# TIMES- Kazakhstan: from model scenarios to mitigation policies and measures

*(A contribution to the 3rd National Communication to the UNFCCC)*

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## *Background on Kazakhstan*

| | |
|---|---|
| Population: | 16.5 Million; |
| GDP/capita: | 11.6 US$'2005ppp/cap |
| Oil reserves: | 30-40 B.bbl |
| Consumption, 2009: | primary 63 Mtoe; final 32.5 Mtoe, elc 78 TWh |
| Emissions, 2009: | GHG 260 MtCO2eq; CO2 energy 177 MtCO2 |

Kazakhstan and the Kyoto protocol:

- Signed on 1999, when it was not yet annex 1 state
- Ratification accepted on 2009, under Annex B country, but the mitigation target was not determined

## Background on the TIMES-Kazakhstan model

The Kazakh economy-energy system is not yet fully stabilised: it is a good candidate for using bottom up models, which are based on the stock of technologies, instead of top-down models relying on past behaviours of macro-economic indicators.

This explains why the Nazarbayev University wants to train some researchers in TIMES modelling.

The TIMES-KZK and the TIMES-Caspian-4R models are primarily training tools.

Same elements / results have been presented at IEW / ETSAP WS.

One paper has been published in Energy Policy [Yerbol Sarbassov, et al.: Electricity and heating system in Kazakhstan: Exploring energy efficiency improvement paths, Energy Policy, Available online 28 May 2013, http://www.sciencedirect.com/science/article/pii/S0301421513001663],

a few others have been submitted or are in preparation.



## Outline

1. The assignment
2. Emissions and Climate Change mitigation in Kazakhstan
3. The task of the modellers
4. How to build a without measures scenario?
5. The three scenarios
6. Results: time development of the main energy-emission indexes
7. Decoupling drivers
8. From decoupling drivers to sectoral contribution to mitigation
9. Quantifying the contribution of P&M to mitigation

# 1. The assignment

Prepare the following sections of the 3rd National Communication of Kazakhstan to the secretariat in Bonn of the United Nations Framework Convention for Climate Change (NC3 to UNFCCC):

- IV.C: Policies and measures (P&M) and their effects
- V.A: Projections (three scenarios)
- V.B: Assessment of aggregate effects of P&M
- V.D: Methodology used for the presented GHG emission projections

We were in charge of focussing on CO2 emissions from the energy systems, other members of the team on non CO2 GHG emissions.

This presentation focusses on CO2 emissions of the energy system



# IV.C: Policies & measures (P&M), their effects, 1/2

Excerpt from the UNFCCC guidelines:

"Parties shall communicate information on P&M adopted to implement commitments […]. These need not have the limitation and reduction of GHG emissions and removals as a primary objective. […] Parties may report on adopted P&M and those in the planning stage, but should clearly distinguish these from implemented P&M throughout. […]

| Name of policy or measure[b] | Objective and/or activity affected | GHG affected | Type of instrument | Status[c] | Implementing entity or entities | Estimate of mitigation impact, by gas (for a particular year, not cumulative, in $CO_2$ eq.)[d] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1995 | 2000 | 2005 | 2010 | 2015 |
| | | | | | | | | | | |
| | | | | | | | | | | |

Where status is implemented, or adopted, or planned

## *IV.C: Policies & measures (P&M), their effects, 2/2*

Implemented P&M are those for which one or more of the following applies:

(a) national legislation is in force;

(b) one or more voluntary agreements have been established;

(c) financial resources have been allocated;

(d) human resources have been mobilized.

Adopted P&M are those for which an official government decision has been made and there is a clear commitment to proceed with implementation.

Planned P&M are options under discussion and having a realistic chance of being adopted and implemented in future.]



