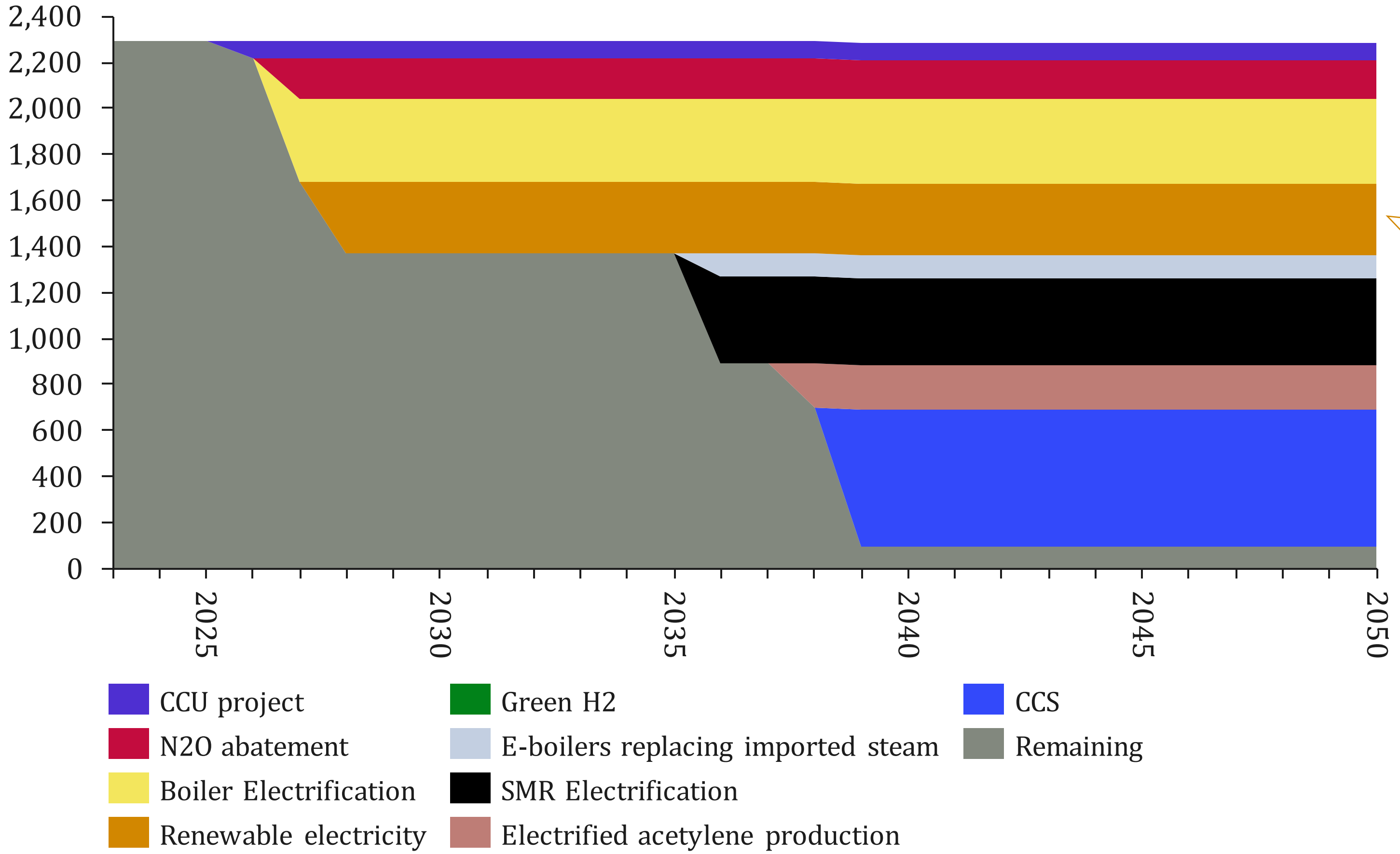


Boiler electrification

- Natural gas boilers replaced with commercially mature electric boilers use renewable electricity for steam production
- This can be a low-cost way of abating fuel natural gas emissions, and does not require significant re-engineering of plant heat systems
- This option requires significant grid upgrading and rollout of several renewable energy projects

Renewable electricity could reduce emissions by 14% but will require fast action to increase grid capacity

