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Impact of possible shale gas extraction on the Polish economy

INSTITUTE OF ECONOMETRICS

Plan of the presentation

Impact of possible shale gas extraction
on the Polish economy

1. Introduction - facts
2. Model
3. Simulations
4. Conclusions

Project: *The prospect of exploitation of shale gas deposits in Poland in light of the "resource curse" concept*
funded by National Science Center in Poland

Introduction

EIA, 2011. *World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States*. U.S Energy Information Administration, Washington DC.

IEA, 2011. *Are We Entering a Golden Age of Gas*. WEO-2012 special report. International Energy Agency, Paris.

Possibility of exploitation of unconventional resoures of gas is a big challenge for

- countries
- modelers

Introduction

Gas – a fuel of 21th Century?

Remaining technically recoverable resources of gas by type and region, end 2011 (in tcm)

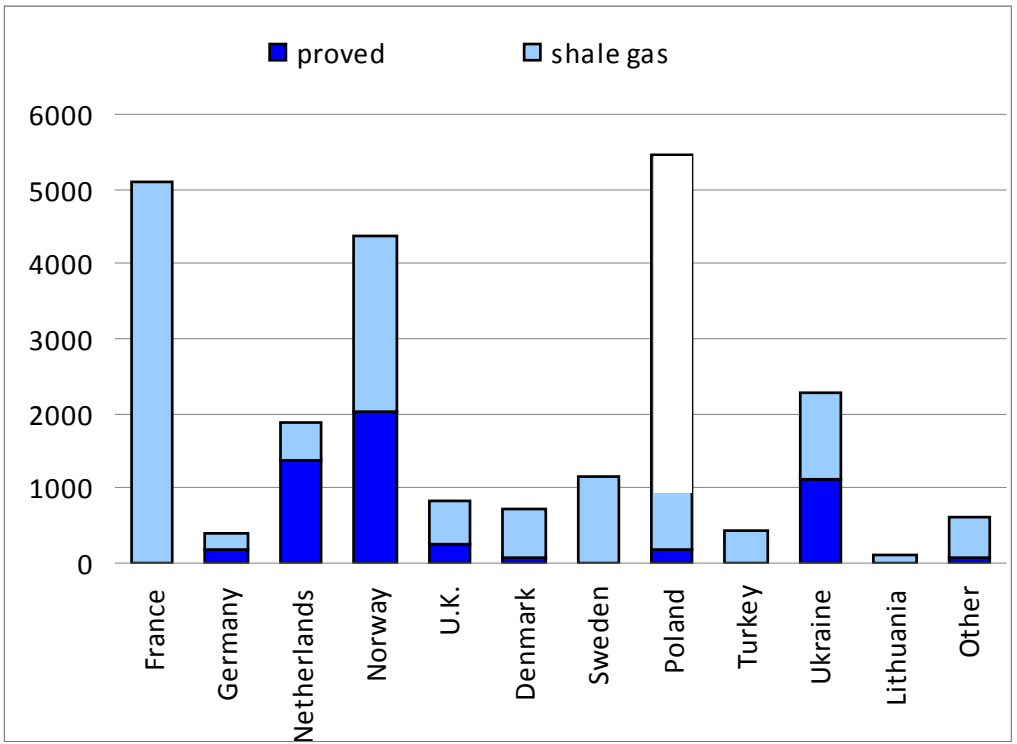
	Total	Conven-tional	Unconventional				Unconv share (%)
				Tight	Shale	Coalbed	
E. Europe/Eurasia	174	131	43	10	12	20	24.7
Middle East	137	125	12	8	4	-	8.8
Asia/Pacific	128	35	93	20	57	16	72.7
OECD Americas	122	45	77	12	56	9	63.1
Africa	74	37	37	7	30	0	50.0
Latin America	71	23	48	15	33	-	67.6
OECD Europe	45	24	21	3	16	2	46.7
World	752	421	331	76	208	47	44.0

Source: IEA 2012: 68

Introduction

Shale gas – the hope for Poland?