## *V.A: Projections, in three scenarios*

Excerpt from the UNFCCC guidelines:

"Parties shall report

1. A with measures (WM) scenario, encompassing currently implemented and adopted policies and measures. […]
2. A with additional measures (WAM) scenario, encompassing planned policies and measures, and
3. A without measures (WOM) scenario – entitled as a baseline or reference projection – excluding all policies and measures implemented, adopted or planned after the year chosen as the starting point for this projection.

[…]

Projections shall be presented on a sectoral basis, to the extent possible, using the same sectoral categories used in the P&M section (i.e. energy, transport, industry, agriculture, forestry, waste management). […]"

## V.B: Assessment of aggregate effects of P&M (1 of 2)

Excerpt from the UNFCCC guidelines:

"Parties shall present the estimated and expected total effect of implemented and adopted P&M. The effects of individual P&M are to be reported in the P&M section, the total effects are to be reported in the projections section. Parties may also present the total expected effect of planned policies and measures.

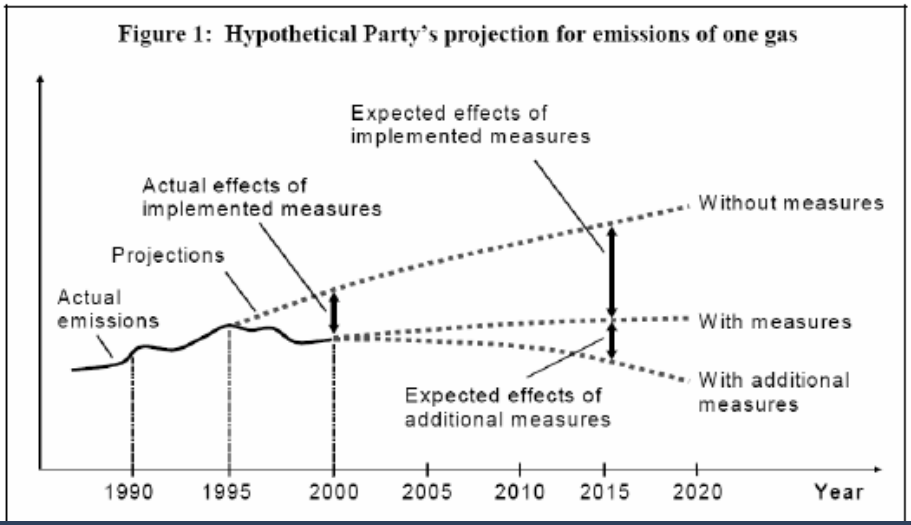
[…] Parties shall provide an estimate of the total effect of their P&M, in accordance with the with measures definition, compared to a situation without such P&M.

The total effect of P&M can be calculated as the difference between with and without measures scenario, or as an aggregation of individual effect of each significant P&M."

