



Global Trade Analysis Project

GTAP-POWER

Instructors:

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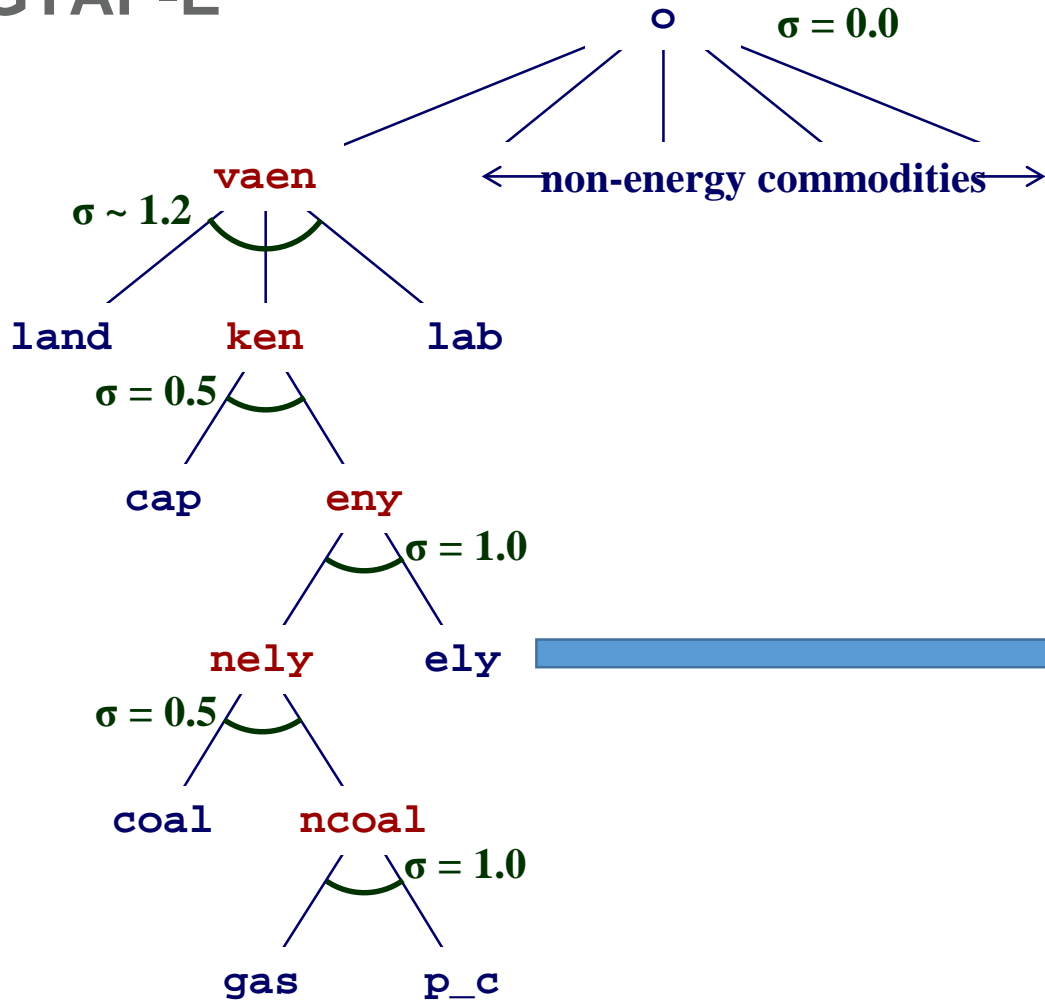


Group Members

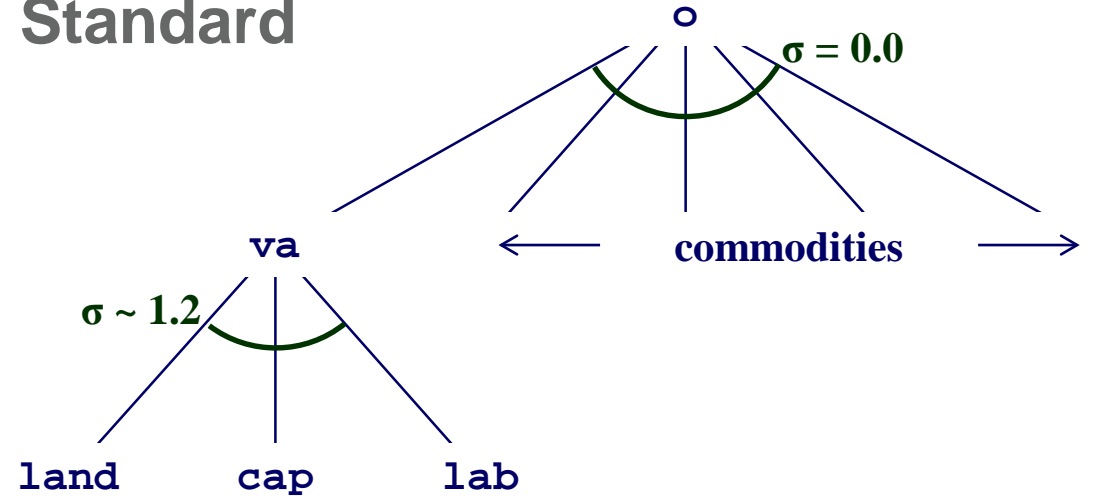
- **Liz Wachs and Jess Chen**
 - Electrification of Private Consumption in the U.S.
- **Abiola Akande and Jong-Hwan Ko**
 - Domestic Gas Subsidy Removal in SSA
- **Francesco Clora and Jindra Nuella Samson**
 - Coal Consumption Reduction in the EU