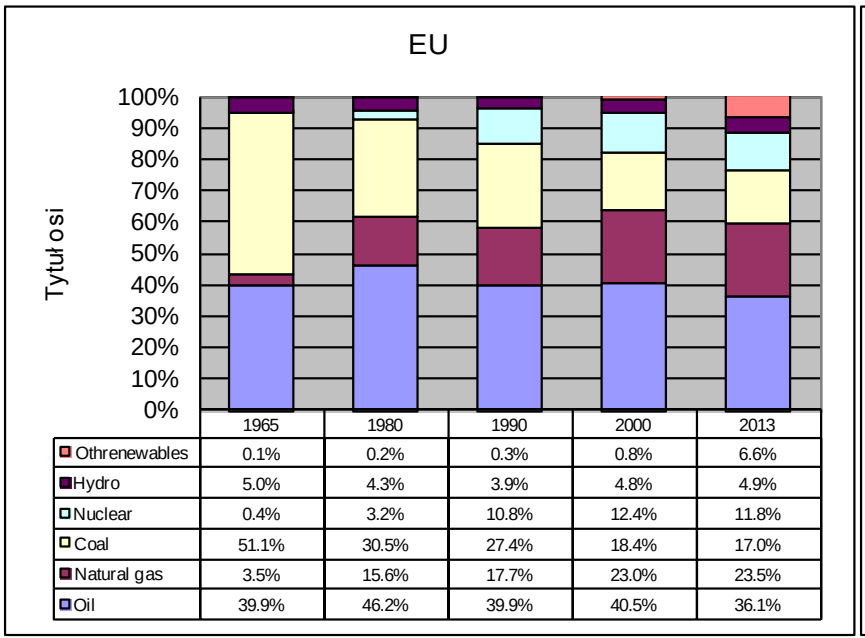
Reserves of gas in Europe (billions of cubic meters)



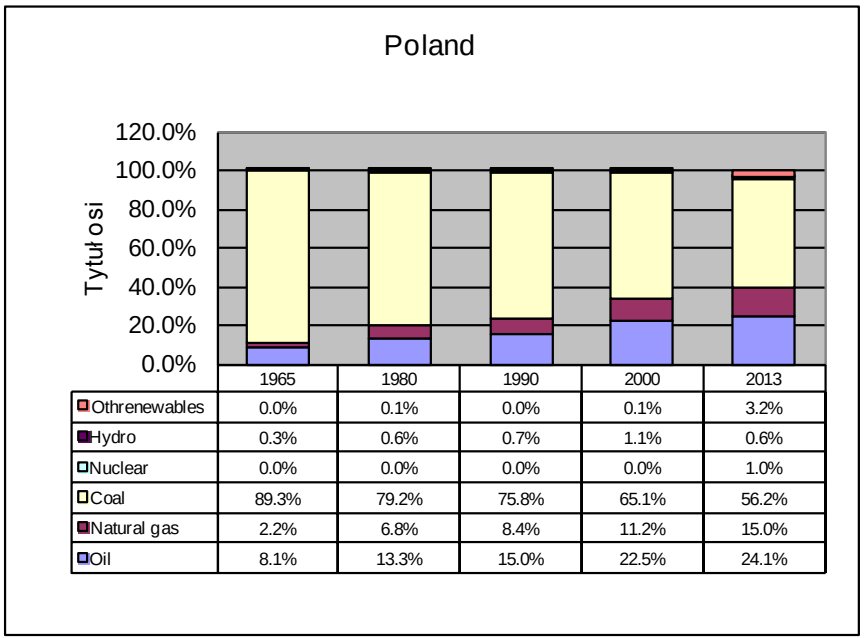
Source: Author's elaboration based on EIA 2011

Introduction

Why shale gas might be important for Poland



	1965	1980	1990	2000	2013
Othrenewables	0.1%	0.2%	0.3%	0.8%	6.6%
Hydro	5.0%	4.3%	3.9%	4.8%	4.9%
Nuclear	0.4%	3.2%	10.8%	12.4%	11.8%
Coal	51.1%	30.5%	27.4%	18.4%	17.0%
Natural gas	3.5%	15.6%	17.7%	23.0%	23.5%
Oil	39.9%	46.2%	39.9%	40.5%	36.1%

