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GHG-emissions of Russian long distance gas transport pipelines and options for mitigation

based on results of new measurements of Wuppertal Institute in Cooperation with MPI Mainz and VNIIGAZ Moscow

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Workshop on
“Modern Technologies of Detection and Elimination of Methane Leakages from Natural Gas Systems”

Tomsk, 15 & 16 September 2005

Overview

- Background and Target of the Survey
- Measurements at The Russian Natural Gas Export System
- Operational Data Obtained from Gazprom
- Overview over GHG emissions
- Mitigation Options

Background to the Survey

- Russian gas industry as a globally important emitter of CH_4
- Discussion on advantages of natural gas on GHG emissions compared to other fossil fuels
  - Discussion emerged in Germany in the early nineties (lignite based East German energy system came under pressure by gas fired CHP)
  - Some Studies stating extreme emissions of Russian gas export system are in the public debate in Germany
- Existing measurements in Russia
  - 1996/97 by Gazprom&Ruhrgas; 1995 by Gazprom&US EPA (not published)
  - Critics on representativeness, transparency and, on uncertainty ranges
  - Made by gas industry without independent know-how

Targets of the Survey in Russia

- To make new measurements:
  - According to international standards for greenhouse gas inventories (US EPA, IPCC)
  - Organized and carried out by independent scientists
  - With bigger and more representative sample
  - Transparently documented
- Produce sound and credible information on GHG emissions of the Russian natural gas export system
  - To verify the old results and build up reliable emission-factors for all relevant sections
  - To improve the data basis for mitigation

The Russian Natural Gas Export System

Focus: Export corridors as most relevant part of the gas transmission System

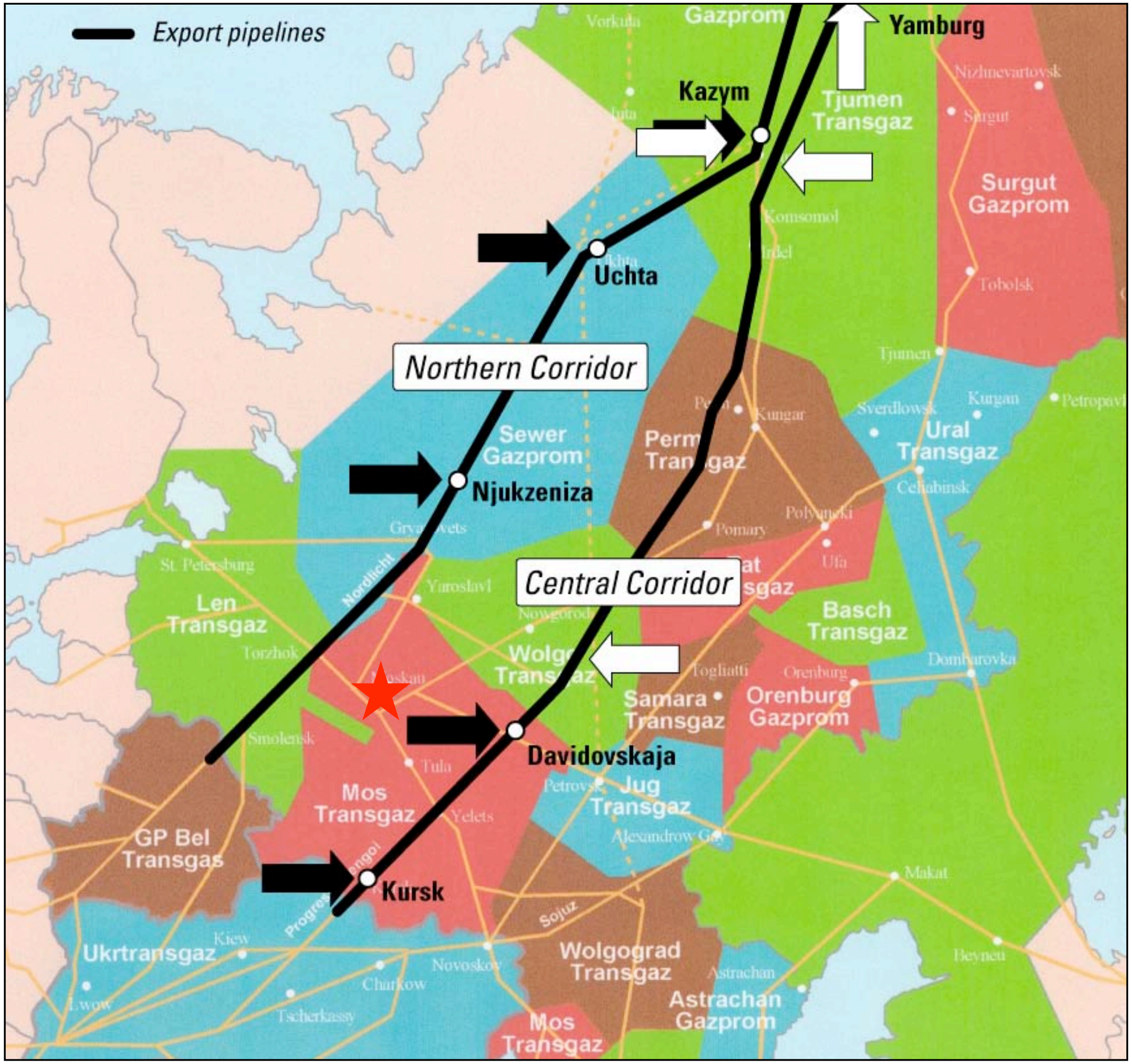
- The long distance transport system:
  - 153 000 km pipelines
  - 324 compressor stations
  - 4 000 compressors with 41 000 MW installed
- Export pipeline corridors:

Corridor	Length in Russia	Pipeline installed	Compressor stations	MW Installed (% of total)
Northern	3 075 km	12 000 km	23	5 442 MW (13%)
Central	3 376 km	22 000 km	30	14 544 MW (35%)
Survey	*>600 km*	*2 380 km*	*5*	*540 MW (1,3%)*

The Measurements



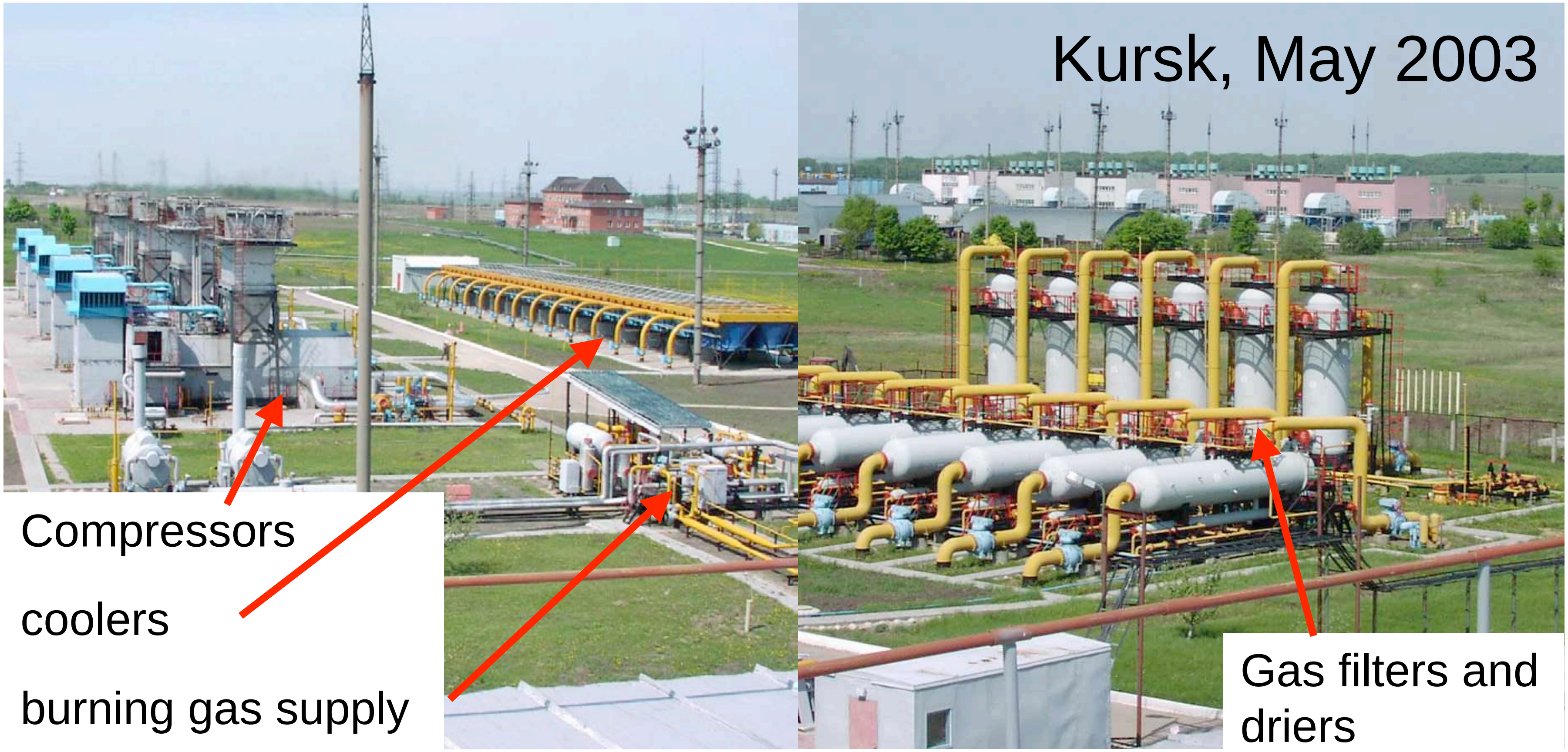
Russian Gas Export Mains and Location of Measurements



