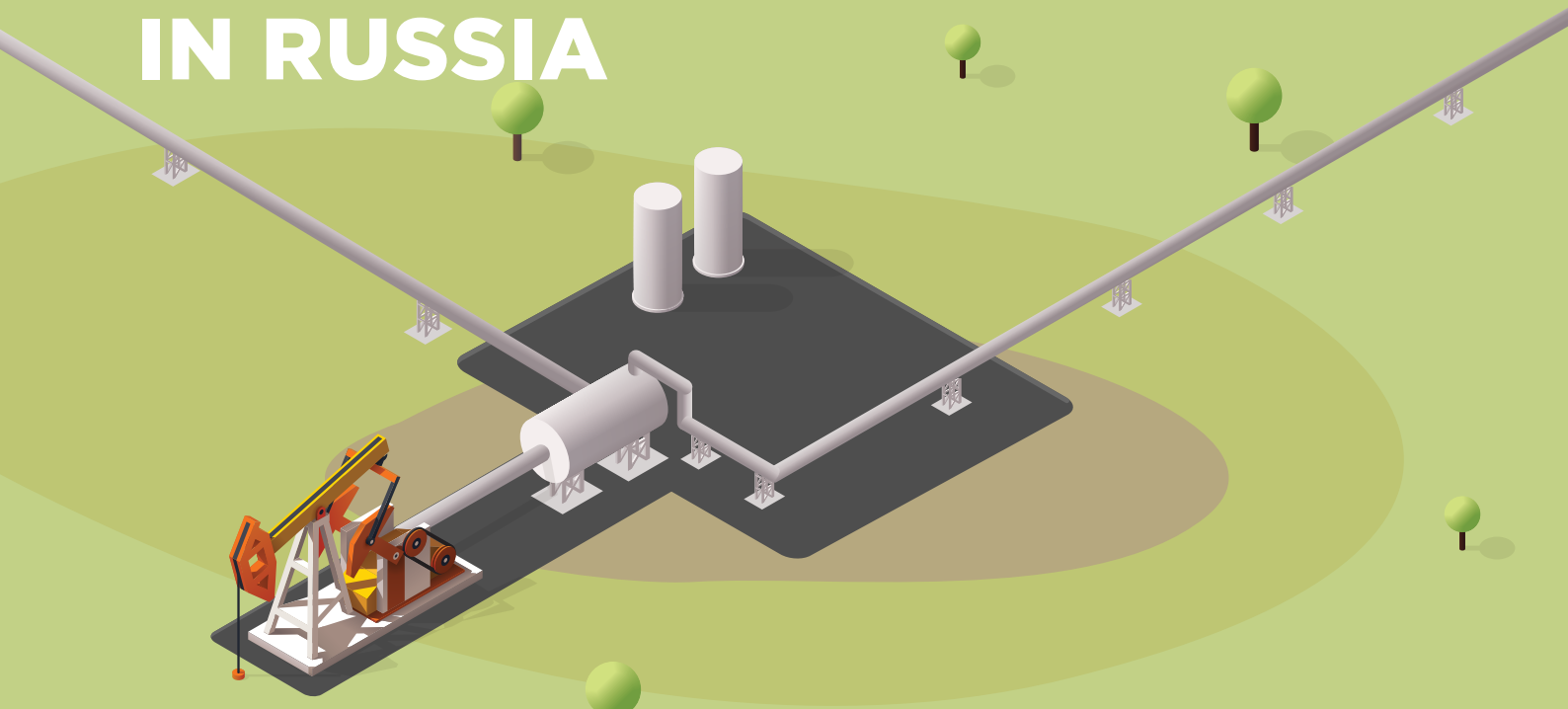
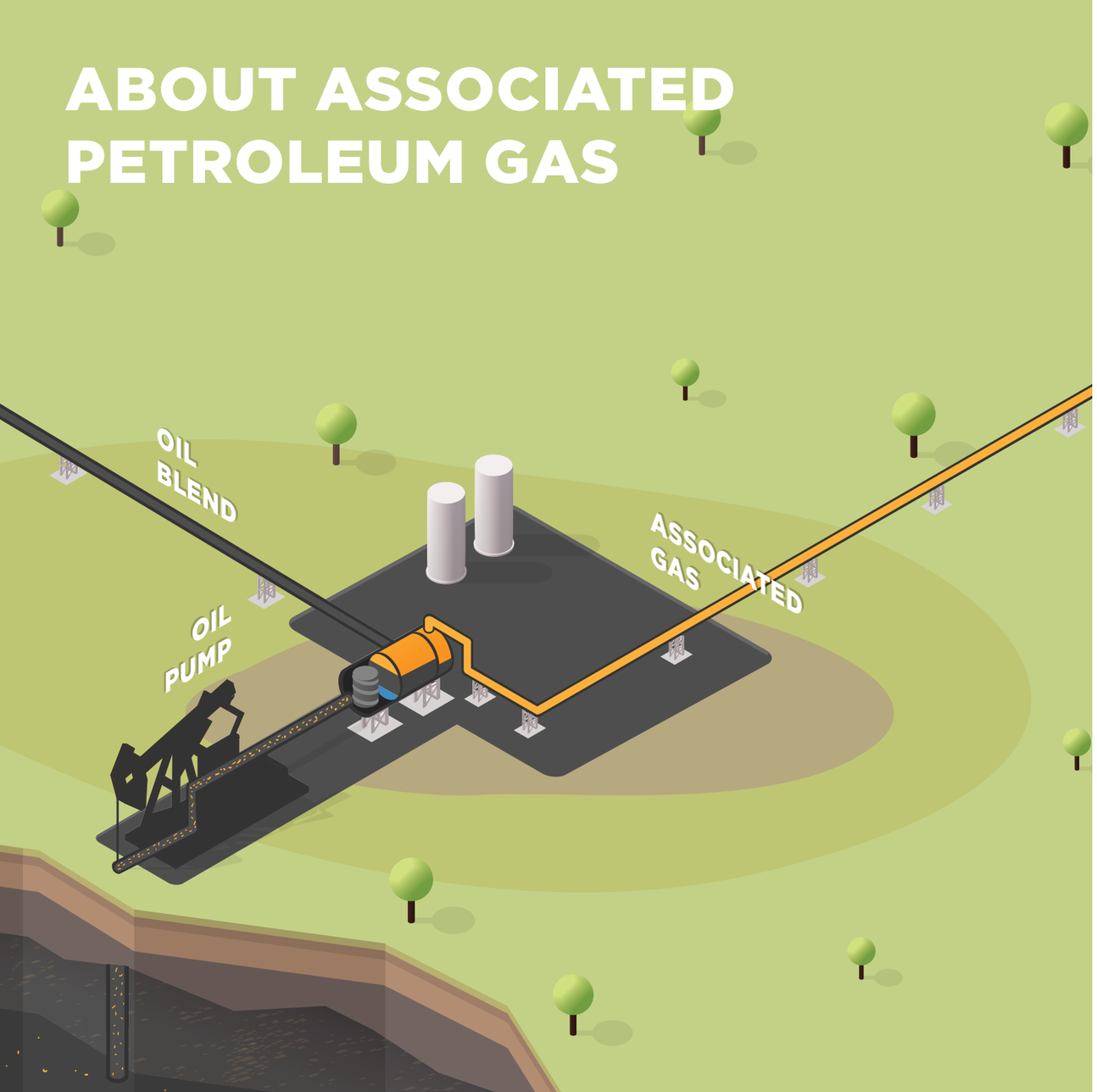
WWF