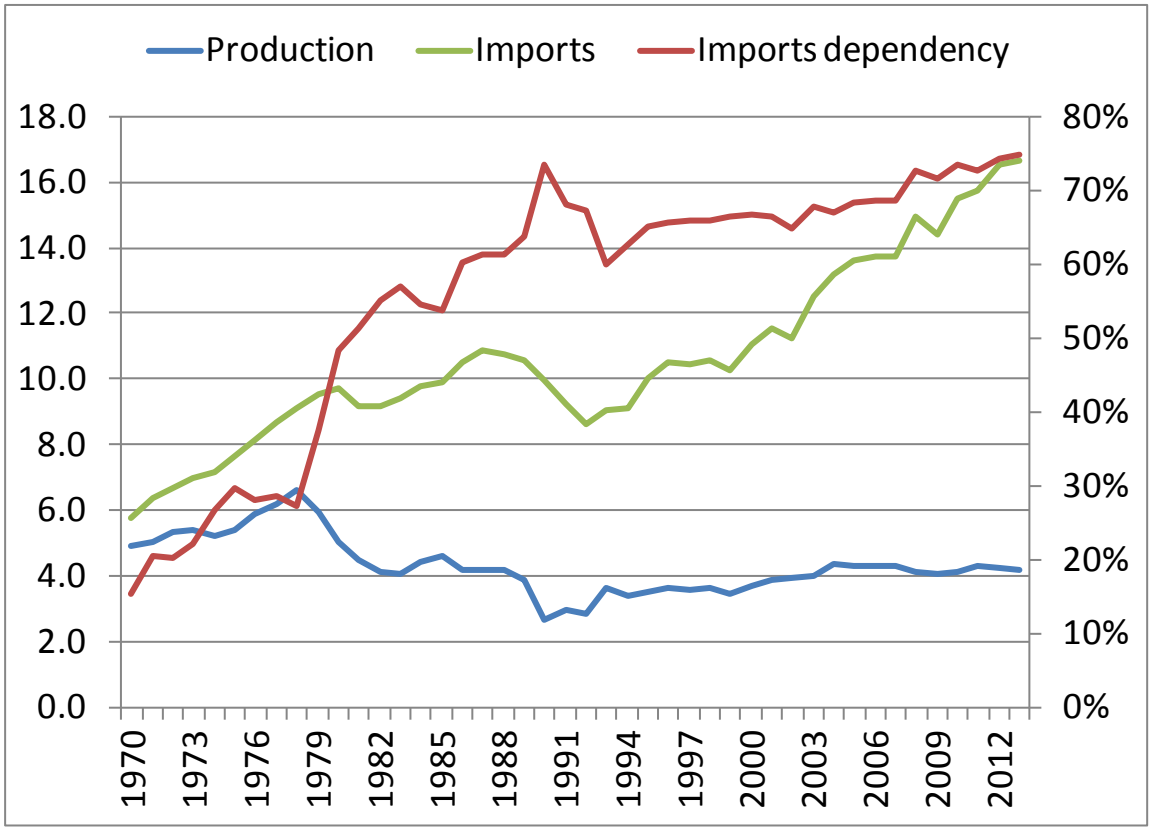


	1965	1980	1990	2000	2013
Othrenewables	0.0%	0.1%	0.0%	0.1%	3.2%
Hydro	0.3%	0.6%	0.7%	1.1%	0.6%
Nuclear	0.0%	0.0%	0.0%	0.0%	1.0%
Coal	89.3%	79.2%	75.8%	65.1%	56.2%
Natural gas	2.2%	6.8%	8.4%	11.2%	15.0%
Oil	8.1%	13.3%	15.0%	22.5%	24.1%

Source: Author's elaboration based on BP report

Introduction

Sources of gas supply (in Bcm) and imports dependency



Source: Author's elaboration based on BP report

Introduction

Uncertainties of shale gas extraction

Three main uncertainties:

- **Prices**
  - uncertainty as to world price trends (Poland is gas price taker)
  - import prices of gas in Poland are higher than in Western Europe – creating global market and diversifications of supply will stimulate processes of price convergence
  - diversification (LNG terminal; long term contract with Quatar, imports from Germany, Norway, Czech Republic)
- **Size of the recoverable resources of shale gas**
  - aplicability of techchnologies
  - improvements of existing technologies (R&D)
- **The volume of supply**
  - full unit costs (including costs exploration, exploitation and uncertainty)
  - efficiency of extraction
  - demand for Polsih gas (domestic and foreign)

Model

Issues for construction scenarios for Poland

Supply side	Demand side
Investments in - drilling (depending on life cycle of wells) - gas storage (proportional to demad) - installations for NG liquefaction (to satisfy possible demand for LNG) - transmission network	Investments in - modernization of existing power plants and CHP to replace coal with natural gas - construction of gas power plants and CHP - distribution network (depends on location of final customers
Decline in imports of gas	Exports of NG or LNG
Unit costs of production of shale gas sector (assumed learning curve)	Energy efficiency of new and modernized power plants and CHP
Financing of investments - public-private - domestic-foreign - crowding out	
Royalties and taxation	
Prices of primary fuels on world markets	

Model

Modeling framework

IMPEC model (Interindustry Macroeconomic Model of the Polish Economy):

- Inforum type (input-output +econometric equations)
- 54 products (+ 2 - oil&gas, distribution of gas)
- hybrid approach (interindustry flows in monetary & energy in natural units)
- 14 energy sources (primary and secondary) for 54 indusstries (+2)

Problem: new data

- new versions of industrial and product classifications (CPA & NACE)
- new SUT (end of June 2014)
- new product by product table (end of July 2014)

Model

Modeling framework

Results for this presentation are based on a simplified version:

- Lentief model (set path of final demand)

but…

- io coefficients change according to historically observed trends and relative prices of different types of energy
- reduction of energy intensity (but no benefits like decline in energy prices and GDP growth are included)
- imports is proportional to output, but imports of gas is residual (demand minus domestic supply)