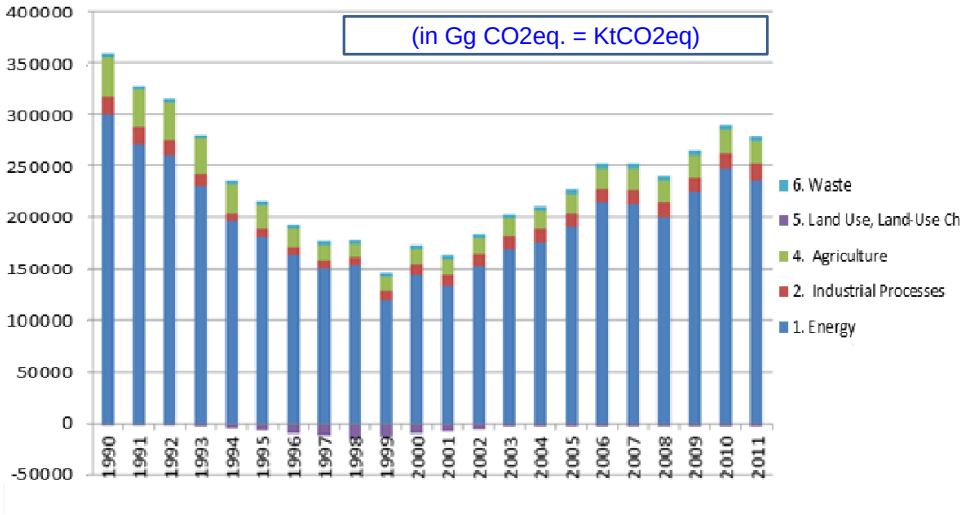


## V.B: Assessment of aggregate effects of P&M (2 of 2)

Excerpt from the UNFCCC guidelines: EXAMPLE



## 2. Past GHG emissions in Kazakhstan



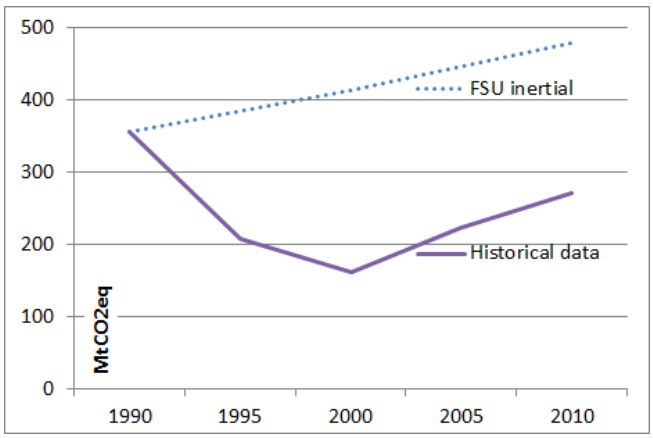

GHG emissions reduced by more than 25% in the Kyoto Protocol reporting period, 1990-2010



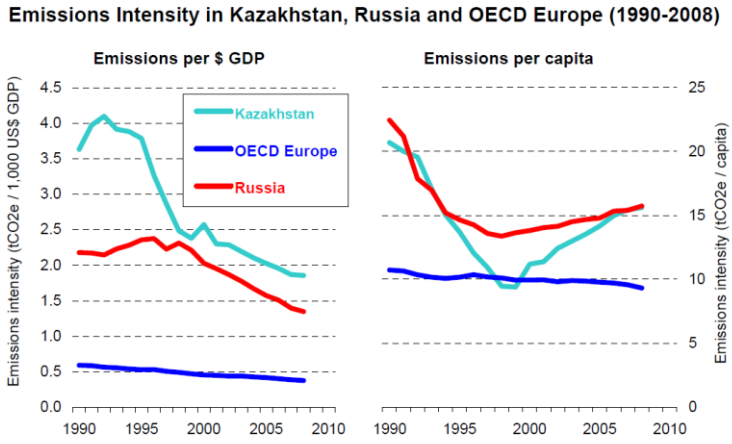
## 2. Past CC mitigation P&M in Kazakhstan, 1/2

What policy achieved this CC mitigation?

The 1991 decision to undertake the transition from the central planned system of the FSU to the market economy!



## 2. Past CC mitigation P&M in Kazakhstan, 2/2




***Source**: IEA and UNFCCC; GDP is in 2000 prices, and PPP-adjusted*

NERA Consulting – Bloomberg New Energy Finance: "The Demand for Greenhouse Gas Emissions Reduction Investments: An Investors' Marginal Abatement Cost Curve for Kazakhstan", Prepared for EBRD, October 2011



## 2. Present CC mitigation P&M in Kazakhstan

Since 2010 the Government decided to adopt a set of mitigation P&M.

Power sector: investment in new hydro, wind, coal pp; replacement of some old coal pp with new ones, preferentially using natural gas, transmission & distribution network refurbishment

End-use sectors:

Transport : adoption of EURO 4 or higher standards, production of better gasoline, adoption of CNG car/buses

Buildings: better thermal insulation standards, preferential development of cities and district heating

Industrial: renovation of the capital stock, energy audits, emission reporting, etc.