GTAP-Power

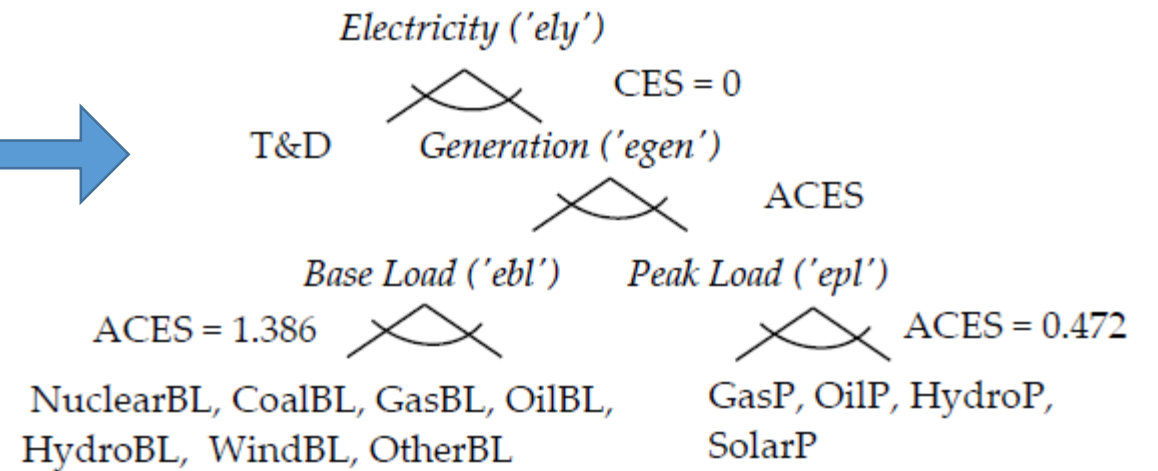
GTAP-E



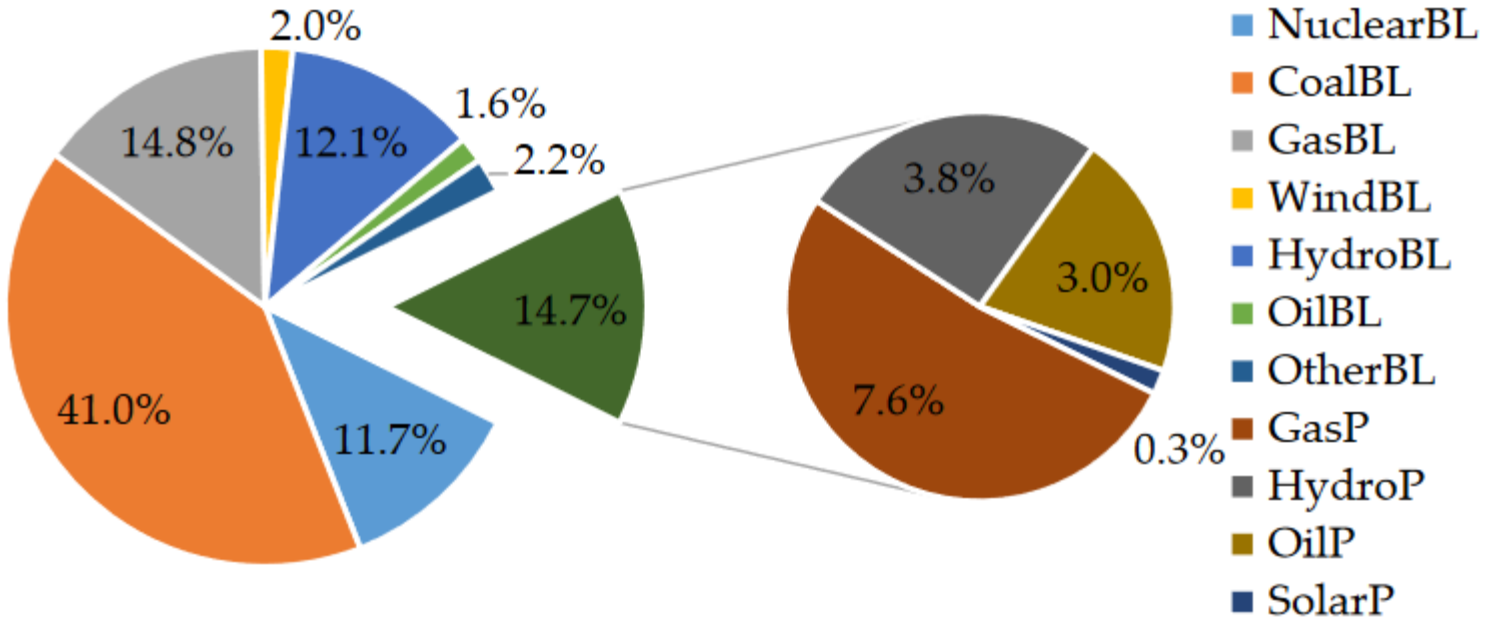
Standard



GTAP-Power



Electricity sector is split into 11 generation technologies + T&D



Shares of global electricity generation from different technologies in base and peak (green cut-out) load (2011)

Source: Peters (2016)

Motivation to split electricity sector

- Richer representation of technologies
- Substitution possibilities
- Explicit renewables targeting
- Extends the set of policy options (e.g. feed-in tariffs, subsidies to renewables, nuclear moratoriums, etc.)



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Electrification of Private Consumption in the U.S.