CASE-Orlen scenarios (2012)

- average production from well twice lower then in US

Scenarios of shale gas extraction:

- Base - no shale gas extraction
- Moderate (3.5 Bcm)
- Significant (6 Bcm)
- Huge (19 bcm)

Model

Scenarios of drilling to 2050

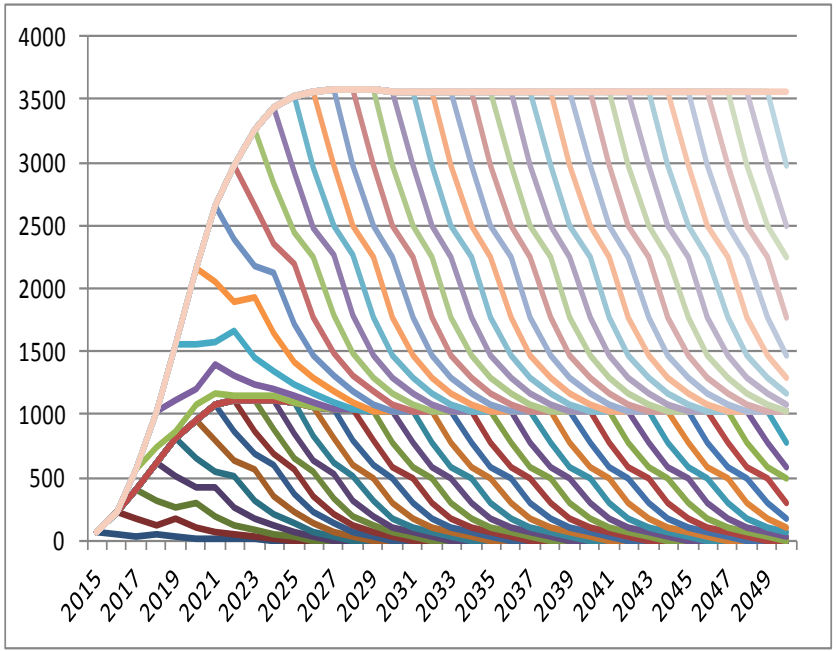
T - appraisal drillings transformed into operational
N - new drillings (operational)

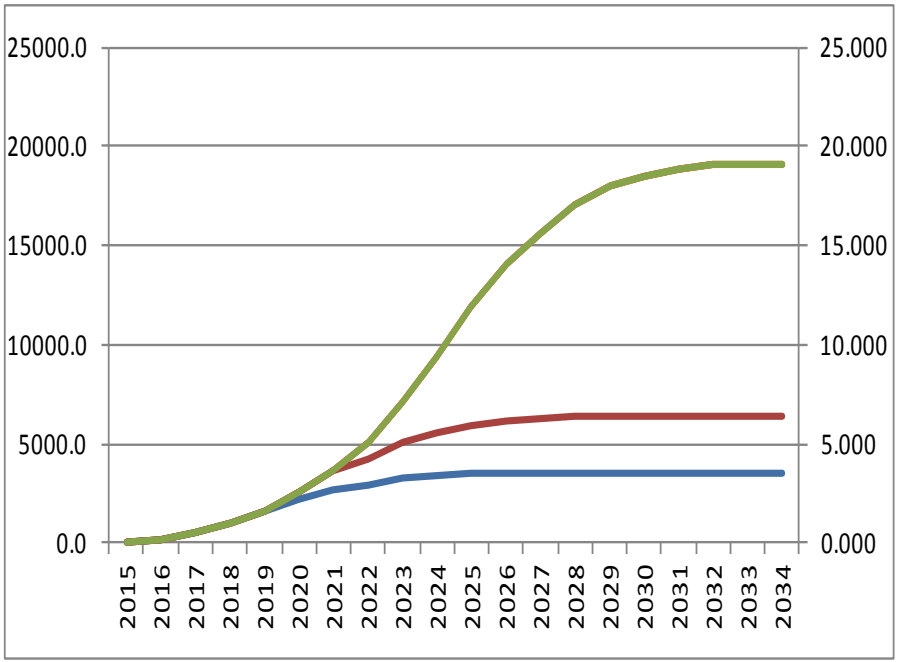
Distribution of yearly performance of a well in Poland (in MCM)			
Year	% of max	in MCM	
		T	N
1	100	12.0	15.0
2	80	9.6	12.0
3	40	4.8	6.0
4	80	9.6	12.0
5	50	6.0	7.5
6	30	3.6	4.5
7	20	2.4	3.0
8	15	1.8	2.3
9	10	1.2	1.5
10	0	0	0