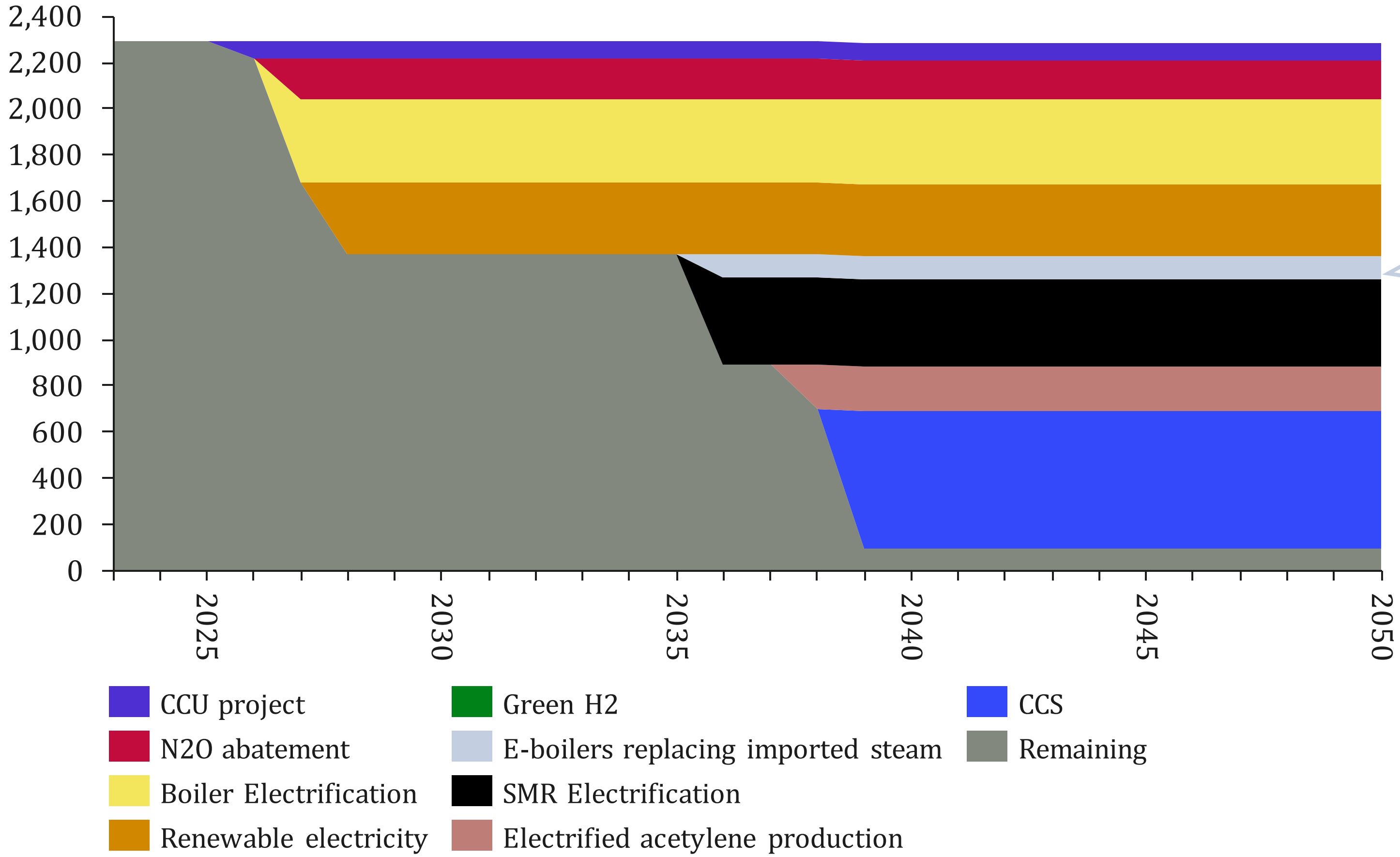
Production emissions reductions by abatement technology (ktCO$_2$ / yr)



Renewable electricity

- Uzbekistan has high potential for low-cost renewable electricity via solar and wind
- Renewable electricity purchased via contracts and/or dedicated UKS owned projects to replace fossil electricity consumption of the plant is assumed

Emissions from current purchased steam can be abated by increasing onsite steam production via electric boilers