How much could each P&M contribute?

## 3. The task of the modellers

To build three scenarios using the existing TIMES-Kazakhstan model:

- Without Measures (WOM)
- With (existing) Measures (WM)
- With Additional Measures (WAM)

To identify and quantify the forces that drive the change

- from WOM to WM, and
- from WM to WAM

To quantify the effects of existing P&M, identify gaps, and
To propose additional P&M, and estimate their contribution to mitigation

**CONSISTENTLY**



## 4. How to build a without measures scenario? (1/3)

Normally we label base / reference scenario" the least cost run, without any constraint on investments, emissions or other. This scenario assumes that in the future all cost optimal options are used. But although already available today, they are not fully used due to several market imperfections or hidden extra cost or administrative constraints.

The group thought that in a country such as Kazakhstan, where the transition to a market economy is still underway, assuming that market imperfections would be overcome in the next 15-20 years would have not been realistic. The least cost scenario is not without measures!

Only a proactive policy in the energy-environment sector could result in a development of the energy system closer to the least cost case. In other words, the least cost run is already a policy scenario!

How to build a scenario, completely without mitigation P&M, and consistent with the least cost scenario?

## 4. How to build a without measure scenario? (2/3)

In order to be consistent it has to be a bottom up scenario, with the same details as the least cost scenario.

The simplest way we found was to build a scenario with a growth by end-use sector equal to the exogenous projections of the demand for energy services in the TIMES-Kazakhstan model. Out of them we built the final energy consumption and the primary energy supply assuming that technologies and shares are "frozen" to the calibration year values. In other words the TIMES-Kazakhstan model is used in "simulation mode"

This approach is less unrealistic than I could initially think. I was explained the without proactive policies, in a country with abundance of cheap energy resources, scarcity of capital and insufficient investments particularly in the distribution sector, and huge costs of importing new technologies, the life time of power plant can be easily extended by 100,000 hrs., old second hand German cars can be used for another ten years, Compact Fluorescence Lamps (CFL) are not in the shelf.



## 4. How to build a without measures scenario? (3/3)

Practically, the Total Final Consumption (TFC) of the new reference scenario (s=WOM) in each model year (y) is the sum of the amount of (final) energy (FE) consumed by each demand sector (d) if end-use technologies and shares are frozen to the values of the calibration year (y0). (DES=Demand for Energy Services, any unit)

$$TFC(y,WOM) = \Sigma_{(d)} FE(d, y_0) * DES(d, y) / DES(d, y_0)$$

In other words the composite index of TFC growth in the new reference scenario (WOM) is calculated weighing the sectoral demands, which can be tons of cement or passenger * kilometres, by their final energy consumption in the base year.

Since technologies and shares are frozen, total primary energy supply and CO2 emissions have the same time development.

## 5. The three scenarios, 1/2

**Without Measures (WOM)**:

The frozen (technologies and shares) scenario

**With Measures (WM)**:

The least cost scenario, which includes win-win options

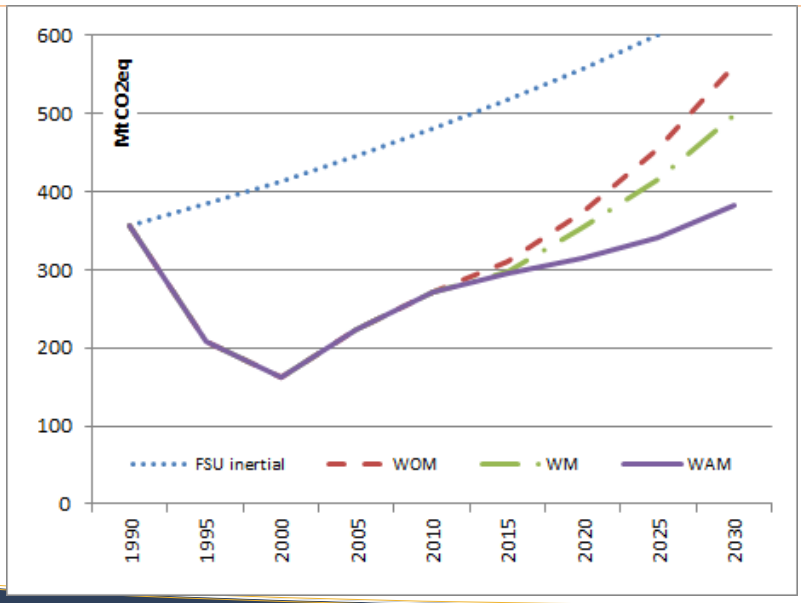
**With Additional Measures (WAM)**:

The partial equilibrium scenario with a CO2 penalty of 10-20 $'2000ppp/tCO2 in 2020-2030, which can be assimilated to possible development of mild CO2 permit prices in the European Emission Trading System, plus some more expensive carbon free electric generation plants (wind, PV, nuclear), dictated by the recent Green Economy Strategy (R.Kzk, June 2013)

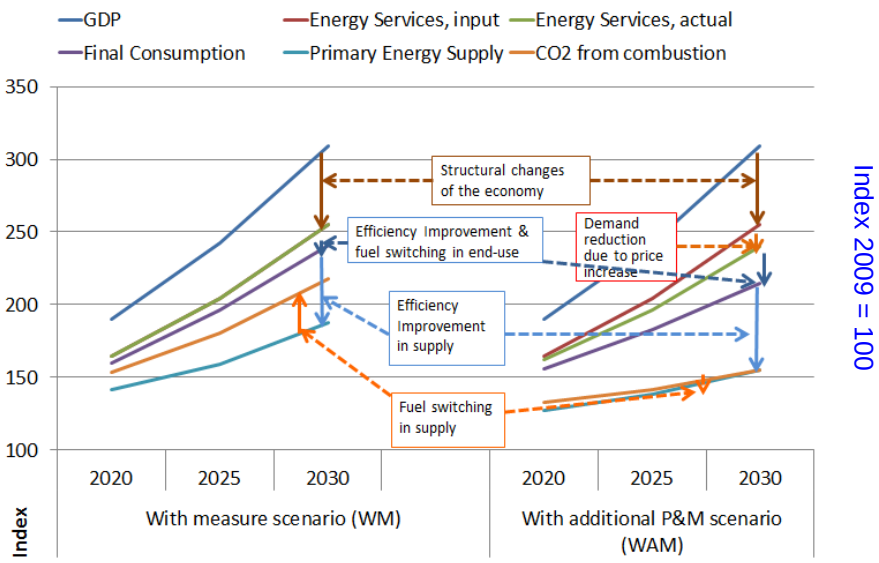


## 5. The three scenarios, 2/2

…



## 6. Results: time profile of energy-emission indexes






## 7. Decoupling drivers

1. Structural changes of the economy
2. Price induced demand reductions in end-uses
3. Energy efficiency improvement and fuel switching in end-use sectors
4. More efficient technologies in the supply sector
5. Fuel switching in the supply sectors

## 7.1 Structural changes of the economy

The demand for energy services is exogenously projected from population and GDP growth assumptions, assuming elasticities of the demand to the drivers lower than 1 in most case.

All together, the demands for energy services grow from 2009 to 2030 by a factor 2.55, compared to 3.09 of GDP; in other words the elasticities of the single demand sector combine to an overall (average) elasticity of 0.825 in the period.

In the WOM scenario CO2 emissions from combustion grow at this same rate.



## 7.2 Price induced demand reductions in end-uses

The with added measures scenario WAM envisages slight energy price increases due to the adoption of CO2 emission restrictive P&M. If final energy users are exposed to energy price increases, a slight but important reduction of emissions takes place. Due to the mitigation effort some key energy commodities, such as natural gas, increase their price, and final users tend to reduce the demand for the energy services that cost more energy.