Year	Scenarios (number of wells per year)					
	Moderate		Significant		Huge	
	T	N	T	N	T	N
2015	5	0	5	0	5	0
2016	15	0	15	0	15	0
2017	20	10	20	10	20	10
2018	25	20	25	20	25	20
2019	25	30	25	30	25	30
2020	25	40	25	70	25	70
2021	25	40	25	80	25	80
2022	20	40	25	80	25	130
2023	20	40	25	80	25	180
2024	20	40	25	80	25	230
2025	20	40	25	80	25	280
…	…	…	…	…	…	…
2050	20	40	25	80	25	280

Model

Scenarios of drilling to 2050





Model

Adjusting io data

Data for IMPEC model is expressed in classifications based on older version of CPA 2002

Section C: mining and querrying includes natural gas
Divisions
- 10 coal
- **11 oil and gas**
- **12 uranium and thorium ores**
- **13 metal ores**
- **14 other mining and quarrying**
	Section E: electrecity, gas, water
	Divisions
	- **40 electricity, gas, steam and hot water**
	  - *40.2 Manufacture of gas, distribution of gaseous fuels through mains*
	  - …

Additional information used to isolate gas extraction and gas manufacturing and distribution

- natural gas supply in quantity units (domestic production and imports)
- natural gas use by final users (sectors) in quantity units
- prices of natural gas
- the newest *supply and use table* for 2008 with 84 products and 83 activities) of the year 2008
- experts' estimates of cost structure in the two sectors

Model

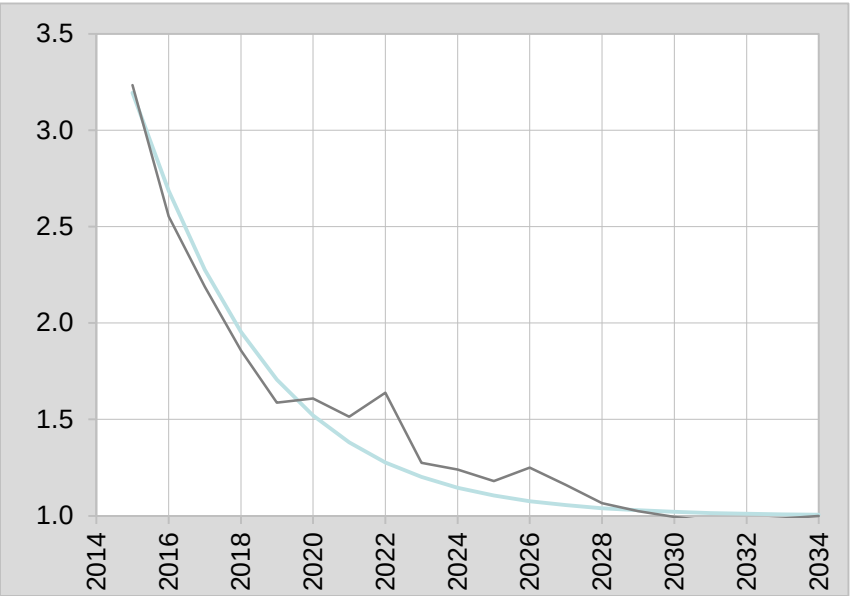
Adjusting io data

Factors

- future (minimum) coefficients
- learning curve
- ammount of domestic extraction
- time

Learning curve

(based on CASE-Orlen scenarios)



Unit costs (io coefficients of *extraction of oil and gas*)

$$a_{ijt}^{s+c} = (1 - u_t^s)a_{ij\,0}^{c} + l_t u_t^s a_{ijd}^{s}$$

where:

s - shale gas

c - conventional gas

d - future (minimum) value of coefficient

0 - base period of io table

a_{ij}^{g} - io coefficient for g(as) industry

l_t - value of learning curve in year t

u_t^s - share of shale gas in output

Model

Adjusting io data

Highlited from 0.0001 to 0.0020

Unit costs of extraction of oil and gas

		gaz konwencjonalny				shale gas - target	
		NL2007	DE2007	UK2005	PL2008	How many % more, compared to con-ventional	level
1	Products of agriculture, hunting and					0%	
2	Products of forestry, logging and rela		0.005			0%	
3	Fish and other fishing products; serv					0%	
4	Coal, lignite &peat mining					0%	
5	Extraction of natural gas and crude p	0.021	0.119	0.066	0.1749	10%	**0.1924**
6	Other mining	0.002			0.0140	0%	**0.0140**
56	Other services		0.003	0.000		0%	
57	Taxes less subsidies on products	0.001	0.003	0.002		0%	
58	Compensation of employees	0.060	0.124	0.052	0.1820	0%	**0.1820**
59	Other net taxes on production	0.008	0.016	0.005	0.0140	0%	**0.0140**
60	Consumption of fixed capital	0.127	0.109	0.708	0.0790	50%	**0.1185**
61	Operating surplus, net	0.652	0.258		0.4530		**0.3715**
	Total	**1.000**	**1.000**	**1.000**	**1.0000**		**1.000**