2017 YEAR OF ECOLOGY IN RUSSIA

ASSOCIATED PETROLEUM GAS UTILISATION IN RUSSIA



ABOUT ASSOCIATED PETROLEUM GAS

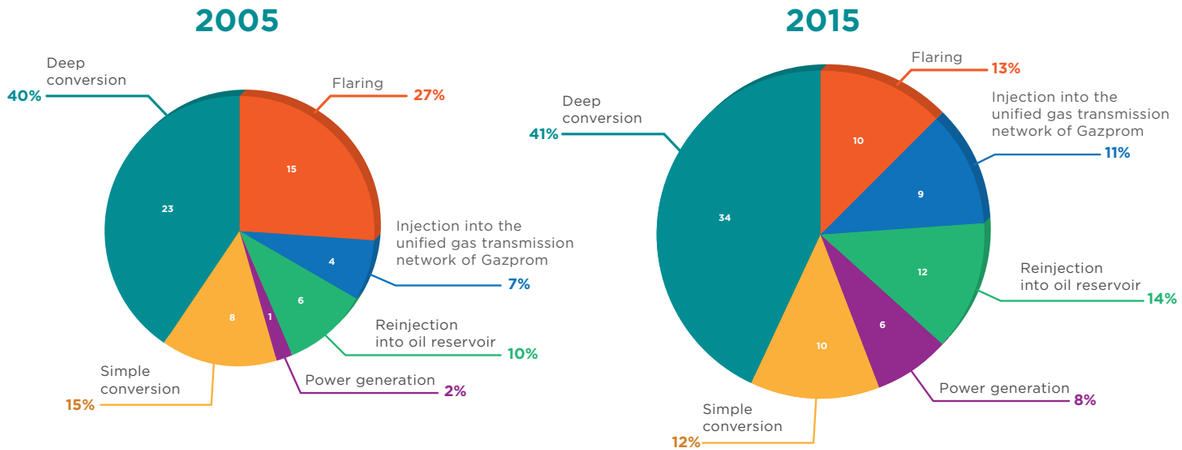


Associated petroleum gas (APG) is the gas dissolved in oil fluids, which contains methane, a common natural gas, and natural gas liquids (NGLs) used as fuel or raw materials for deep conversion. Below is the overview of all APG utilisation methods focusing on the per unit costs, economic benefits and environmental impacts.