Assuming that Kazakh energy consumers react to price increases like in other similar countries this demand reduction could be about 2% in 2020, 4% in 2025 and 6% in 2030. Assuming price increases in 2030 of 2-3% in transport fuels, the demand for passengers and tons kilometre would reduce about 2%. Assuming price increases of 5-6% in electricity, 20-40% in district heat and natural gas, the demand for energy services could reduce by 7% in the residential and commercial sectors.

## 7.3 Energy efficiency improvement and fuel switching in end-use sectors

With the assumptions adopted here, the improvement in 2030 could reduce consumption (and emissions) by 6% in 2030. This is an average reduction resulting from completely different behaviours: a huge improvement in the transport sector of almost 20%, a slight improvement in industry (3-4%) and no improvement at all in the residential and commercial sectors.

In the with additional measure scenario (WAM), consumers reduce their final energy needs in 2030 by 11%, unevenly across sectors. The technology in the transport sector improves precisely as in the base case, as the price signal is too low compared to the extra cost of more efficient technologies / fuels without changing the quality of the service (size of cars/trucks). On the contrary there is a considerable jump in the industrial sectors (from 3-4% to 8-9%) and even larger in the residential and commercial sectors (from 0 to 8%).



## 7.4 More efficient technologies in the supply sector

Another option that decouples emissions from economic growths is the use of a more efficient energy supply system. In Kazakhstan this primarily means improving the efficiency of the electricity and district heating chains: generation, transmission and distribution.

In the base scenario (WM) existing low efficiency plants at the end of their lifetime are replaced by new more efficient ones because they are cost effective. In order to satisfy the final energy consumption growing at 4.0-4.3%pa in the period 2020-2030, the primary energy supply grows much less at 1.1-2.9%pa in the same period. If the energy system develops in a cost optimal way, the average efficiency of electricity, heat and CHP plants increases from 43% to 68%.

In the with additional measures scenario (WAM) the efficiency improvement can be even higher, reaching an average efficiency of 73% in 2030, also using a slightly different technology mix.

## 7.5 Fuel switching in the supply sectors

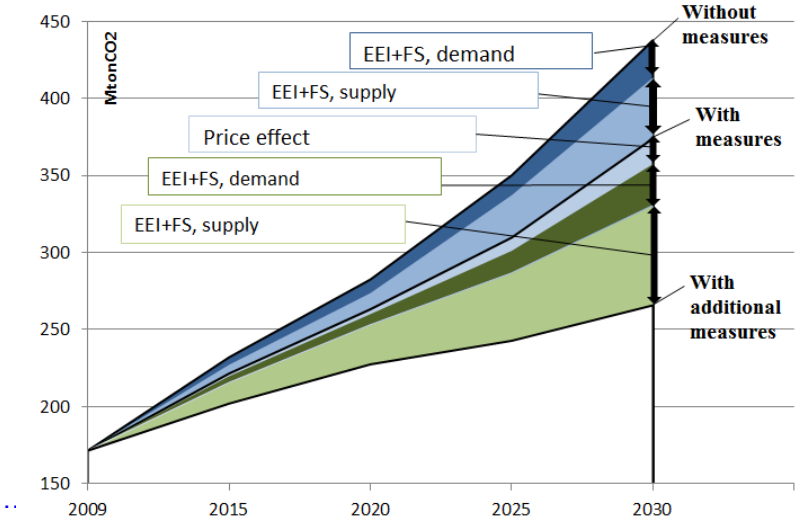
In this context fuel switching includes also switching from fossil energy supply to no-carbon sources / technologies, such as wind, solar and nuclear.

In the base case (WM) scenario some of the gains due to the previous effects are lost due to fuel switching towards more carbon intensive energy vectors.