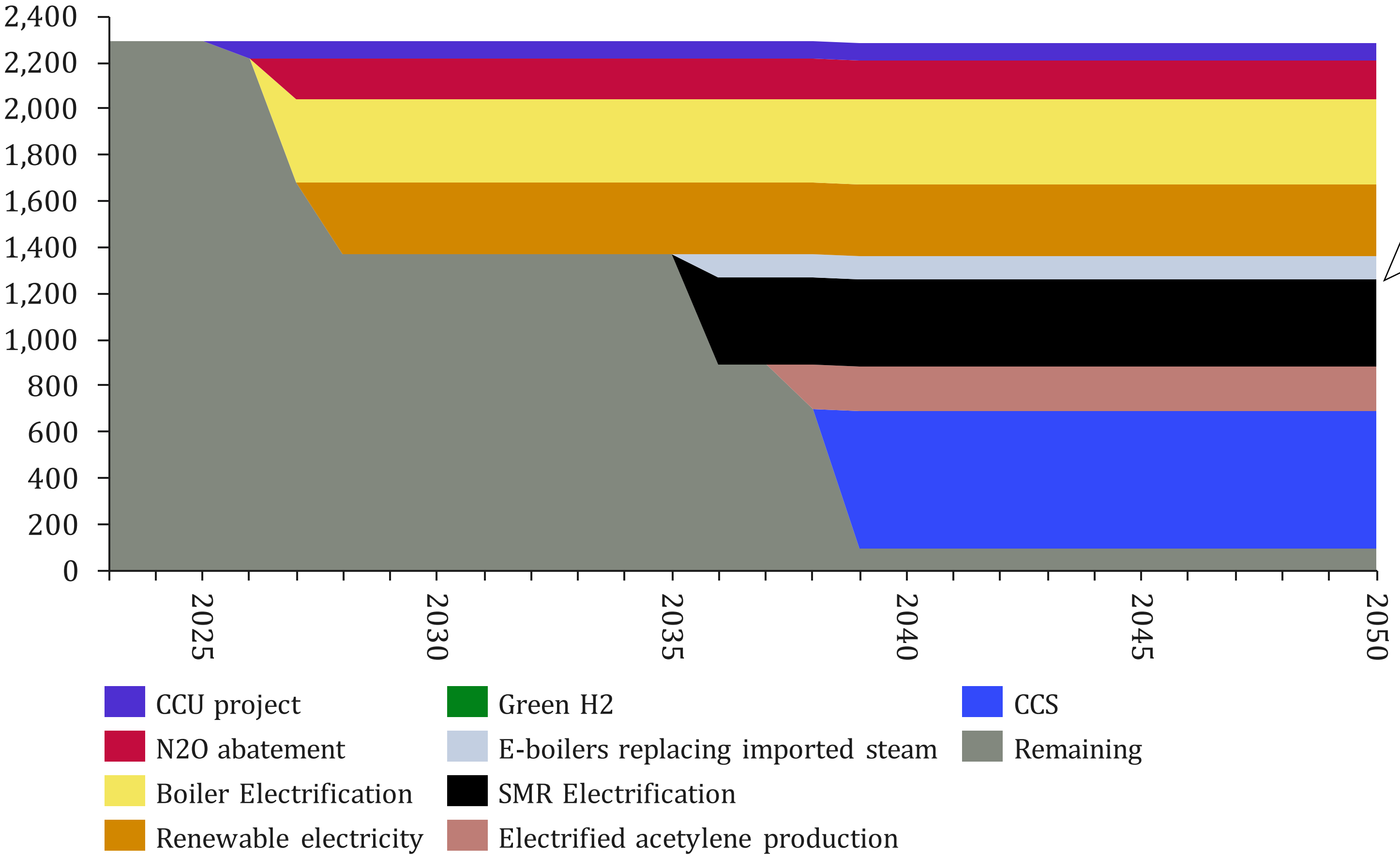

Production emissions reductions by abatement technology (ktCO$_2$ / yr)

Decarbonisation of imported steam via electric boilers

- Increase of on-site steam production from electric boilers to replace the steam imported from the local power station
- Assumed to be in operation from 2035 to ensure adequate electric boiler capacity has been developed
- Electric boilers are a technologically and commercially mature option

Emissions from the SMR heating demand can be abated using an electric SMR, expected to be commercially available in the late 2030s

Production emissions reductions by abatement technology (ktCO$_2$ / yr)