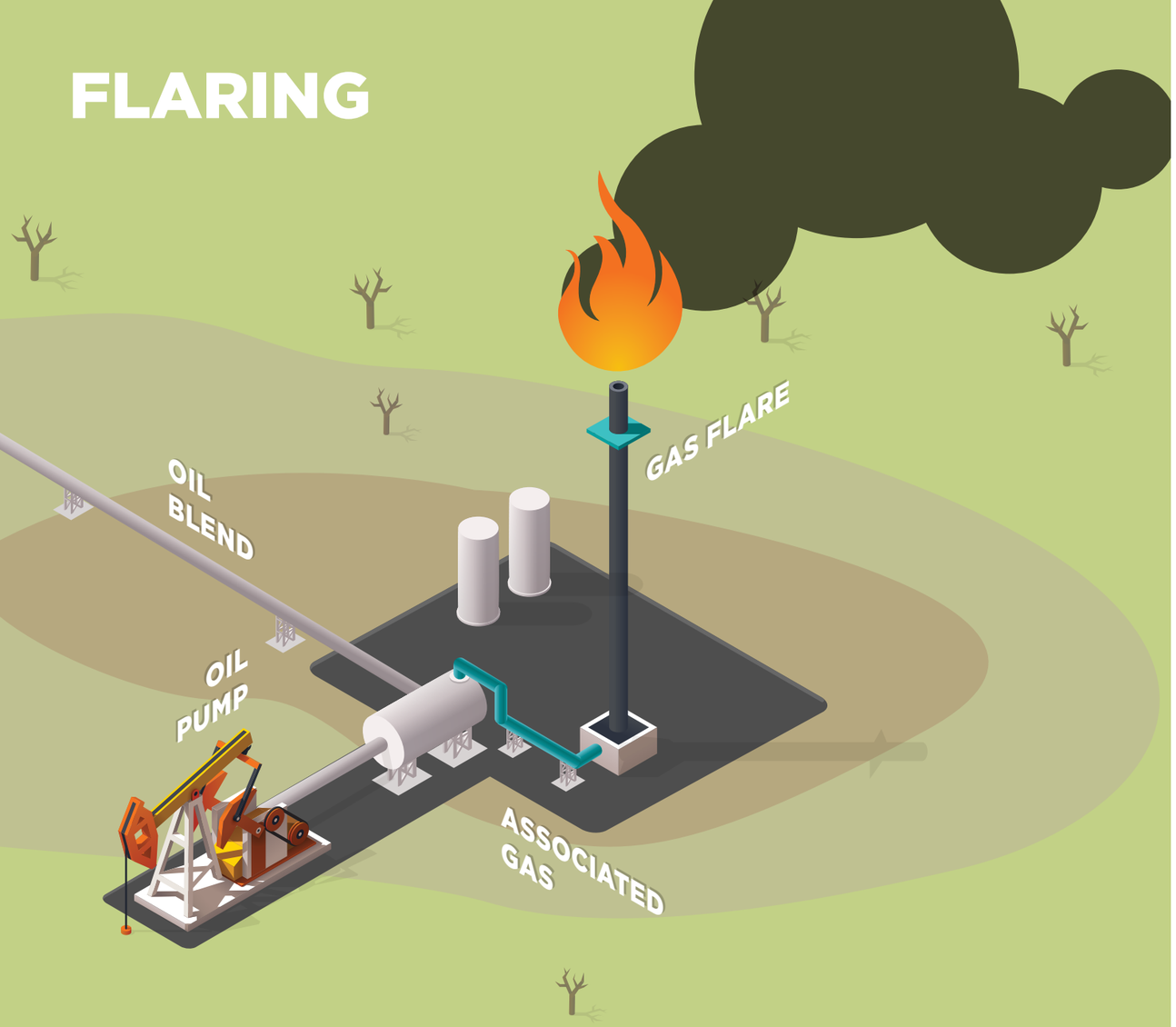
HOW IT WORKS

After the extraction of oil fluids, they undergo special treatment to remove all by-products, including water, sulphur and associated gas. Without such treatment, the oil will not be allowed into the main oil pipeline due to the technical requirements. Once APG has been separated from the oil, it needs to be further utilised or disposed of. It is forbidden to simply release the associated gas into atmosphere, as it is highly inflammable and can even explode.

APG UTILISATION IN 2005–2015 (BCM)



FLARING



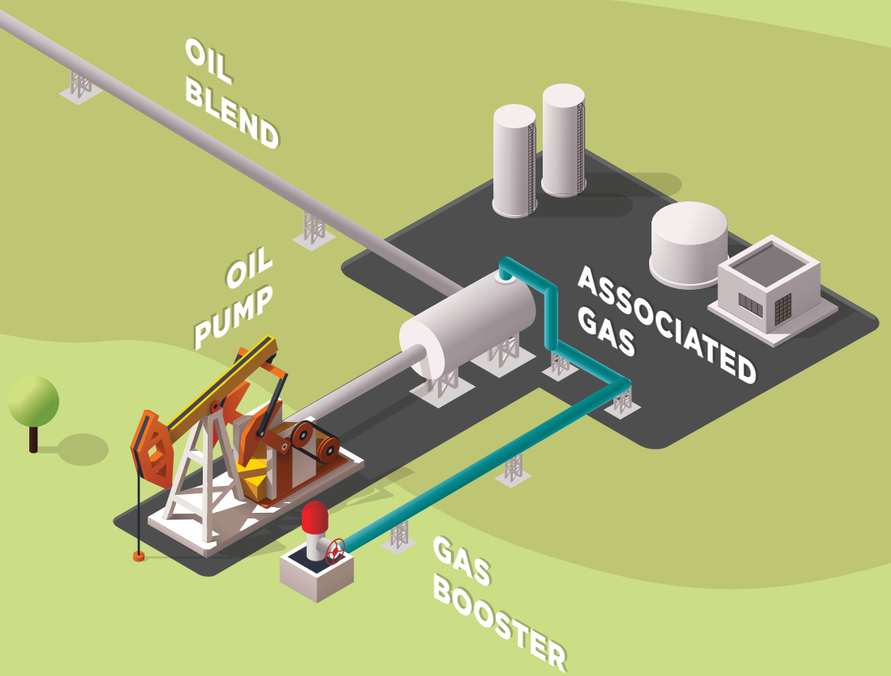
HOW IT WORKS

The easiest way to dispose of associated gas is to build a flare at the oil field and burn the gas off.