In the WAM scenario a considerable amount of electricity is generated by wind, some by solar, and in 2030 by nuclear, as mandated by the Green Economy Strategy. This has the effect of compensating the increase of generation by the cheapest source (coal) and maintains the development of CO2 emissions below the profile of TPES.



## 8. From the decoupling drivers to the sectoral contribution to mitigation



# 9.1 The contributions to mitigation of P&M:

Table 1: CO2 emissions from combustion: cost effective P&M in the energy demand sectors

| N. | Name | Objective, activity affected | Type of instrument | Status | Imple-menting entity | Emission reductions (in Mt CO2) 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| 1 | New cars: EURO 4 or higher | transport | Legal | Implem. | Min. Tra. | | | |
| 2 | Production of better gasoline | transport | Direct inv. | adopted | Min o&g, + | | | |
| | | | *Together tra* | | | *2* | *5* | *8* |
| 3 | Adoption of CNG car/buses | transport | Direct inv. | planned | Urban Au. | 0 | 0.1 | 0.5 |
| 4 | Better thermal insulation standards | buildings | Legal | adopted | Urban Au. | 2 | 3.5 | 5 |
| 5 | Preferential development of cities + DH | buildings | Urban plans | planned | Urban Au. | 1 | 1.5 | 2 |
| 6 | Energy audits, emission reporting, etc. | industry | Legal/Info | adoped | Min Ind. | | | |
| 7 | Renovation of the capital stock | industry | Direct inv. | Implem. | Factory O. | | | |
| | | | *Together ind* | | | *5* | *6* | *10* |
| | | | | | **TOTAL** | **9** | **13** | **24** |

Min o&g, +: Ministry of Oil & Gas for the legal part, + refinery owners for the direct investment part; Urban Au.: urban authorities; buildings refers to Residential and Commercial sectors; etc.; TOTAL < SUM



# 9.2 The contributions to mitigation of P&M:

Table 2: CO2 emissions from combustion: cost effective P&M in the energy supply sectors

| N. | Name | Objectiv, activity affected | Type of instrum ent | Status | Imple-menting entity | Emission reduc-tions (in Mt CO2) 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| 1 | Hydro: Moynak 0.3 GW; Shardarinsk 0.1 GW; small 0.1GW | power p. | Dir.Inv. | Adopted+ | KEGOC/Mind | 1.2 | 1.1 | 1 |
| 2 | Wind, 300 MW | power p. | Dir.Inv. | Adopted | KEGOC/Mind | 1 | 1 | 1 |
| 3 | Balkhash, 1.3+1.3 GW | power p. | Dir.Inv. | Adopted+ | KEGOC/Mind | 5 | 5 | 5 |
| 4 | Replacement of old coal plants with new more efficient ones | power p. | Dir.Inv. | Adopted+ | KEGOC/Mind | 3 | 10 | 10 |
| 5 | Preferential use of natural gas to replace old coal plants | power p. | Dir.Inv. | Adopted+ | KEGOC/Mind | 2 | 2.5 | 3 |
| 6 | Transmission & distribution network refurbishment | elc net. | Dir.Inv. | adopted | KEGOC | 0.1 | 0.3 | 0.5 |
| 7 | Reduction of normative and above normative losses | Inters. | several | planned | several | 4 | 8 | 12 |
| 8 | Continuation of the transition to a market economy | Inters. | various | Planned | Min.Ind. | 3 | 6 | 9 |
| | | | | | **TOTAL** | **7** | **17** | **40** |

adopted + = adopted and partly implemented; Min.Ind. = Ministry of industry and new technology; Dir.Inv. = Direct investment; elc net.= electric network; Inters.= intersectoral; power p.= power plants; Min o&g, +: Ministry of Oil & Gas for the legal part, + refinery owners for the direct investment part; Urban Au.: urban authorities; buildings refers to Residential and Commercial sectors; etc.; TOTAL Contribution < SUM