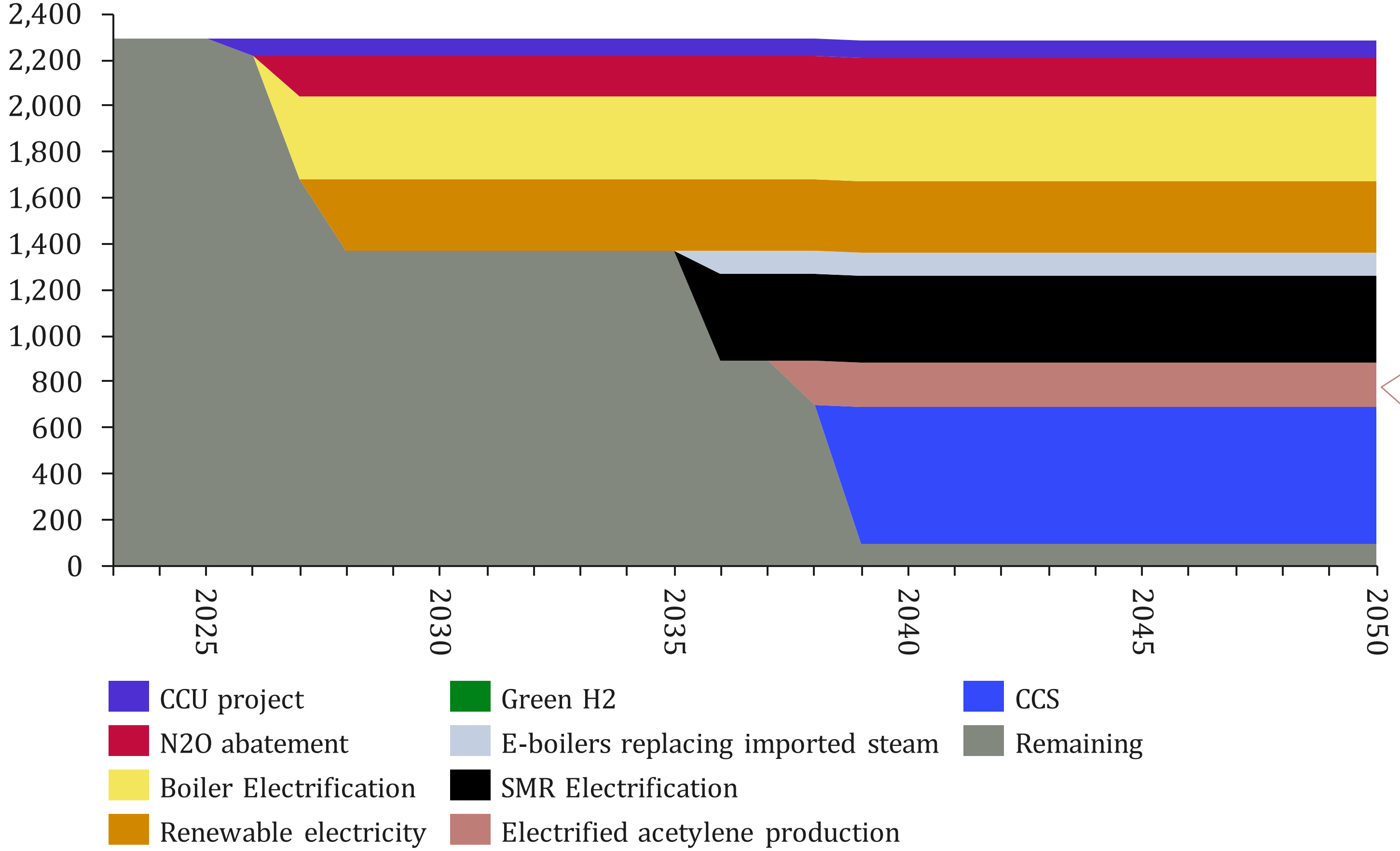


SMR electrification

- SMR electrification uses renewable electricity to heat the SMR reactor
- Electrified SMR technologies are not yet available commercially, although demonstration plants have been put into operation
- It is assumed that electrified SMRs are commercially mature at the end of the 2030s
- SMR electrification cost assumptions make it a lower cost abatement option than flue gas CCS

Novel electric technology producing acetylene and H_2 can decarbonise current excess emissions from syngas

Production emissions reductions by abatement technology (ktCO$_2$ / yr)