METRICS COMPARISON ACROSS UTILISATION METHODS

	FLARING	REINJECTION INTO OIL RESERVOIR	INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM	POWER GENERATION	SIMPLE CONVERSION	DEEP CONVERSION
CAPEX RUB/м³	**0,1**	4,4	5	54,2	15	13,8
Construction of a flare and feed pipelines						
Economic benefits RUB/м³	**-2,8**	0 potential increase in oil recovery	3 – 6,1	3,6 – 5,2	7,6 – 10,7	19,8 – 20,1
Losses equal to the flaring fine						
Lost profit RUB/м³	from **–2,8** to **–22,6**	from **–3** to **–19,8**	from **–2,2** to **–16,8**	from **–2,4** to **–14,6**	**–12,2**	0
The range between fine-related savings and profits from the sale of petrochemical products						
Environmental impact mt of CO_2 equivalent / bcm	**7,1**	0	1,2	1,2	0	0
Pollutant emissions. Contamination area within 80–100 km from the flare						
Data sources	United Nations Framework Convention on Climate Change (UNFCCC)	RUPEC estimates	Report on Clean Energy by ECOLUR	Market Review by B2B-Center	RUPEC estimates	RUPEC estimates

REINJECTION INTO OIL RESERVOIR



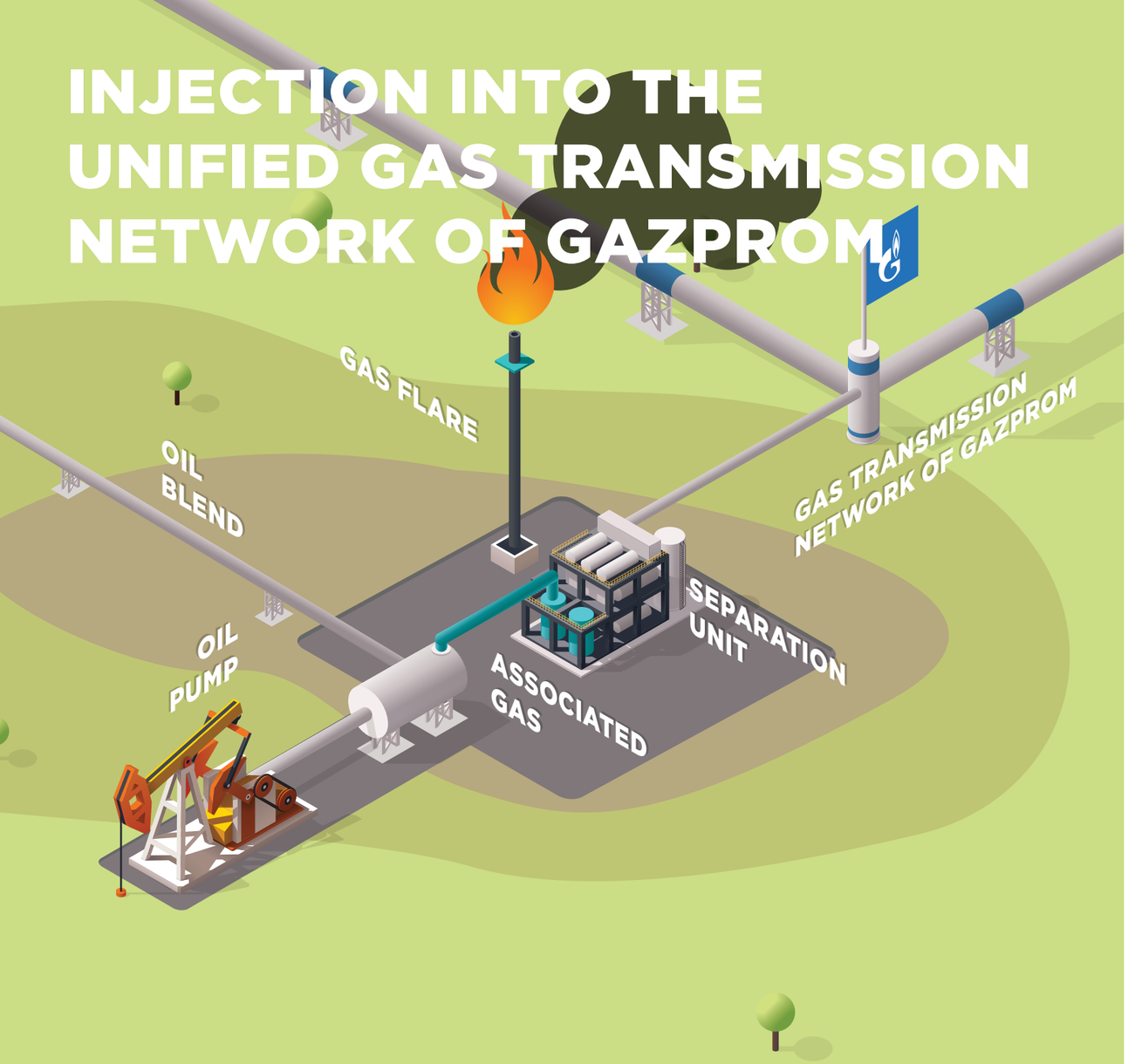
HOW IT WORKS

After removal from the oil fluids, APG is collected and reinjected into the oil reservoir along with other by-products.

METRICS COMPARISON ACROSS UTILISATION METHODS

	FLARING	REINJECTION INTO OIL RESERVOIR	INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM	POWER GENERATION	SIMPLE CONVERSION	DEEP CONVERSION
CAPEX RUB/м³	0,1	**4,4**	5	54,2	15	13,8
APG collection system and gas injection wells						
Economic benefits RUB/м³	-2,8	**0** potential increase in oil recovery	3 – 6,1	3,6 – 5,2	7,6 – 10,7	19,8 – 20,1
There are practically no publicly available data about the economic benefits stemming from increased oil recovery due to the higher pressure in the oil reservoir						
Lost profit RUB/м³	from **–2,8** to **–22,6**	from **–3** to **–19,8**	from **–2,2** to **–16,8**	from **–2,4** to **–14,6**	**–12,2**	**0**
The range between fine-related savings and profits from the sale of petrochemical products						
Environmental impact mt of CO_2 equivalent / bcm	7,1	**0**	1,2	1,2	0	0
Environmentally neutral solution provided that APG is utilised in the next extraction cycle						
Data sources	United Nations Framework Convention on Climate Change (UNFCCC)	RUPEC estimates	Report on Clean Energy by ECOLUR	Market Review by B2B-Center	RUPEC estimates	RUPEC estimates

INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM



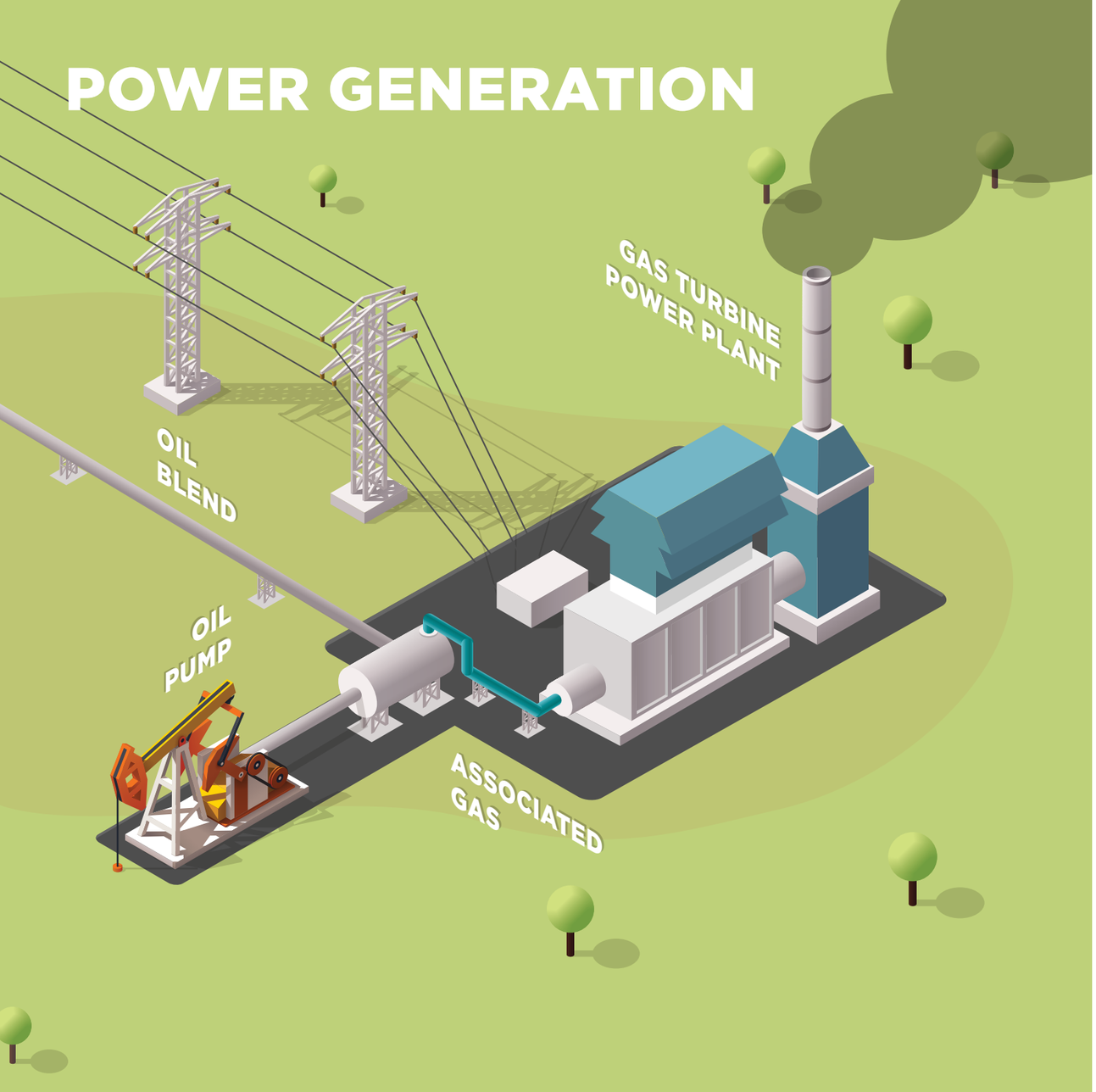
HOW IT WORKS

Small amounts of APG can go into the main pipeline to be sold to end consumers as part of natural gas. However, there is a number of technical restrictions imposed on the APG pumped into the gas transmission network (GTN):

- The volume of natural gas transported via the GTN must be significantly higher (by 20–50 times) than that of the injected APG.
- The APG must be dehydrated and undergo primary treatment to remove aerosols, H2S, mercaptans and most of the heavy hydrocarbons.
- Gas pumped into the main pipeline must meet the OST 51.40-93 industrial standard, with the gas dehydration and treatment rate being sufficient to eliminate the risk of condensation in the main gas pipeline. This requires that the water and hydrocarbon dew points of the gas be 5–7 K below the lowest temperature to which the gas is cooled during its transportation in the pipeline.

METRICS COMPARISON ACROSS UTILISATION METHODS

	FLARING	REINJECTION INTO OIL RESERVOIR	INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM	POWER GENERATION	SIMPLE CONVERSION	DEEP CONVERSION
CAPEX RUB/м³	0,1	4,4	**5**	54,2	15	13,8
Development of a collection system and a network of local pipelines to deliver gas to the main pipeline. Construction of a flare and feed pipelines (to burn the gas off)						
Economic benefits RUB/м³	-2,8	0 potential increase in oil recovery	**3 – 6,1**	3,6 – 5,2	7,6 – 10,7	19,8 – 20,1
Monetisation of APG as a common fuel gas						
Lost profit RUB/м³	from **–2,8** to **–22,6**	from **–3** to **–19,8**	from **–2,2** to **–16,8**	from **–2,4** to **–14,6**	**–12,2**	0
Profits from the sale of petrochemical products (excluding profits from simple conversion)						
Environmental impact mt of CO_2 equivalent / bcm	7,1	0	**1,2**	1,2	0	0
Factors in the economic benefits						
Data sources	United Nations Framework Convention on Climate Change (UNFCCC)	RUPEC estimates	Report on Clean Energy by ECOLUR	Market Review by B2B-Center	RUPEC estimates	RUPEC estimates