Liz Wachs

Jess Chen

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ABSTRACT

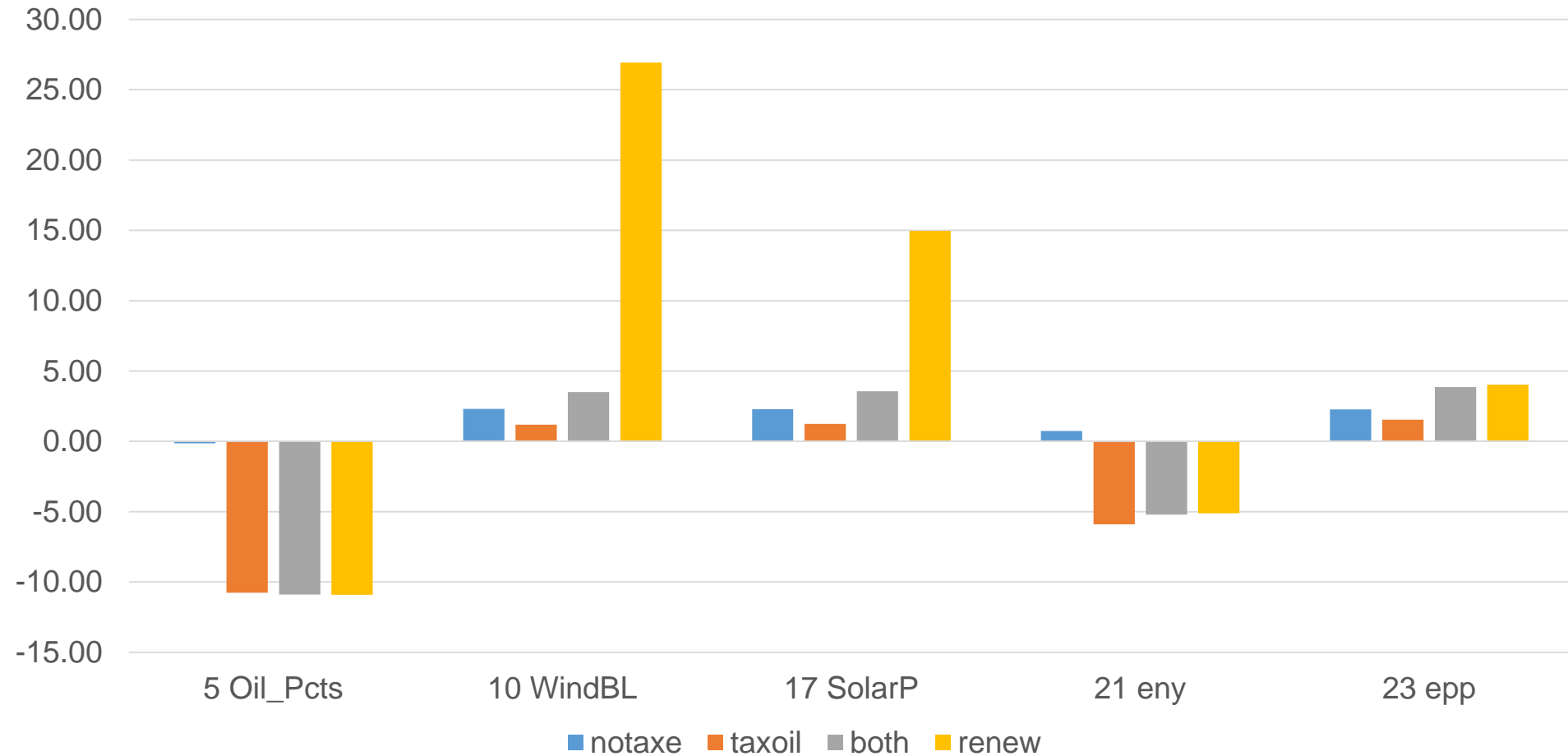
- **What are the effects of electrification of private consumption in the U.S.?**
 - Need energy tax increase to reduce energy consumption
 - Oil tax hurts welfare in oil-exporting regions, helps non-exporters
 - Greatest reduction in CO₂ if oil tax only (no subsidy)
 - Welfare costs are greater for other countries than for U.S.

EXPERIMENTS

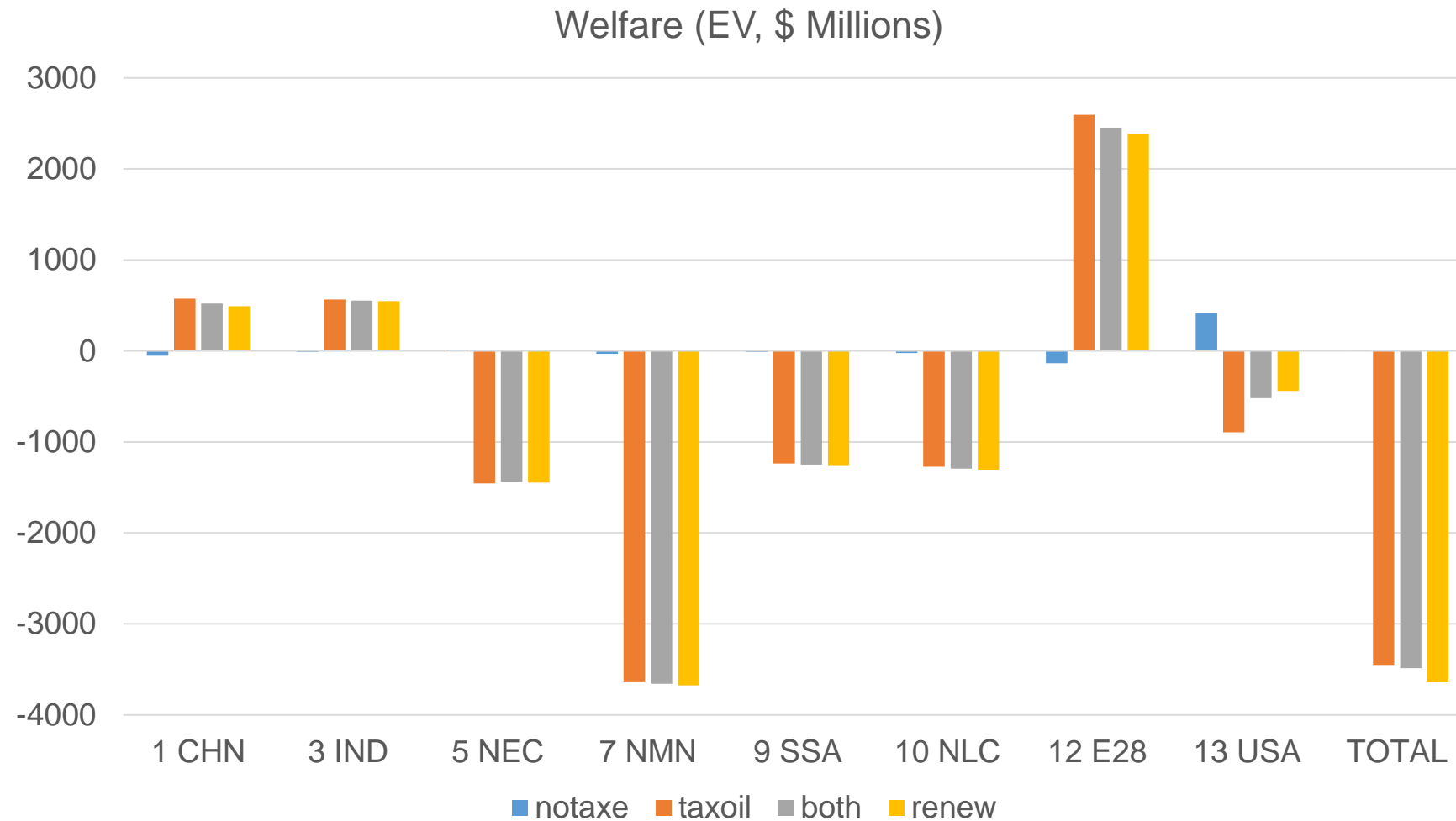
- 1. Eliminate private consumption taxes on electricity sectors**
 1. Shock tpd("EGEN_COMM", "USA") to target 0%
 2. Base load: NuclearBL, CoalBL, GasBL, WindBL, HydroBL, OilBL, OthBL
 3. Peak: GasP, HydroP, OilP, SolarP
- 2. Double private consumption tax on refined oil (fuel)**
 1. Oil_Pcts
- 3. Both 1) and 2)**
- 4. 3) and subsidize renewable electricity sectors**
 1. WindBL, SolarP