Model

Other assumptions

Final demand

average annual growth rates

Households consumption	3.0%
Government	3.0%
Investmnts	3.0%
Exports	3.0%

Improvement of energy efficiency (annually)

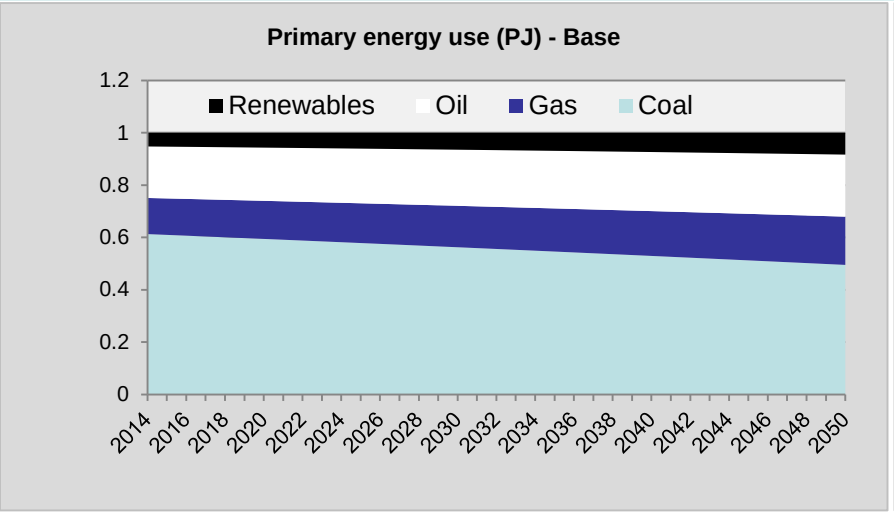
Coal	1.0%
Petroleum products	1.0%
Electricity&heat	1.0%
Gas	1.0%

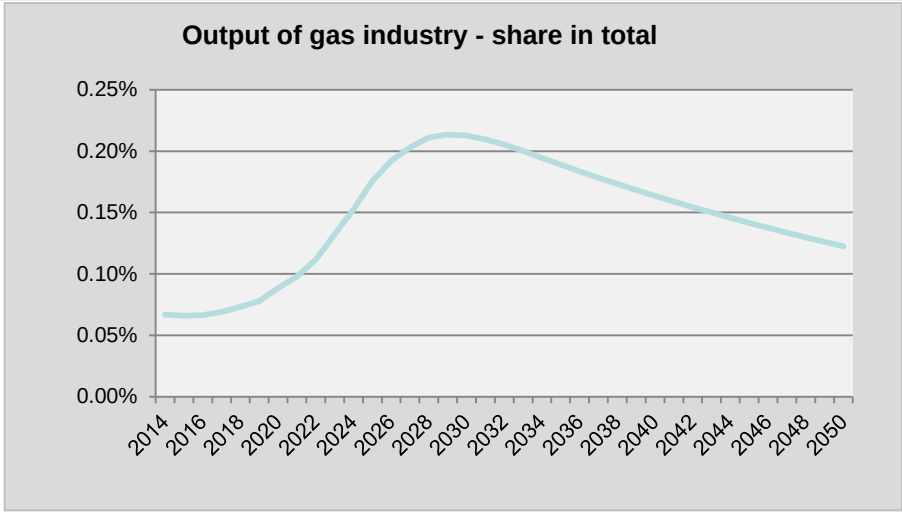
Trends in energy prices & substitution by gas

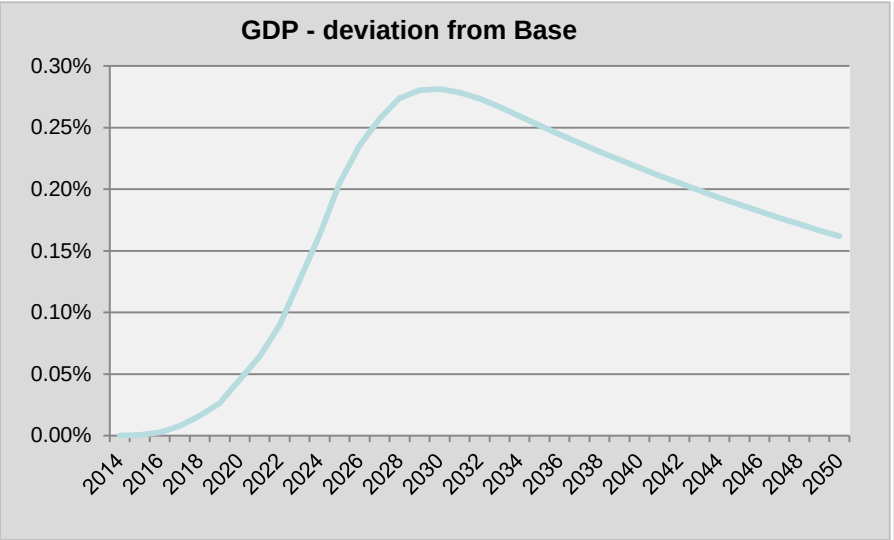
	Price elasticity of gas	Average annual growth	2050		
			Prices		Index of gas demand (substitution)
			index	gas / other energy	
Gas		0.0%	1.000		
Coal	-0.300	0.8%	1.332	0.751	1.090
Petroleum products	-0.200	0.8%	1.332	0.751	1.059
Electricity&heat	-0.100	0.8%	1.332	0.751	1.029