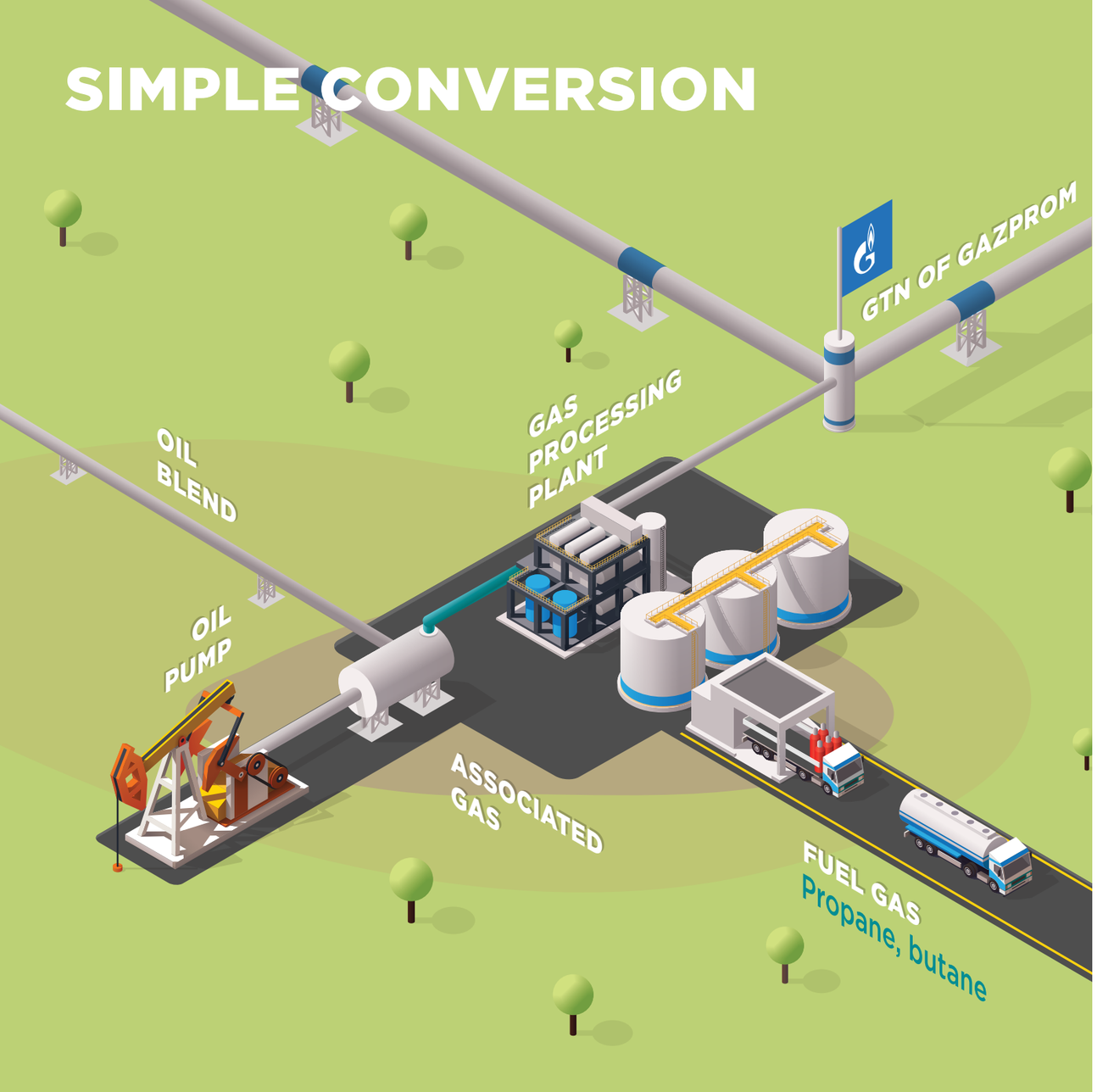


HOW IT WORKS

APG can be used as fuel to generate power at the oil fields or in close proximity.

METRICS COMPARISON ACROSS UTILISATION METHODS

	FLARING	REINJECTION INTO OIL RESERVOIR	INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM	POWER GENERATION	SIMPLE CONVERSION	DEEP CONVERSION
CAPEX RUB/м³	0,1	4,4	5	**54,2**	15	13,8
APG collection system, gas turbine units						
Economic benefits RUB/м³	-2,8	0 potential increase in oil recovery	3 – 6,1	**3,6 – 5,2**	7,6 – 10,7	19,8 – 20,1
Profit from in-house power generation						
Lost profit RUB/м³	from **–2,8** to **–22,6**	from **–3** to **–19,8**	from **–2,2** to **–16,8**	from **–2,4** to **–14,6**	–12,2	0
The range between profits from utilisation at the small gas processing plants (excluding profits from in-house power generation) and profits from the sale of petrochemical products (excluding profits from in-house power generation)						
Environmental impact mt of CO_2 equivalent / bcm	7,1	0	1,2	**1,2**	0	0
Substantial environmental risks associated with CO2 emissions stemming from large-scale power generation leveraging APG rich in NGLs						
Data sources	United Nations Framework Convention on Climate Change (UNFCCC)	RUPEC estimates	Report on Clean Energy by ECOLUR	Market Review by B2B-Center	RUPEC estimates	RUPEC estimates