PRIVATE CONSUMPTION

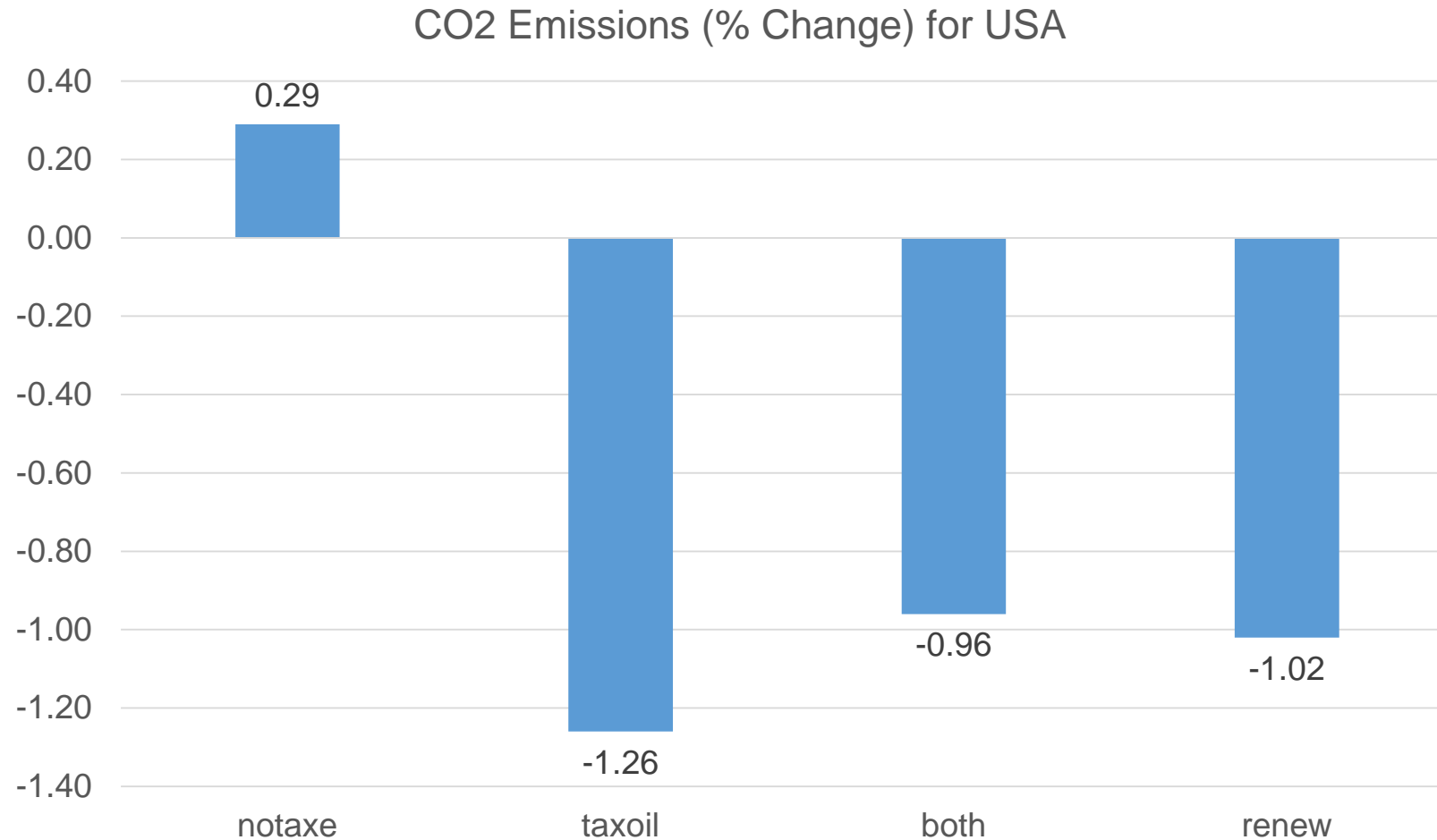
Private Energy Consumption Mix



WELFARE



CO2 EMISSIONS



COST OF CO2 REDUCTION

Scenario 4: Tax oil, eliminate elec. tax, subsidize renewables

	<u>CO2 emissions change ("gco2t")</u>	<u>Welfare change ("EV")</u>
USA	-1.02 %	\$ (440)
Oil Exporters	0.47 %	\$ (7,684)
Non-oil exporters	0.67 %	\$ 4,491
Total/overall	-0.0013 %	\$ (3,633)
World price per ton CO2 reduction		\$ 100
US price per ton CO2 reduction		\$ 8

CONCLUSION

- Full electrification of HH consumption in the U.S. is **hard**
- Even with:
 - Double oil tax + remove elec tax + subsidize renewables
 - Only reduces oil consumption by households by 10%
 - Not full replacement of energy use
- **Because oil is large part of HH energy consumption (~50%)**
- However, relatively cheap way for U.S. to reduce CO₂ (sorry, ROW!)