## 9.3 The contributions to mitigation of P&M:

Table 3: CO2 emissions from combustion: additional P&M, price increase effect

| N. | Name | Objective, activity affected | Type of instrument | Status | Imple-menting entity | Emission reduc-tions (in Mt CO2) 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| 1 | Partly liberalised price system | transport | Several | planned | Many | 0 | 0.5 | 1 |
| 2 | Partly liberalised price system | industry | Several | Planned | Many | 0 | 3 | 6 |
| 3 | Partly liberalised price system | buildings | Several | planned | Many | 0 | 6 | 10 |
| | | | | | **TOTAL** | **0** | **9** | **17** |



## 9.4 The contributions to mitigation of P&M:

Table 4: CO2 emissions from combustion: additional P&M in the energy demand sectors

| N. | Name | Objective, activity affected | Type of instrument | Status | Imple-menting entity | Impact (MtCO2) 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| 1 | Better EURO standard for trucks | transport | Legal | Planned | Min. Tra. | | | |
| 2 | Production of improved quality gasoline | transport | Dir.Inv. | Planned | Min.o&g+ | | | |
| | | | *Together tra* | | | *3* | *6* | *9* |
| 3 | Heat meters | R&C | Info+Legal | Planned | M.Housing | | | |
| 4 | Better thermal insulation standards | R&C | Info+Legal | Planned | M.Housing | | | |
| 5 | improved standard of boilers | R&C | Info+Legal | Planned | M.Housing | | | |
| 6 | Labels of electrical appliances | R&C | Info+Legal | Planned | M.Housing | | | |
| | | | *Together r&c* | | | *2* | *5* | *9* |
| 7 | Subsidies to renew the stock of devices | intersectoral | Dir. Inv. | planned | Min.EF | * | * | * |
| 8 | Make available 5 Bcm of natural gas | R&C+industry | Dir.Inv. | planned | ??? | 6 | 6 | 6 |
| | | | | | **TOTAL** | **11** | **17** | **21** |

Min. Tra.+ = Ministry of Transport; , Ministry of oil and gas, Refinery owners; Min o&g, +: Ministry of Oil & Gas for the legal part, + refinery owners for the direct investment part; Info+Legal = information campaigns + legal instruments; Dir.Inv.=direct investment; R&C+industry = Residential, Commercial and Industrial end users; Min.EF. = Ministry of Economy and Finance; * = the mitigation impact of this measure is included in the figures above; TOTAL < SUM

## 9.5 The contributions to mitigation of P&M:

Table 5: CO2 emissions from combustion: additional P&M in the energy supply sectors

| N. | Name | Objective, activity affected | Type of instrument | Status | Imple-menting entity | Impact (MtCO2) 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| 1 | Emission Trading Scheme | Plants+ | legal | adopted+ | Min. Env. | 20 | 25 | 30 |
| 2 | Wind | power pl. | | planned | Min. Ind. | 2 | 10 | 10 |
| 3 | Solar | power pl. | | planned | Min. Ind. | 0.2 | 0.5 | 1 |
| 4 | Nuclear | power pl. | | planned | Min. Ind. | 0 | 0 | 9 |
| 5 | Own consumption, losses reduction | Mining +++ | | planned | Min o&g ++ | 5 | 10 | 15 |
| | | | | | **TOTAL** | **26** | **44** | **64** |

Plants, += plants plus large industries; adopted + = the framework law has been adopted but emission reduction targets will be established by decree on an annual or biannual basis; Min. Env. = ministry of Environment; power pl.=power plants; Min. Ind.=Ministry of industry and new technology; mining +++ = coal mining, oil & gas upstream sectors; Min o & g ++: Ministry of Oil & Gas, Ministry of mining and mineral resources for the legal part, + owners of the companies operating in the primary energy sector; TOTAL Contribution < SUM



## Thank you for your attention!

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