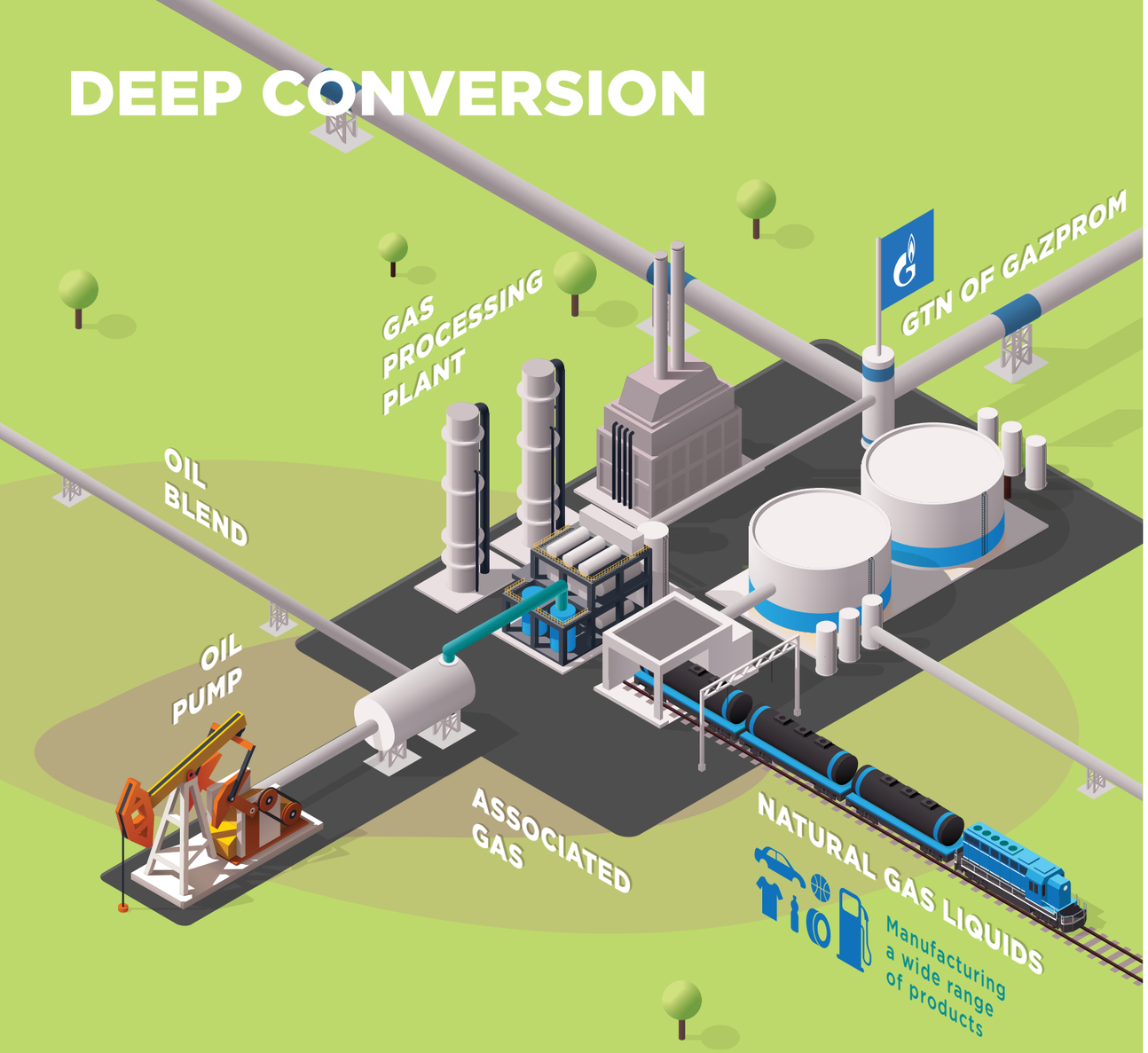
HOW IT WORKS

By using small mobile processing units, APG can be separated into methane, ethane and propane/butane. Methane is pumped into the gas transmission network, while propane/butane is loaded into tanks and sent to end consumers.

METRICS COMPARISON ACROSS UTILISATION METHODS

	FLARING	REINJECTION INTO OIL RESERVOIR	INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM	POWER GENERATION	SIMPLE CONVERSION	DEEP CONVERSION
CAPEX RUB/м³	0,1	4,4	5	54,2	**15**	13,8
APG collection system, primary treatment units, gas pipelines to connect to the main pipeline, transportation of finished products						
Economic benefits RUB/м³	-2,8	0 potential increase in oil recovery	3 – 6,1	3,6 – 5,2	**7,6 – 10,7**	19,8 – 20,1
Monetisation of dry stripped gas (DSG) and NGLs as fuel						
Lost profit RUB/м³	from **–2,8** to **–22,6**	from **–3** to **–19,8**	from **–2,2** to **–16,8**	from **–2,4** to **–14,6**	**–12,2**	0
Profits from the sale of petrochemical products (excluding profits from simple conversion)						
Environmental impact mt of CO_2 equivalent / bcm	7,1	0	1,2	1,2	**0**	0
Data sources	United Nations Framework Convention on Climate Change (UNFCCC)	RUPEC estimates	Report on Clean Energy by ECOLUR	Market Review by B2B-Center	RUPEC estimates	RUPEC estimates

DEEP CONVERSION



HOW IT WORKS

APG is delivered to large gas processing plants, where it is separated into methane (dry stripped gas) and natural gas liquids. The dry gas is fed to the main gas transmission network, while NGLs (unlike in the simple conversion scenario) are sent for further processing to manufacture a wide range of petrochemical products.