Global Trade Analysis Project

Domestic Gas Subsidy Removal in SSA and Its Impacts

Abiola Akande
Jong-Hwan Ko

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ABSTRACT

- **Research Questions**

- What are the likely impacts of domestic natural gas subsidy removal in SSA on the global economy?
- What are the likely impacts of domestic natural gas subsidy removal in SSA and the implementation of the NDCs without trade on the global economy?

- **Major shocks**

Domestic natural subsidy removal in SSA (S1)

Domestic natural subsidy removal and the implementation of the NDCs without permits trade in the global economy (S2)

- **Major findings**

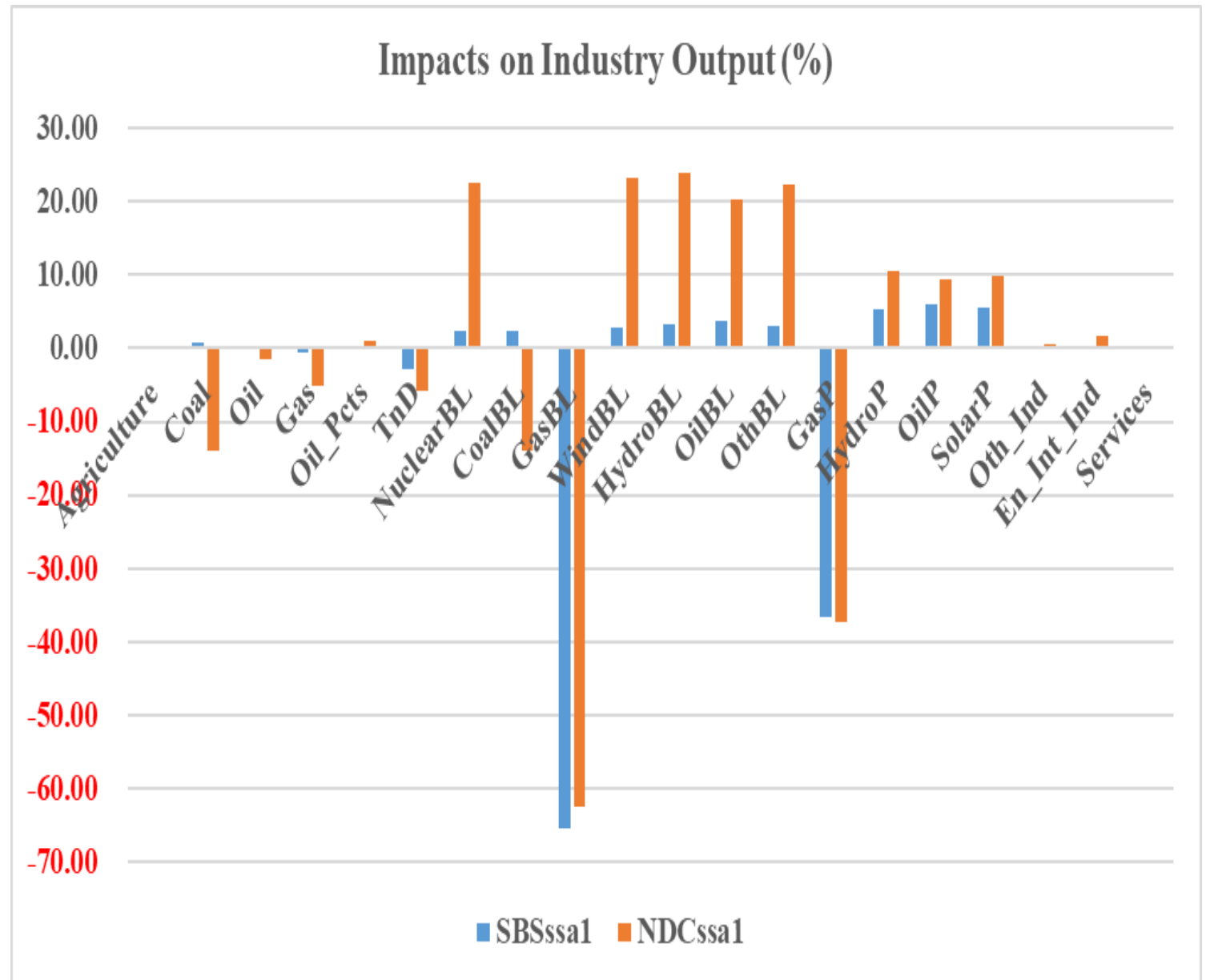
- Industry output
- Prices
- Welfare

Subsidy rates by sector in SSA (%)