Measurements 1996 / 97
Ruhrgas AG and Gazprom
- 2 compressor stations
- 1 pipeline section
- Production and processing at Yamburg

Measurements 2003
Wuppertal Institute and Max-Planck-Institute
- 5 compressor stations
- 2380 km of pipelines

Measurements at all potentially emitting component of the compressor stations



And at the Pipeline routes


Davidovskaya, May 2003


Kazym, October 2003

Validity of the survey

- **5 stations** out of 23/30 (northern corridor/central corridor)
  - 8 shops with 50 machines and adjacent facilities
- **4** Russian **regions** covered:
  - Central Russia; Northwest; European Polar Region; Western Siberia
- 3 regional gas transportation companies covered
- **50** Machines of **all sizes and representative types** covered:
  - All relevant sizes (6 MW - 25 MW)
  - Representative range of ages (year of commission: 1972 - 2001)
- Pipelines 25 valve nodes in the pipelines were investigated
  - Approx. 2 380 km of pipeline surveyed by helicopter overflight
- **Total number** of measurements:
  - Approx. 4 500 screenings; 436 leakages found
  - 304 of which were exactly measured (volumetric)

The Measurements
Coverage and Program On Site

- Measurement programme covered
  - unplanned emissions (leakages) and
  - planned releases (from machine vents, fuel gas plants, compressor seal oil system)
- Program on site:
  - Screening of almost all aggregates at compressor stations
    - Machine halls, compressors, dust filters, gas coolers, piping
  - Screening of valve knots of adjoining pipeline
  - Identifying, documenting and marking of elevated methane levels
  - Measuring of places with significant concentration via flux method, vents direct volumetric
  - Adjoining pipeline sections were screened for elevated methane concentration via laser leak detector (reliable detection >200 m^3/d)

Screening at Fittings

Measurements at Vent Stacks

Measurements at Vent Stacks:

Njukzeniza
June 2003

Davidovskaja, May 2003

Measurement at gate valve

Screening at pipeline intersection

Screening of Pipelines

Detector indication on paper strip

Laser detector

Quality Assurance & Quality Control

- Standardised measurements
- Documentation:
  - Project manual (agreed standards; procedures; regulations) as guideline for measurement teams
  - Day logs (measurement; site; team; number; method; meter; temperature, wind, air pressure, results)
  - Technical report prepared at every station and signed by all partners
- Independent Monitoring of Measurements by expert of MPI
- Database with all measurements completed on-site
  - Allowed direct on-site check
  - Check of subsequent statistical analyses for completeness and errors
- Archiving of all relevant documents at WI