METRICS COMPARISON ACROSS UTILISATION METHODS

	FLARING	REINJECTION INTO OIL RESERVOIR	INJECTION INTO THE UNIFIED GAS TRANSMISSION NETWORK OF GAZPROM	POWER GENERATION	SIMPLE CONVERSION	DEEP CONVERSION
CAPEX RUB/m³	0,1	4,4	5	54,2	15	**13,8**
Highest CAPEX to develop comprehensive infrastructure: APG collection system, compressor stations and gas processing capacities, transportation of DSG and NGLs, expenses associated with further processing						
Economic benefits RUB/m³	-2,8	0 potential increase in oil recovery	3 – 6,1	3,6 – 5,2	7,6 – 10,7	**19,8 – 20,1**
Average economic benefits: monetisation of methane (dry stripped gas) as a fuel gas, monetisation of NGLs as a raw material for the petrochemical industry with subsequent manufacturing of finished products from polymers and synthetic rubbers. Highest economic benefits for the business and government						
Lost profit RUB/m³	from **-2,8** to **-22,6**	from **-3** to **-19,8**	from **-2,2** to **-16,8**	from **-2,4** to **-14,6**	-12,2	**0**
Profits from the sale of petrochemical products (excluding profits from simple conversion)						
Environmental impact mt of CO_2 equivalent / bcm	7,1	0	1,2	1,2	0	**0**
Data sources	United Nations Framework Convention on Climate Change (UNFCCC)	RUPEC estimates	Report on Clean Energy by ECOLUR	Market Review by B2B-Center	RUPEC estimates	RUPEC estimates

METRICS CALCULATION PRINCIPLES AND DATA SOURCES

	 FLARING	 REINJECTION INTO OIL RESERVOIR	 INJECTION INTO THE UNIFIE GAS TRANSMISSION NETWORK OF GAZPROM	 POWER GENERATION	 SIMPLE CONVERSION	 DEEP CONVERSION
CAPEX	RUPEC data for CAPEX required to build a flaring system with a capacity of 1.5 bcm of gas per annum	RUBEC data for CAPEX required to build compressor and pipeline facilities	RUBEC data for CAPEX required to build compressor and pipeline facilities	Calculated based on the per unit cost of power in relation to CAPEX, adjusted for gas consumption per unit of power (as per the Energosistema Magazine, first issue, 2010)	RUBEC data for CAPEX required to build compressor and pipeline facilities, internal CAPEX estimates for a small gas fractionation unit	RUBEC data for CAPEX required to build compressor and pipeline facilities, internal CAPEX estimates for a gas processing plant and petrochemical production facilities
Implementation period	**Under one year:** installation of a flaring system, pipelines and compressors	**Under one year:** installation of pipelines and compressors	**Under one year:** installation of pipelines and compressors	**Under one year:** installation of pipelines, compressors and a gas turbine unit	**2–3 years:** construction and launch of the pipeline network and gas processing plants	**5 years:** construction and launch of the pipeline network, gas processing plants and petrochemical production facilities
Economic benefits	Average economic benefits: losses equal to the flaring fine (Sergey Donskoy, Improvements in efficiency of associated petroleum gas utilisation in Russia)	No average economic losses. The direct impact on oil production cannot be calculated. Lost profit / unincurred losses: the range between profits from deliveries to the gas transmission network and profits from the sale of petrochemical products	No average economic losses. The economic benefits are related to the sale of all APG to the GTN of Gazprom at the price of DSG	No average economic losses. The economic benefits are related to the sale of power generated at in-house facilities	Conversion of APG into low value-added marketable products (DSG, LPG and stable gas naphtha (SGN) produced through gas fractionation)	Full APG conversion into marketable products: basic polymers (polyethylene and polypropylene) and elastomers (polybutadiene) made from monomers produced through pyrolysis of fractions after APG fractionation
Lost profit	Lost profit is calculated as the range of differences between the economic benefits of five other potential utilisation methods and the negative economic benefits of flaring (fine)	Lost profit is calculated as the range of differences between the economic benefits of four other potential utilisation methods and the economic benefits of reinjection	Lost profit is calculated as the range of differences between the economic benefits of three other potential utilisation methods and the economic benefits of injection into the unified GTN of Gazprom	Lost profit is calculated as the range of differences between the economic benefits of two other potential utilisation methods and the economic benefits from the sale of power generated at in-house facilities	Lost profit is calculated as the difference between the economic benefits of deep conversion into basic polymers and elastomers and the economic benefits from the sale of hydrocarbon products, including DSG, LPG and SGN	No lost profit (deeper conversion is impossible under the chosen model)
Environmental impact	Calculated based on the typical emissions from APG flaring: greenhouse gases CO_2, CH4 and NOX, inclusive of the greenhouse effect ratios of each gas (data of the United Nations Framework Convention on Climate Change (UNFCCC))	Environmental impact is deemed to be zero	Calculated based on the typical emissions from gas flaring: greenhouse gases CO_2, CH_4 and NOX, inclusive of the greenhouse effect ratios of each gas (data of the United Nations Framework Convention on Climate Change (UNFCCC))	Calculated based on the typical emissions from gas flaring: greenhouse gases CO_2, CH_4 and NOX, inclusive of the greenhouse effect ratios of each gas (data of the United Nations Framework Convention on Climate Change (UNFCCC))	Typical emissions of greenhouse gases CO_2, CH_4 and NOX from gas processing plants and petrochemical production facilities (RUPEC data), inclusive of the greenhouse effect ratios of each gas	Typical emissions of greenhouse gases CO_2, CH_4 and NOX from gas processing plants and petrochemical production facilities (RUPEC data), inclusive of the greenhouse effect ratios of each gas