rTFD	1 Agricult	2 Coal	3 Oil	4 Gas	5 Oil_Pcts	6 TnD	7 Nuclear	8 CoalBL	9 GasBL	10 WindBL	11 HydroB	12 OilBL	13 OthBL	14 GasP	15 HydroP	16 OilP	17 SolarP	18 Oth_In	19 En_Int	20 Service
1 Agricult	0.10	0.10	(0.80)	(0.90)	0.30	0.70	0.20	0.20	0.90	0.70	0.70	0.50	0.80	0.10	0.00	0.80	0.20	0.60	0.10	(0.30)
2 Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.50	0.00	0.00	0.00	0.60	0.50	0.00	0.20	0.00	(0.10)	0.00	(0.50)
3 Oil	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	2.40	3.70
4 Gas	0.50	0.00	0.00	0.00	0.00	1.10	0.00	2.00	0.70	0.00	0.00	(0.40)	0.20	1.30	0.00	(0.10)	0.00	1.30	1.40	1.00
5 Oil_Pcts	14.90	0.00	0.00	0.00	0.00	(0.10)	0.00	(2.00)	5.80	0.00	0.00	(0.40)	2.50	(4.20)	0.00	(1.10)	0.00	(1.00)	8.50	2.00
6 TnD	(41.50)	(11.00)	(37.10)	(15.40)	(12.30)	(21.10)	(10.80)	(19.00)	(42.80)	(19.60)	(50.40)	(40.60)	(49.40)	(43.10)	(61.00)	(43.40)	(12.60)	(38.80)	(37.00)	(36.70)
7 Nuclear	(10.80)	(10.80)	0.00	(10.70)	(10.80)	(10.80)	(10.80)	(10.80)	0.00	(10.80)	0.00	0.00	(10.80)	0.00	(10.80)	(10.80)	(10.80)	(10.80)	(10.80)	(10.80)
8 CoalBL	(22.20)	(10.80)	(35.60)	(12.30)	(10.90)	(11.40)	(10.80)	(13.30)	(43.30)	(11.60)	(71.80)	(37.50)	(34.40)	(14.30)	(64.50)	(27.60)	(10.70)	(16.30)	(14.40)	(16.50)
9 GasBL	(53.00)	(43.90)	(42.90)	(38.90)	(29.10)	(41.10)	0.00	(43.10)	(42.00)	(57.10)	(46.10)	(46.00)	(52.60)	(42.50)	0.00	(45.60)	(48.10)	(50.20)	(48.60)	(42.80)
10 WindBL	(14.10)	(10.80)	(2.20)	(10.80)	(10.90)	(13.10)	(10.80)	(11.90)	(57.70)	(34.60)	(54.60)	(53.10)	(29.10)	0.00	(10.80)	(50.10)	(10.80)	(14.20)	(13.20)	(20.70)
11 HydroB	(63.90)	(28.10)	(40.30)	(24.20)	(27.90)	(46.30)	0.00	(75.50)	(42.30)	(55.80)	(51.20)	(44.70)	(53.20)	(42.60)	(60.20)	(44.60)	4.30	(52.50)	(55.90)	(49.60)
12 OilBL	(28.00)	(20.40)	(8.40)	(9.20)	(23.80)	(37.60)	0.00	(37.60)	(46.30)	(44.10)	(40.90)	(35.40)	(36.50)	5.10	0.00	(38.50)	(25.80)	(21.40)	(30.60)	(29.10)
13 OthBL	(51.60)	(11.70)	(34.90)	(22.10)	(12.50)	(26.40)	(10.80)	(31.00)	(53.50)	(22.30)	(51.70)	(42.40)	(39.60)	(56.10)	(74.00)	(44.80)	(17.60)	(26.10)	(27.00)	(32.20)
14 GasP	(46.50)	(2.20)	(0.20)	(1.80)	(27.60)	(36.90)	0.00	3.40	(42.90)	0.00	(47.80)	5.10	(55.90)	(43.80)	(41.80)	(47.00)	5.10	(51.90)	(50.80)	(40.60)
15 HydroP	(72.70)	(10.80)	(62.10)	(31.40)	(10.80)	(49.90)	(10.80)	(71.10)	0.00	(10.80)	(60.60)	0.00	(75.50)	(42.80)	(65.10)	(46.90)	(10.80)	(65.60)	(61.10)	(62.80)
16 OilP	(26.90)	(11.40)	(36.50)	(16.80)	(12.00)	(25.50)	(10.80)	(13.70)	(46.10)	(28.90)	(43.70)	(38.50)	(41.10)	(54.80)	(44.80)	(42.50)	(8.70)	(33.00)	(32.00)	(32.40)
17 SolarP	(13.40)	(10.50)	(1.10)	(2.10)	(10.40)	(14.70)	(10.80)	(10.70)	(48.10)	(10.80)	4.40	(6.90)	(17.60)	5.10	(10.80)	0.90	(13.00)	(12.50)	(16.40)	(16.30)
18 Oth_In	2.70	3.00	4.80	0.80	2.70	5.90	2.90	2.50	8.50	4.90	9.60	5.80	7.40	9.80	6.20	8.60	3.30	3.60	2.90	3.90
19 En_Int	2.20	2.60	7.60	2.30	2.40	3.90	0.10	0.10	3.00	1.60	5.00	3.90	4.60	3.10	4.70	5.40	0.50	1.40	2.00	3.20
20 Service	1.00	1.40	3.60	0.40	3.40	1.40	2.30	2.00	0.80	1.50	0.90	1.10	0.70	1.20	0.30	1.50	1.10	1.20	1.60	2.00
Total	-423	-175.5	-286.1	-193.1	-190.1	-322	-81.2	-329.5	-444.6	-297.9	-498.3	-329.7	-479.1	-317.9	-432.5	-425.5	-154.4	-384.1	-379.1	-375.4

Impacts on Industry Output of SSA (%)

No.	qo	SBSssa1	NDCssa1
1	Agriculture	0.01	0.14
2	Coal	0.67	-13.96
3	Oil	0.04	-1.42
4	Gas	-0.67	-5.10
5	Oil_Pcts	0.41	1.03
6	TnD	-2.93	-5.82
7	NuclearBL	2.28	22.54
8	CoalBL	2.33	-13.90
9	GasBL	-65.46	-62.45
10	WindBL	2.84	23.21
11	HydroBL	3.23	23.94
12	OilBL	3.70	20.20
13	OthBL	3.12	22.28
14	GasP	-36.61	-37.31
15	HydroP	5.28	10.61
16	OilP	5.89	9.36
17	SolarP	5.52	9.93
18	Oth_Ind	-0.01	0.54
19	En_Int_Ind	-0.10	1.61
20	Services	0.00	-0.14