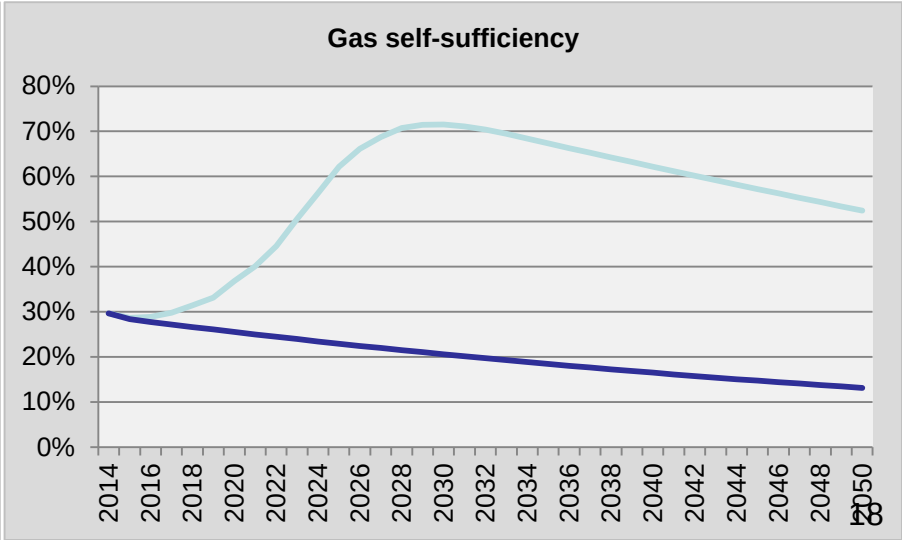
Results of simulations

„Huge” scenario







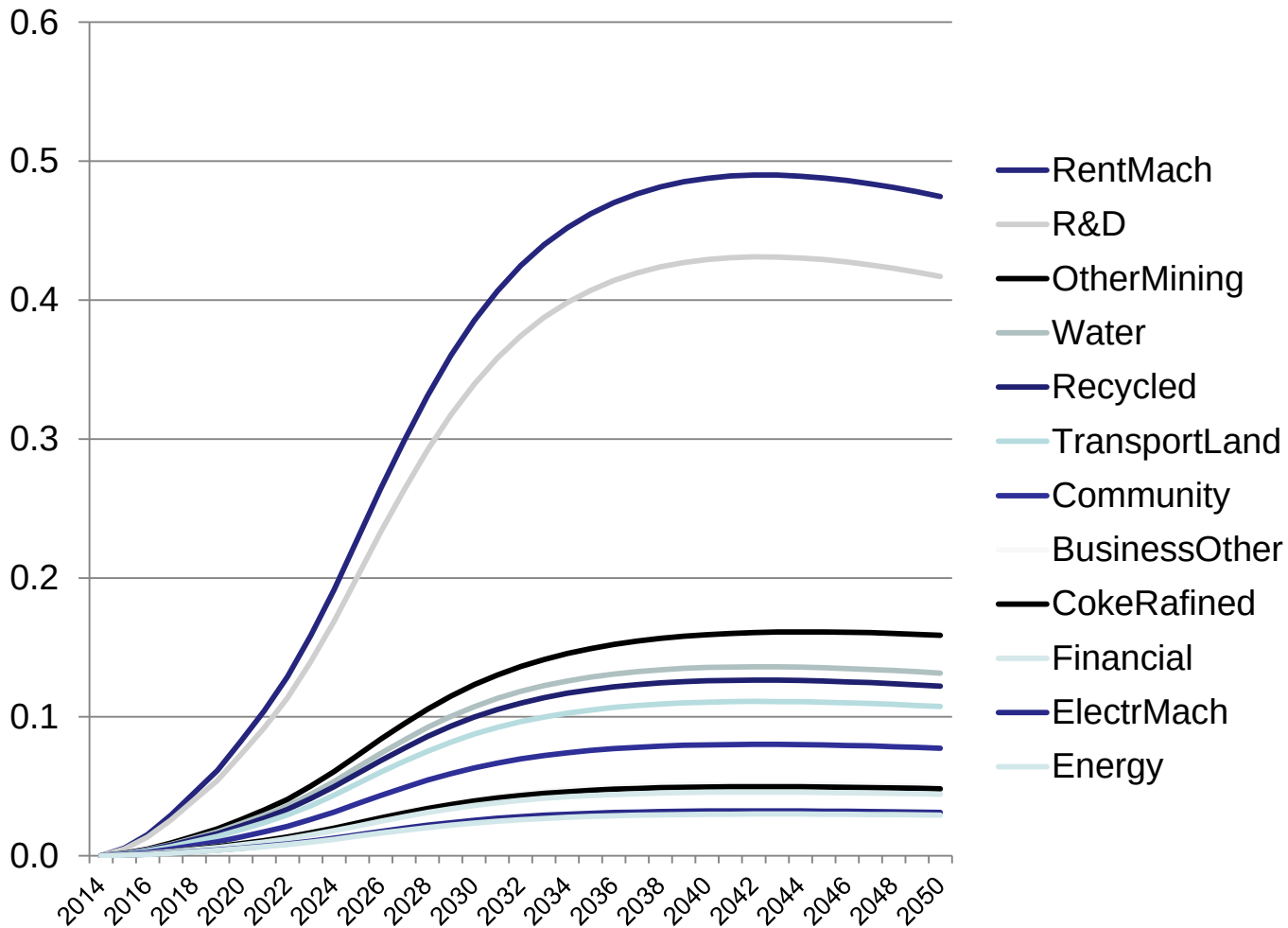


Conclusions

- Long term development of shale gas sector in Poland depends on many factors, like:
  - world market development (prices)
  - possibilities of adaptation of US technologies in Polish geological circumstances
  - size of proved resources of shale gas, which will be recognized within a few years
- In the most optimistic variant considered for Poland for next several dozen of years, gas sufficiency increase from 25% to 70% and the maximum increase in GDP over the base lane is about 0.28%
- Realization of this variant cause that the output of oil and gas sector will triple in 2030, but its share in total output of economy will not exceed 0.21%
- Presented results must be refined using full version of IMPEC

Results of simulations

Winners of shale gas extraction (CSCP) – „huge” scenario



Structural changes

An *ex post* method

$\boldsymbol{X_t} = (\boldsymbol{I} - \boldsymbol{A}_t)^{-1}\boldsymbol{Y}_t$ where t = 0, 1, 2, ...T

$\boldsymbol{X}_t = (\boldsymbol{I} - \boldsymbol{A}_t)^{-1}\boldsymbol{B_t}\boldsymbol{Y}_t^C$

Simulations (constant parameters):