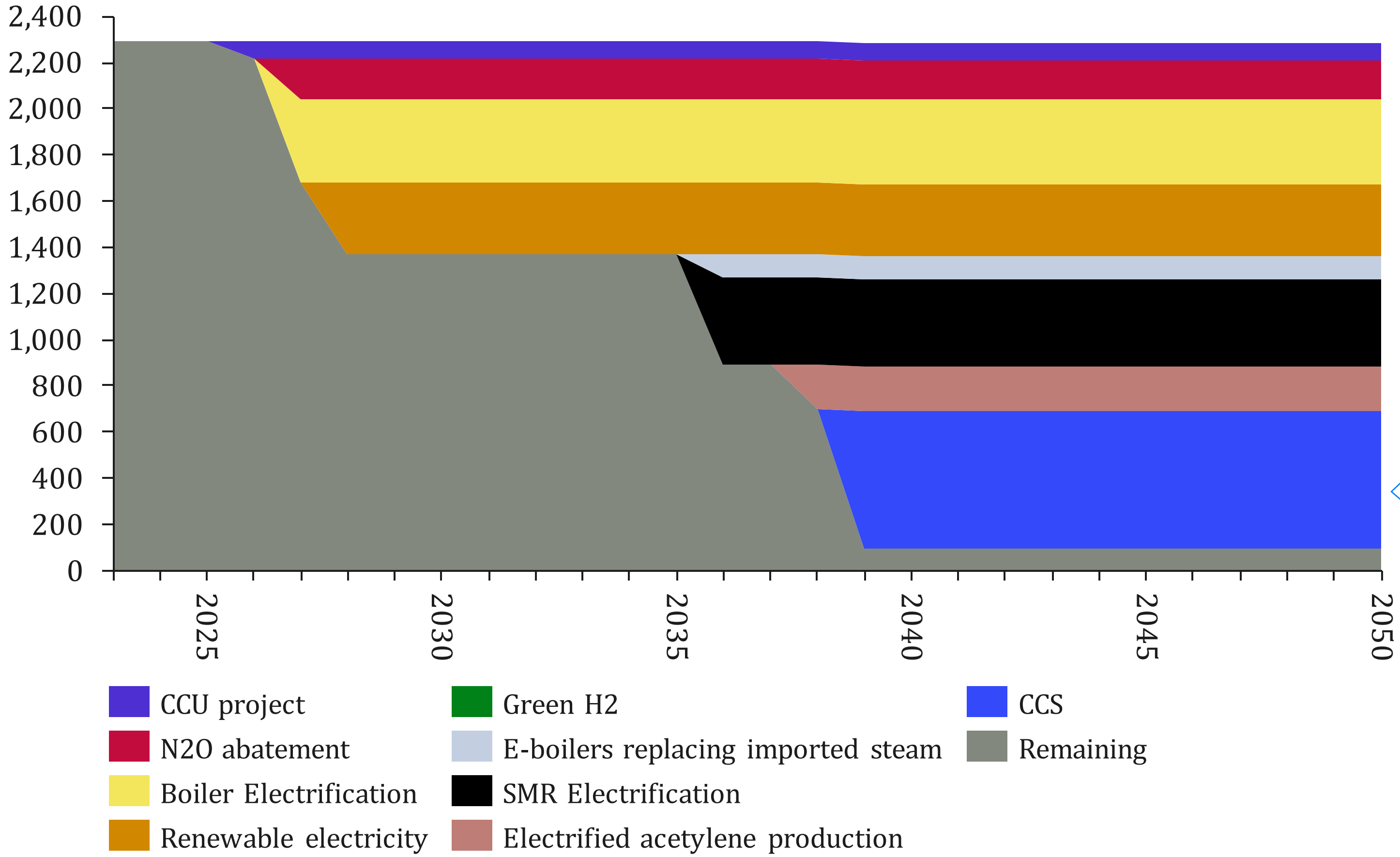
Electrified acetylene production

- Electrified acetylene technology, such as that developed by Transform Materials[1], can displace natural gas feedstock emissions
- An electric plasma reactor to convert natural gas to acetylene and H_2. This is a novel and relatively expensive option based on today's costs estimates
- The current acetylene process produces steam from excess syngas. In this option, this steam is covered by electric boilers using renewable electricity
- Carbon monoxide used for methanol production is expected to be replaced with SMR syngas

[1] Transform Materials. www.transformmaterials.com

CCS can abate significant NH_3-related emissions but is not expected to come online before 2038 due to infrastructure requirements

Production emissions reductions by abatement technology (ktCO$_2$ / yr)

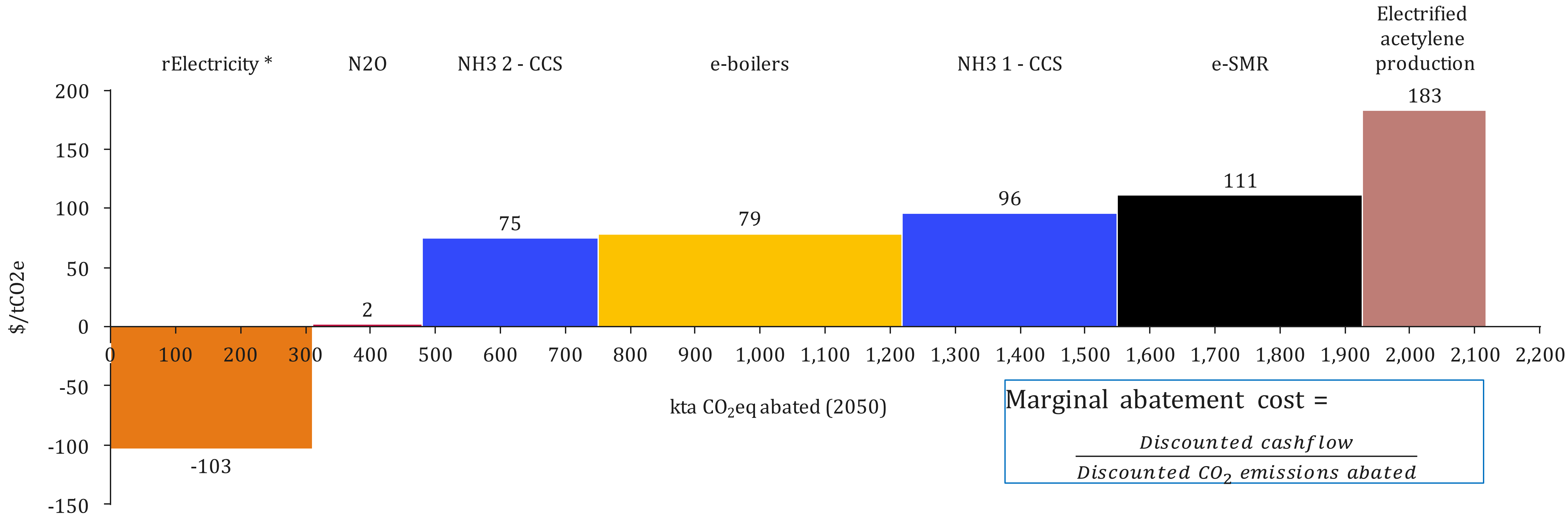


CCS

- CCS is applied to the two ammonia lines, abating the CO_2 originating from the feedstock natural gas
- Capturing high-concentration CO_2 emissions from the SMR process (already being captured in the newer NH_3 line), transporting and storing them is relatively low-cost
- CCS at the older ammonia line remains the lowest cost option, despite the need for additional capture equipment (due to the lower CO_2 concentration)
- Significant investment and coordination is needed across the CCS value chain. Thus, this option is considered only after 2038
- Major legislation might be needed across the entire CCS value chain, similar to the EU CCS directive*

* The CCS Directive lays down extensive requirements for selecting sites for CO_2 storage. A site can only be selected if a prior analysis shows that, under the proposed conditions of use, there is no significant risk of leakage or damage to human health or the environment. [1]

LCP marginal abatement cost highlights the relative cost of each technology and attractiveness of switching to renewable electricity