Impacts on Prices of SSA (%)

pp[*SSA]	sbsssa1	ndcsbs1
1 Agriculture	-0.0	0.2
2 Coal	0.0	30.0
3 Oil	0.0	-1.4
4 Gas	-0.2	5.0
5 Oil_Pcts	0.0	1.3
6 TnD	0.0	0.6
7 NuclearE	-0.0	0.7
8 CoalBL	0.0	20.1
9 GasBL	68.0	74.6
10 WindBL	0.0	0.4
11 HydroB	0.1	0.1
12 OilBL	0.0	1.4
13 OthBL	0.1	0.6
14 GasP	61.0	68.6
15 HydroP	-0.0	0.0
16 OilP	0.0	1.2
17 SolarP	0.0	0.1
18 Oth_Inc	0.0	0.4
19 En_Int_	0.0	0.8
20 Service	-0.0	0.2

ppd[*SSA]	sbsssa1	ndcsbs1
1 Agriculture	-0.0	0.2
2 Coal	0.0	35.5
3 Oil	0.0	-1.4
4 Gas	-0.2	5.4
5 Oil_Pcts	0.0	1.0
6 TnD	0.0	0.6
7 NuclearE	-0.0	0.7
8 CoalBL	0.0	20.1
9 GasBL	69.5	76.1
10 WindBL	-0.0	0.2
11 HydroB	0.1	0.1
12 OilBL	0.0	1.4
13 OthBL	0.1	0.5
14 GasP	65.3	72.6
15 HydroP	-0.0	0.0
16 OilP	0.0	1.2
17 SolarP	-0.0	-0.1
18 Oth_Inc	0.0	0.2
19 En_Int_	0.0	0.7
20 Service	-0.0	0.2

pm[*SSA]	sbsssa1	ndcsbs1
1 Agriculture	-0.0	0.2
2 Coal	0.0	-1.3
3 Oil	0.0	-1.4
4 Gas	-0.2	-1.0
5 Oil_Pcts	0.0	-0.8
6 TnD	0.0	0.6
7 NuclearE	-0.0	0.7
8 CoalBL	0.0	20.1
9 GasBL	0.6	4.5
10 WindBL	-0.0	0.2
11 HydroB	0.1	0.1
12 OilBL	0.0	1.4
13 OthBL	0.1	0.5
14 GasP	0.5	4.9
15 HydroP	-0.0	0.0
16 OilP	0.0	1.2
17 SolarP	-0.0	-0.1
18 Oth_Inc	0.0	0.2
19 En_Int_	0.0	0.7
20 Service	-0.0	0.2 ⁸

Welfare Impacts for Scenarios 1 and 2 (USD million)

S1

WELFARE	1 co2t	2 alloc_A1	3 endv	4 tech	5 pop_	6 tot_	7 IS_F	8 pref_	Total
1 CHN	0	4	0	0	0	6	-9	0	1
2 XEA	0	-1	0	0	0	-14	-1	0	-15
3 IND	0	5	0	0	0	-1	0	0	4
4 XSA	0	0	0	0	0	0	0	0	-1
5 NEC	0	-130	0	0	0	-27	11	0	-146
6 XEC	0	-2	0	0	0	0	0	0	-3
7 NMN	0	-7	0	0	0	-4	8	0	-4
8 XMN	0	1	0	0	0	2	0	0	2
9 SSA	0	112	0	0	0	-4	-1	0	107
10 NLC	0	-2	0	0	0	5	-1	0	2
11 XLC	0	1	0	0	0	1	0	0	2
12 E28	0	24	0	0	0	31	-3	0	53
13 USA	0	1	0	0	0	-1	3	0	3
14 XHY	0	7	0	0	0	6	-6	0	7
Total	0	13	0	0	0	0	0	0	13

S2

WELFARE	1 co2t	2 alloc_A1	3 endv	4 tech	5 pop_	6 tot_E1	7 IS_F1	8 pre	Total
1 CHN	0	-1,972	0	0	0	2,658	-2,281	0	-1,595
2 XEA	0	-1,857	0	0	0	638	-256	0	-1,475
3 IND	0	421	0	0	0	1,679	-86	0	2,015
4 XSA	0	-24	0	0	0	313	63	0	352
5 NEC	0	-7,957	0	0	0	-11,048	1,426	0	-17,579
6 XEC	0	102	0	0	0	-70	-20	0	12
7 NMN	0	-2,597	0	0	0	-20,170	2,616	0	-20,151
8 XMN	0	-67	0	0	0	833	178	0	945
9 SSA	0	-1,667	0	0	0	-4,365	-157	0	-6,189
10 NLC	0	-3,072	0	0	0	-3,580	-74	0	-6,726
11 XLC	0	-8,453	0	0	0	3,608	-91	0	-4,936
12 E28	0	-38,219	0	0	0	19,175	-666	0	-19,710
13 USA	0	-11,260	0	0	0	4,738	797	0	-5,725
14 XHY	0	-11,430	0	0	0	5,394	-1,390	0	-7,427
Total	0	-88,051	0	0	0	-197	58	0	-88,191

Conclusions

- Output of GasBL and GasP whose subsidy is eliminated declines drastically, and the output of the other energy sectors increases (S1).
- There are no big changes in output of GasBL and GasP. Output of other energy sectors such as coalBL, coal, oil and gas, drops a lot, while output of renewable energies (windBL, hydroBL, hydroP, solarP) increases a lot (S2).
- Prices of intermediate inputs and prices faced by private household increase, while the market prices do not decrease.
- SSA gains welfare, which is caused mainly by the removal of distortion of subsidies, i.e. more efficient allocation of resources, while SSA loses in welfare due to NDCs, which is caused by less efficient allocation, deteriorated TOT and reduced I-S.