Data Obtained from Gazprom

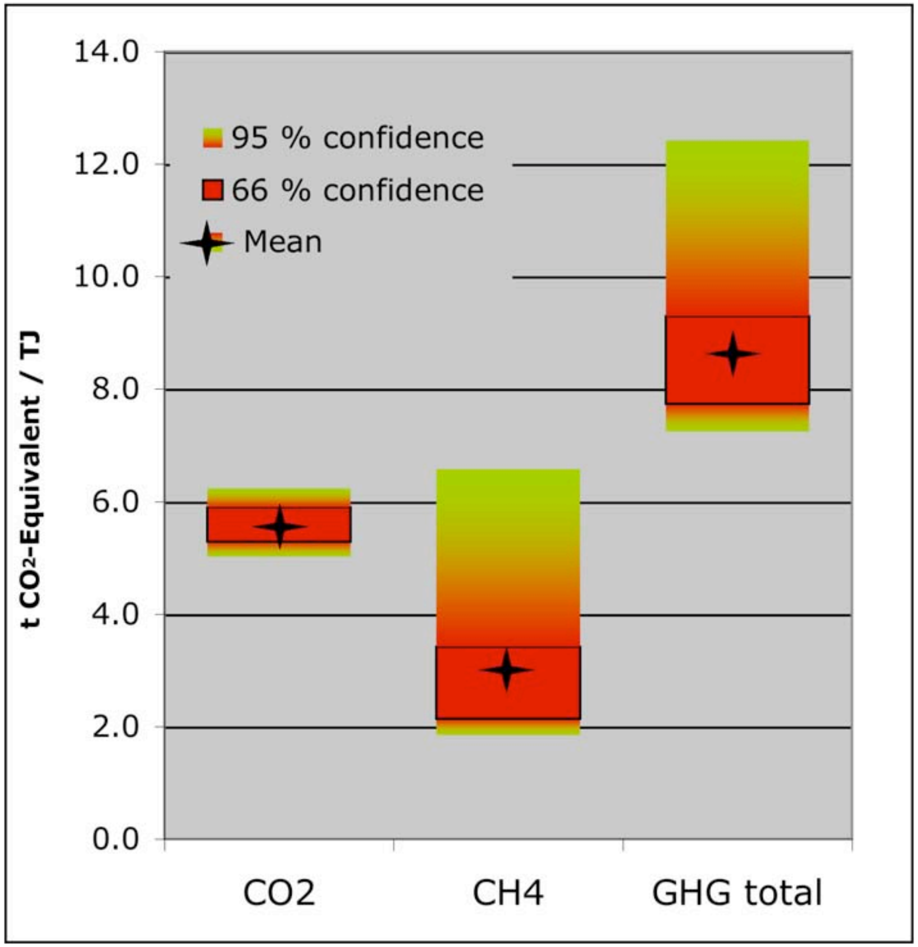
- Comprehensive data set of export corridors to determine all operation related emissions and emissions due to breakdowns
- Detailed information given for every machine hall, pipeline sections for both corridors (machines, running hours, fuel gas usage, maintenance, etc.)
- Parallel collection of data at 5 surveyed stations to complete and verify given data
- Analyses and comparison of Gazprom data and data collected at stations and literature

⇒ **Typical emission factors for all operation related emissions could be calculated**

Results of measurements

Confidence Interval of Results

Indirect CH_4 Emissions for Russian Gas at German Border



- CO_2 dominates emissions
  - 2/3 of total GHG emissions
  - 95%-range: **-10 – +11 %**
- CH_4 dominates uncertainty
  - 1/3 of total GHG emissions
  - 95%-range: **-40 – +120 %**
- Compared to direct emissions of 55 t/TJ indirect emissions are small
  - 16 % of direct emissions
  - Range from 13 to 23 %
  - 95%-range: **-17 – +42 %** (98 % dominated by CH_4)

Comparison of results
(for long distance transmission system)

- Our results reveal slightly lower emissions than calculated by the previous field studies
  (1995 to 1997, by US EPA; Ruhrgas/Gazprom)
- We are generally in line with results created by TransCanada at two sites at the central corridor (2001)

- Results of field studies:
  - Show a consistent picture
  - Reveal comparable emission figures
  - Prove that estimates of extreme gas losses are unrealistic

Results

- **Approx. 1 % of natural gas is emitted** (from production site in Yamburg to German border) (range: 0.6 to 2.4 %)
- **Two third** of GHG result from **transport energy** demand (CO_2)
- **Main sources** for CH_4-emissions:
  - Leakages at machines
  - CH_4-emissions at production and processing
  - Repairs and maintenance works at pipelines and stations
  - Breakdowns and leakages at pipelines are less than 2 % of total GHG emission
- A first **extrapolation** of our results to the complete Russian natural gas industry shows an emission range comparable to the US situation
  - Russia: 1.4 % losses (Range: 1.0 – 2.5 %) / USA: 1.5 % (1.0 – 2.0 %)
  - Russia benefits from a younger system and bigger size of wells, pipelines etc.