Marginal abatement cost =

$$\frac{Discounted\ cashflow}{Discounted\ CO_2\ emissions\ abated}$$

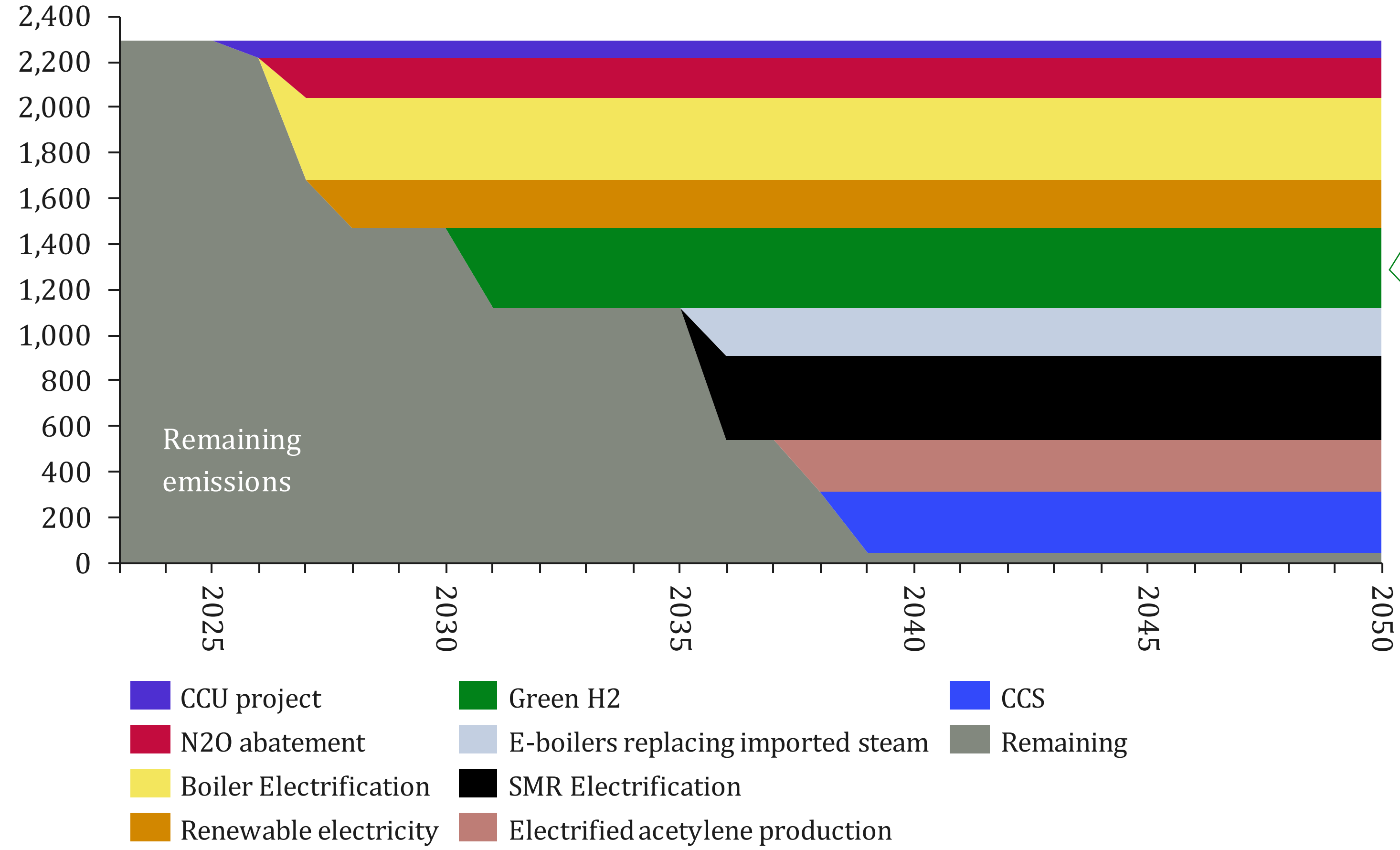
- The overall marginal abatement cost for the LCP is **$34/t CO_2eq** – this is the weighted average over the entire lifetime of the LCP
- Decarbonising current electricity consumption with renewable electricity is by far the lowest cost technology option and can be implemented early in the LCP
- There is additional cost to CCS for the older NH3 unit (NH3 1) due to the lower concentration of the CO_2

* rElectricity refers to the replacement of all fossil electricity requirement of the plant with renewable electricity.

Sensitivity Analysis

The Low RE price scenario considers lower cost renewable electricity and green H_2 – resulting in green H_2 utilisation in the pathway