$\widehat{\boldsymbol{X}}_t = (\boldsymbol{I} - \boldsymbol{A}_b)^{-1}\boldsymbol{B}_b\boldsymbol{Y}_t^C$ where $b \in \{0, 1, 2, \dots, T\}$

Lets denote growth of any variable Z from the period s to t by

${}_s^t\Delta Z_i = Z_{it} - Z_{is}$

Consider the growth of output of industry i:

If ${}_s^t\Delta X_i - {}_s^t\Delta\hat{X}_i < 0$ sector *i* "looses" from *s* to *t*

If ${}_s^t\Delta X_i - {}_s^t\Delta\hat{X}_i > 0$ sector *i* "wins" from *s* to *t*

Measure of structural changes between period *0* (base) and *t*

$SC_0^t = {}_0^t\Delta X_i - {}_0^t\Delta\hat{X}_i$ (1) - flow

$CSC_0^n = \sum_{t=0}^{n} SC_0^t$ (2) - stock

$SCP_0^t = \frac{SC_0^t}{X_0}$ $CSCP_0^t = \frac{CSC_0^t}{\sum_{k=0}^{t} X_k}$

Structural changes

An *ex ante* method

The idea of *SC* and *CSC* can be generalized (extended) to comparison of two simulations when using multi-equation model: with base assumptions and other assumptions which.

B - simulated (base)

O - simulated (other - not base)

If ${}_{s}^{t}\Delta X_i^B - {}_{s}^{t}\Delta X_i^O < 0$ sector *i* "looses" from *s* to *t*

If ${}_{s}^{t}\Delta X_i^B - {}_{s}^{t}\Delta X_i^O > 0$ sector *i* "wins" from *s* to *t*

$$SC_0^t = {}_{0}^{t}\Delta X_i^B - {}_{0}^{t}\Delta X_i^O \qquad (1)$$

$$CSC_0^n = \sum_{t=0}^{n} SC_0^t \qquad (2)$$