Global Trade Analysis Project

Coal Consumption Reduction in EU28

{Francesco Clora and Jindra Samson}

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ABSTRACT

- **What is the impact of 20% reduction in coal consumption in EU28 in terms of:**
 - **Carbon emissions**
 - **Output**
 - **Generation mix**
- **Two scenarios**
 - EV endogenous
 - Increase in output augmenting technical change in WindBL of EU28 so that $EV=0$

Closures and Shocks

```
swap tfd("coal", PROD_COMM, "E28") = gco2fd("coal", PROD_COMM, "E28");
swap tfm("coal", PROD_COMM, "E28") = gco2fm("coal", PROD_COMM, "E28");
swap tpd("coal", "E28") = gco2pd("coal", "E28");
swap tpm("coal", "E28") = gco2pm("coal", "E28");
swap tgd("coal", "E28") = gco2gd("coal", "E28");
swap tgm("coal", "E28") = gco2gm("coal", "E28");
```

```
shock gco2fd("coal", PROD_COMM, "E28") = uniform -20;
shock gco2fm("coal", PROD_COMM, "E28") = uniform -20;
shock gco2gd("coal", "E28") = -20;
shock gco2gm("coal", "E28") = -20;
shock gco2pd("coal", "E28") = -20;
shock gco2pm("coal", "E28") = -20;
```

Additions in **“WIND”** scenario

```
swap EV("E28") = aoall("windBL", "E28");
shock EV("E28") = 0;
```

Results – CO2 emissions

gco2	No wind	Wind
coal	-20	-20
oil	3.2	2.9
gas	0.9	0.7
oil_pcts	-0.3	-0.4

Carbon dioxide emissions in EU28, by fossil fuel

gco2tw	World
No wind	-0.62
Wind	-0.63

World carbon dioxide emissions

gco2t	No wind	Wind
CHN	0.0	0.0
XEA	0.0	0.0
IND	-0.1	-0.1
XSA	0.0	0.0
NEC	0.1	0.1
XEC	-0.1	-0.1
NMN	0.0	0.0
XMN	0.0	0.0
SSA	0.1	0.1
NLC	0.1	0.1
XLC	0.0	0.0
E28	-5.0	-5.1
USA	0.0	0.0
XHY	0.0	0.0

Regional carbon dioxide emissions

Results – Output

qo	No Wind	Wind
Coal	-19.5	-19.5
Oil	0.0	-0.1
Gas	0.4	0.2
Oil_Pcts	-1.2	-1.2
TnD	-1.5	-1.1
NuclearBL	4.2	3.7
CoalBL	-15.1	-15.2
GasBL	3.9	3.6
WindBL	4.3	17.1
HydroBL	4.4	3.9
OilBL	3.8	3.4
OthBL	4.0	3.5
GasP	0.7	0.4
HydroP	1.0	0.7
OilP	0.3	0.1
SolarP	1.1	0.7

Output in EU28

qo	Coal	CoalBL	WindBL
CHN	0.0	0.0	0.0
XEA	-0.7	0.0	0.1
IND	-0.2	0.0	0.0
XSA	-0.2	-0.9	0.1
NEC	-3.8	0.4	0.1
XEC	-0.7	-0.5	0.4
NMN	-0.8	-1.9	0.2
XMN	-0.2	0.0	0.1
SSA	-2.5	0.1	0.1
NLC	-7.1	0.6	0.1
XLC	-0.7	-0.4	0.1
E28	-19.5	-15.1	4.3
USA	-1.4	0.1	0.0
XHY	-1.4	0.0	0.1

Output of selected commodities
“No Wind” scenario

qo	Coal	CoalBL	WindBL
CHN	0.0	0.0	0.0
XEA	-0.7	0.0	4.3
IND	-0.2	0.0	0.1
XSA	-0.2	-0.9	5.3
NEC	-3.8	0.4	10.0
XEC	-0.7	-0.5	6.2
NMN	-0.8	-1.7	6.5
XMN	-0.2	0.0	1.0
SSA	-2.5	0.1	9.1
NLC	-7.1	0.6	0.2
XLC	-0.7	-0.4	1.1
E28	-19.5	-15.2	17.1
USA	-1.4	0.1	0.0
XHY	-1.4	0.0	0.9

Output of selected commodities
“Wind” scenario

Results – EU28 Generation Mix

Generation Mix	Baseline	%	No Wind	%	Wind	%
TnD	122,080.0	20.9	120,248.0	20.5	120,730.0	20.5
NuclearBL	99,109.0	17.0	103,304.0	17.6	102,853.0	17.5
CoalBL	101,545.0	17.4	95,584.0	16.3	95,335.0	16.2
GasBL	45,160.0	7.7	47,019.0	8.0	46,835.0	8.0
WindBL	40,526.0	6.9	42,256.0	7.2	44,654.0	7.6
HydroBL	36,429.0	6.2	38,010.0	6.5	37,838.0	6.4
OilBL	3,083.0	0.5	3,204.0	0.5	3,192.0	0.5
OthBL	40,236.0	6.9	41,879.0	7.1	41,694.0	7.1
GasP	44,016.0	7.5	44,417.0	7.6	44,296.0	7.5
HydroP	10,669.0	1.8	10,768.0	1.8	10,739.0	1.8
OilP	16,374.0	2.8	16,528.0	2.8	16,482.0	2.8
SolarP	24,020.0	4.1	24,249.0	4.1	24,182.0	4.1
Total Generation	583,247.0		587,466.0		588,830.0	

Discussion and Conclusion

- No significant global impact in terms of CO2 emissions reduction
- Electricity generation from coal (CoalBL) is the most affected sector, due to its cost structure
- CoalBL decrease in output is compensated by an increase in other electricity generating sectors
- EV losses due to allocation efficiency can be compensated by technology improvements in other sectors

	No Wind	Wind
gco2t ("EU28")	-5.0	-5.1
qo ("coalBL", "EU28")	-15.1	-15.2
qo ("windBL", "EU28")	4.3	17.1
EV ("EU28")	-5,816	0
ao ("windBL", "EU28")	0	6.27



Global Trade Analysis Project

Panel Q&A

(All presenters from group)