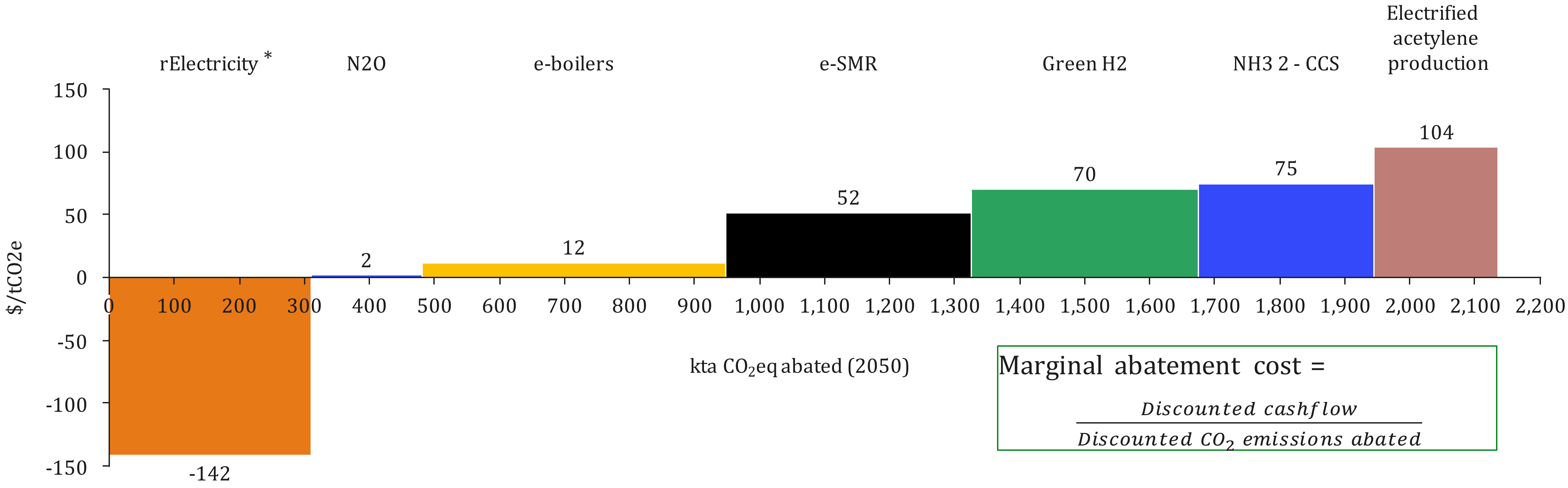
Production emissions reductions by abatement technology (ktCO_2 / yr)



Green H_2

- In this scenario, **green H_2 is selected over CCS** to decarbonise the **older NH_3 unit**
- We assume that green H_2 becomes readily available after 2030 when it has been proven at scale
- We assume that green H_2 is made with 100% renewable electricity, operating at high utilization
- Green H_2 displaces far more NG in the older NH_3 unit and is relatively cheaper, due to lower NG/H_2 efficiency. CCS is still the preferred option for the newer NH_3 unit
- The **water intensity** of **green H_2** should be **considered** in a water-stressed country like Uzbekistan

Lowering the renewable electricity and H_2 price lowers marginal abatement cost and makes green H_2 more attractive



$$\text{Marginal abatement cost} = \frac{\mathit{Discounted\ cashflow}}{\mathit{Discounted\ CO_2\ emissions\ abated}}$$

- The overall marginal abatement cost for the sensitivity pathway is **\$-1/t CO_2eq** – this is the weighted average over the entire lifetime of the LCP
- Lowering the price of renewable electricity and green H_2 reduces the marginal abatement cost of most technologies (except for N_2O abatement and CCS)
- The cost of green H_2 (\$70/tCO_2eq) is lower than the cost of CCS (\$96/t CO_2eq) under the LCP reference scenario for the older NH3 unit (NH3 1) causing the switch from CCS to green H_2 for emissions abatement

* rElectricity refers to the replacement of all fossil electricity requirement of the plant with renewable electricity.

Conclusions

Conclusions and next steps for UKS, EBRD and government

- A low carbon pathway (LCP) has been developed providing decarbonisation of **Navoiyazot fertiliser** and **chemical facility** by 2050
- The LCP reference scenario (using base case cost assumptions) **relies heavily** on the use of **renewable electricity** in the **short term** and on **carbon capture and storage (CCS) longer term**
  - **Replacement** of **fossil** sourced **electricity** with renewable electricity and **electrification** of key process equipment such as boilers and acetylene production occurs, whilst CCS is used to abate CO_2 emitted from the ammonia production lines
  - The total renewable electricity consumption in 2050 under the LCP reference scenario is 5.6 TWh/yr. Implementation would require **significant development of grid infrastructure** and roll out of renewables in Uzbekistan. Some of the demand may be met with on-site solar (UKS has reported a potential 0.4 TWh/yr) and some with planned RE projects in the Navoi region (2.1TWh/yr of RE is planned for the Navoi region).
  - Potential **CCS storage sites** have been **identified** in **Uzbekistan**, and in relative proximity to Navoiyazot. However, rigorous **geological surveys need** to be **performed** to understand their true potential for long term storage. Further **CO_2 transport infrastructure** also needs developing. This will require co-ordination and investment from multiple industry and government stakeholders
- **N_2O abatement** is shown to be a low-cost technology, available today and able to achieve significant emission reductions. This should be **prioritised** as a short-term decarbonisation option
- A lower electricity cost sensitivity scenario was also developed using lower renewable electricity and green H_2 prices. Under this scenario there is a **significant reduction** in the overall **cost of decarbonisation**. **Green H_2** is also **selected** to decarbonise the older NH_3 line in preference to CCS
  - Green H_2 and CCS (depending on the cooling technology used) can have a high-water footprint but **water resources** in **Uzbekistan** are **scarce** and several regions of the country are susceptive to desertification and drought. Careful consideration should be taken of this potential barrier when implementing these options

Appendix

Some carbon is captured in the products, but natural gas used as feedstock remains by far the main emissions contributor.