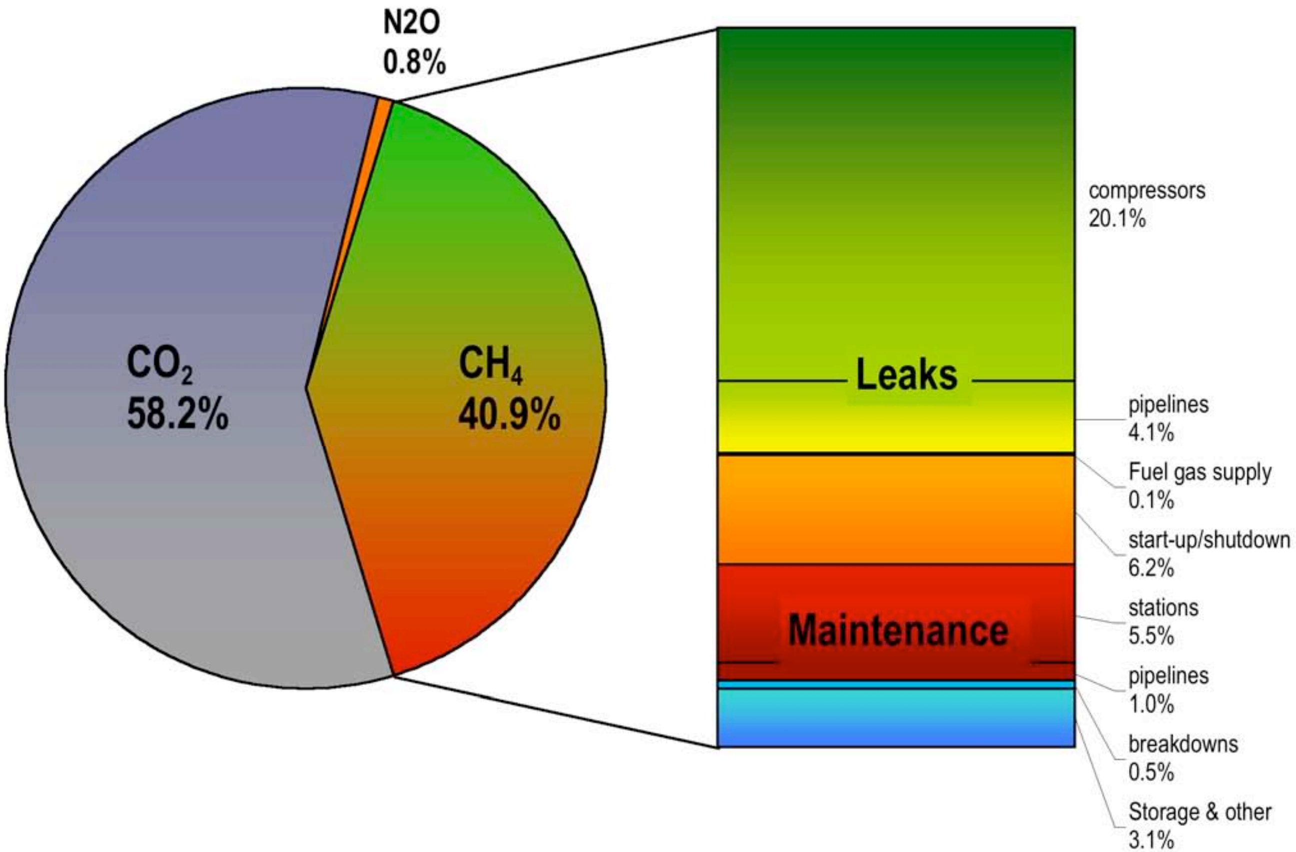
Options for Mitigation

- Based on an extrapolation of our results obtained for export corridors on the total long distance system
- From worst case analysis of emissions to realistic cautious assumption:
  - Emission average (and lower range) relevant for the calculation of reduction potentials
- Mitigation options and costs taken from Robinson et al. 2003

Results extrapolated

- Annual CH_4 emissions from production, processing and long distance pipeline system:
  - Methane emissions — 2.6 to 10 $*10^9$ m^3 CH_4
  - economic value — 260 to 1,000 $* 10^6$ Euro
  - greenhouse gas emissions — 40 to 150 $* 10^6$ t CO_2eq.
- CO_2 emissions :
  - from compressor drives — 68 to 81 $* 10^6$ t CO_2equivalent
- Mitigation potential(10 US$/t$CO_2$): 30 % of CH_4 (Robinson et al. 2003)

Greenhouse gas emissions of long distance pipelines by gas and source



Emitting components at the long distance pipeline network (m³ per year per component)