Emission source or sink	Consumption/ production (per year)	Units	Emission factor (kt CO2/GWh)	Navoiyazot CO_2eq emissions in 2022 (kt/y)
Natural gas (fuel)	3,671	GWh	0.202	741
Natural gas (feedstock) emission potential*	7,549	GWh	0.202	1,525
Urea	495,549	t Urea	0.733 (t CO_2/ t Urea)	-363
Natural gas feedstock carbon contained in other products	59,205	t Carbon	3.67 (t CO_2/ t C)	-217
Electricity (from Navoi CHP plant)	796	GWh	0.391	311
Steam (from Navoi CHP plant)	265	GWh	0.391	103
N_2O emissions (CO_2 equivalent)	720	t N_2O	265 (t CO_2eq/t N_2O)	191
			Total net CO_2eq emissions	**2,291****

* Feedstock carbon not contained within products is assumed to be fully oxidised and emitted as CO_2.

** Emissions may be higher compared to emissions calculated and provided by UKS because:

- Electricity and steam emissions were not accounted
- N_2O emissions were not accounted for
- Products portfolio was slightly different
- Product volumes (most importantly NH_3) were slightly lower

Technology Readiness Level (TRL) is a widely used concept for ranking the maturity of technologies

- Technology readiness level (TRL) is used as an indicator of the technical and commercial maturity of a technology
- TRL is usually graded 1-9 and indicates which stage a technology is on its development from laboratory to full scale commercial operation
- A technology with a TRL score of 8-9 will be commercially available today, whereas those with lower scores will take longer before they are commercially available

TRL	Definition
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies)

Compensating residual emissions

The **credible** Net Zero journey requires you to:

SCIENCE BASED TARGETS

1

Set the ambition

- **Understand** your baseline and ‘business as usual’ emissions forecast
- **Plan** the journey and assess the decarbonization levers available
- **Communicate** your ambition & timeline to achieve Net Zero.

2

Decarbonize (≥90% of emissions*)

- 4.2% reduction per year (scopes 1 & 2 own operations)*
- 2.5% per year (scope 3)*
- 90% overall reduction by 2050*

3

Compensate for residual emissions by removing CO_2 from the atmosphere

- **Invest** directly in nature-based projects or removal technologies
- **Purchase** certified removal units

**Based on SBTi. For near term targets. For longer term targets, a 90% reduction is required.*

Types of compensation projects

1 **Nature based Solutions**
reduce carbon emissions and store more carbon in the landscape (e.g., forest and peatland conservation, reforestation, grasslands and mangroves)

2 **Society, Health and Livelihoods**
boost social impact and create economic opportunity (e.g., clean water and sanitation, efficient cookstoves, biogas)

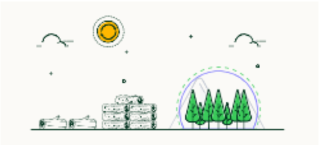
3 **Technology and Sustainable infrastructure**
avoid GHG emissions and reduces the use of fossil fuels (e.g., solar energy, wind and hydro power, biomass conversion, DACCS)

Types of Nature based Solutions projects

Afforestation, Reforestation, Revegetation (ARR)

These projects fall under the "removals" category. They tend to convert degraded and barren land through tree-planting.

Example: restoring a rainforest and ecosystem by replanting trees. These projects can also offer numerous co-benefits for local communities and biodiversity since they can provide jobs and increase biodiversity. This long-term ambition can span from 20 up to 100 years.



Improved Forest Management (IFM)

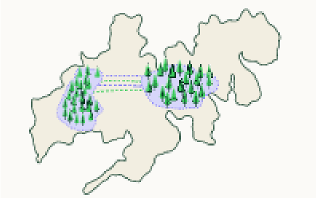
IFM projects aim to better maintain current forest stock during logging activities.

Example: managing a mature forest with selective timber harvesting in combination with activities to maintain the mature forest cover, increasing the carbon sequestration. 90% of these projects are located in the USA and Mexico, with over 65% based in the US.

Blue carbon projects

These projects focus on the restoration and conservation of coastal and marine ecosystems.

Example: mangroves sequester large amounts of carbon, making them powerful and biodiverse carbon sinks.



Jurisdictional and Nested REDD+

Jurisdictional initiatives aim to establish forest baselines at jurisdictional (i.e., region or country) levels, in order to enable more accuracy and a greater scale of impact.

Example: Jurisdictional crediting mechanisms include ARTTREES (used by the LEAF Coalition), Verra JNR and the California Tropical Forest Standard; and results-based financing mechanisms like FCPF World Bank and Green Climate Fund also operate at the jurisdictional scale.

To date, no jurisdictional credits have entered the market, but issuances are expected to grow very significantly in the years ahead.

Regenerative agriculture

Increasing above and below ground carbon in agricultural areas, through a variety of practices including manure application, returning compost residuals to fields, covering crops and introducing trees to landscapes. This also includes projects for which a change in agricultural practices to more sustainable ones can result in emission reductions

Example: stopping the use of synthetic pesticides and fertilizers or improving biodiversity and crop rotation by moving away from monocultures.