Component	Unit	Number	Mean value*) of CH_4	95% Confidence interval from	to
Compressor stations					
Gas coolers and filters					
Vents	Shop	800	7.468	5.894	9.820
Fittings, valves flanges	Shop	800	860	633	1.146
Combustion, start-up and pulse gas treatment	Gas-powered shops	700	145.270	51.324	420.413
Machinery					
Vents (excl. central vents)	Compressor	4047	437.150	142.963	1.499.602
Fittings, valves, flanges	Compressor	4047	2.434	2.059	2.952
Central vents (during operation)	Compressor	4047	6.302	2.552	16.134
Central vents (outside operation)	Compressor	4047	9.396	8.323	10.491
Seal oil system	Compressor	4047	27.693	13.101	68.885
Pipelines (valve nodes)					
Vents	Valve node	8145	43.310	27.074	77.829
Fittings, valves flanges	Valve node	8145	3.535	2.455	5.711

*) Arithmetic mean of 10,000 Monte-Carlo simulations; because the probability distributions are not symmetrical, the arithmetic mean is not the mean value of the lower and upper limits of the confidence intervals.

Examples for mitigation options and potential emission reductions

- **Production and processing:**
  - Emissions: 100 and 330 * 10^6 m^3 per year
  - Mitigation technology: flare systems and green completions at wells
  - Reduction rate: up to 95 %
- **High bleed pneumatic devices at fuel & impulse gas processing:**
  - Emissions: 36 * 10^6 m^3 per year
  - Mitigation technology: exchanging with low bleed or electric devices
  - Reduction rate: up to 100
- **Leakages at compressor stations and pipeline intersections:**
  - Emissions: almost 2,400 * 10^6 m^3 per year
  - Mitigation technology: directed inspection and maintenance
  - Reduction rate: 13 to 50 %
- **Releases due to maintenance works:**
  - Emissions: about 560 * 10^6 m^3
  - Mitigation technology: portable evacuation compressors
  - Reduction rate: up to 72 %

CH_4 mitigation potential
(long distance pipeline system)

- Robinson et al estimate reduction potential of about 30 % of emissions
- Our estimate (for long distance pipeline system):
  - 15 to 40 % of total emissions of the could be mitigated by the given examples
  - 0.7 to 1.7 $*10^9$ m^3 CH_4 per year
  - 10 to 25 $*10^6$ t of CO_2 equivalent per year
  - Potential Revenues (from gas and CO_2):160 to 400 $*10^6$ Euro per year
- Conclusion
  - Relative potential of about 30 % seems to be supported by our results
  - Absolute potential is much smaller due to lower emission values
  - Relatively high share of maintenance-related emissions (expensive mitigation example)
  - Investment needed: Re-Investment of old 6 MW machines, seal oil systems and double valves at pipeline intersection vents

CH_4-mitigation pays double under the Kyoto-protocol

- **First benefit:**
  - Saving of natural gas
  - With declining resources/limited production capacities gas saved can be valued with sales-price
  - Savings: about **0.1 Euro/m³** gas saved
- **Second benefit:**
  - Reduction of CH_4(GHG)-emissions
  - 15 kg/$CO_{2\text{-equivalent}}$ reduced per m^3 of natural gas saved
  - **0.15 Euro/m³** gas saved (if CH_4-emission prevented) (calculated at mitigation costs of 10 Euro per ton of $CO_{2\text{-eq.}}$)
- **Revenues of gas-saving more than doubled**

Joint implementation for CH_4 mitigation

- Revenues of CH_4 mitigation projects can be about doubled by selling GHG reductions
- JI projects may help to acquire the capital needed for investment
- Existing experiences with JI at Gazprom facilities:
  - First experience with “SIMONE” JI-project between Gazprom and E.ON Ruhrgas on CO_2 emission reduction
  - DIM project by TransCanada in 2001 in order to collect experience on suitability for JI
- Necessary steps:
  - Establishment of suitable and successful pilot projects
  - Standardised procedures for JI (e.g. for aggregation of mitigation measures to projects with adequate size, for definition of baselines, for monitoring and verification)

Conclusion

- The detailed measurements of Wuppertal institute, MPI and VNIIGAZ at 5 compressor stations allow for a better estimate of existing mitigation potentials and necessary measures
- A preliminary evaluation based on our results shows:
  - The mitigation potentials are huge, however smaller than sometimes estimated (due to better emission situation)
  - A substantial share of the mitigation potential is connected to re-investment of equipment
- CH_4 mitigation contains a huge economic potential for Gazprom
- Especially for measures with higher investment Joint implementation projects could be attractive to acquire funds needed

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Thank you for your attention!

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