

The new version of ETSAP-TIAM

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New ETSAP-TIAM

ETSAP-WS, June 2009

Most important changes - implemented

- New definition of the **regions**
- New **macro-economic growths**
- **Addition of emissions:** CO₂ from land-use (MIT data), N₂O from agriculture (EMF-22)
- Adjustment of the **exogenous forcing** of the climate module
- **Addition/modification of technologies:** Biomass fired power plants with CCS - Low-emitting technologies for aviation (H₂), navigation (alcohol), train (elc) - Energy flexibility in Agriculture
- **Other modifications** as normal maintenance tasks

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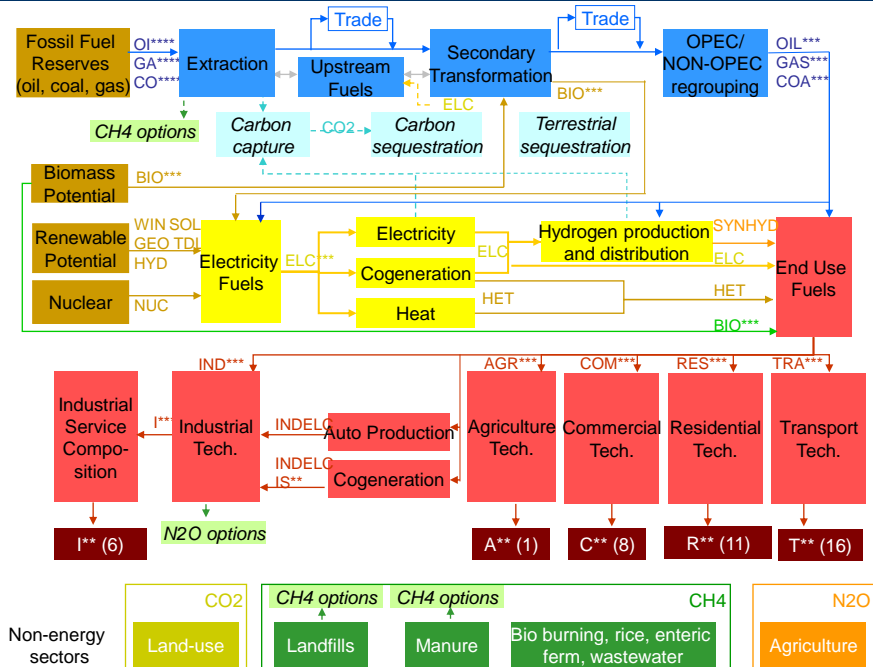
Most important changes – Ready soon

- **Associated gas:** Appropriate computation of the associated gas in the cumulative amount of gas available
- **Biomass resources and biofuels' production:** new structure based on Smeets *et al.* (2004) with energy crops from surplus agriculture land (after food&feed), agricultural and forestry residues, forest/wood for energy. ⇒ Available biomass = from 250 to 300 EJ (230 EJ in the current version of TIAM)
- **Nuclear fuel cycle**

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Reference Energy System



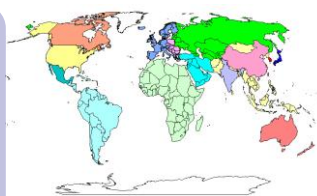
New definition of the regions

TIAM-16R

Africa*
 Australia-New Zealand
 Canada
 Central Asia & Caucasus
 Central & South America*
 China
 India
 Japan
 Mexico
 Middle-East*
 Other Developing Asia*
 Other Eastern Countries
 Russian Federation
 South Korea
 United States
 Europe (EU27+3)

TIAM-15R

Africa*
 Australia-New Zealand
 Canada
 Central & South America*
 China
 Eastern Europe
 Former Soviet Union
 India
 Japan
 Mexico
 Middle-East*
 Other Developing Asia*
 South Korea
 United States
 Western Europe



* OPEC and Non-OPEC countries are separated in primary and secondary sectors ⇒ appropriate modelling of oil production strategies and oil price control by OPEC countries

- **Europe** : EU27+Switzerland+Norway+Iceland (from ex-WEU and ex-EEU)
- **Russian Federation** (from ex-FSU)
- **Central Asia & Caucasus**: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Armenia, Azerbaidjian, Georgia (from ex-FSU)
- **Other Eastern Europe**: Belarus, Moldova, Ukraine, Albania, Bosnia-Herzegovina, Croatia, Macedonia, Montenegro, Serbia-Kosovo (from ex-FSU and ex-EEU)

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Data to be collected (new regions)

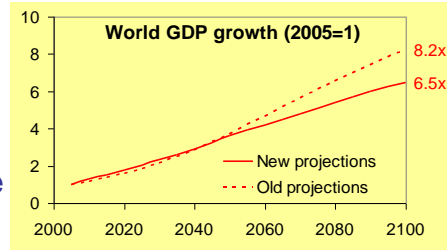
- **Energy balances of the IEA** used to build the initial RES (2005) of the new regions; all sectors are affected
- **Available resources** (coal, oil, gas, renewable, carbon sequestration) of the new regions
- **Other characteristics of the existing stock**: installed capacities, efficiencies, initial energy services, shares of the energy services in residential and commercial, flaring/venting, trade, etc.
- **Growths of the macro-economic drivers**, especially POP, GDP, Industrial Outputs

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Macro-economic drivers

- **GDP, new regions:** national statistics and projections
- **GDP, all regions, post-2050:** estimations accepted by several energy modelers involved in the EU PLANETS project. Long-term growths are lower. More realistic (?)



- **Industrial outputs, all regions, 2005-2100 :** updated with data based on the Coupling of TIAM with the macro-economic model GEMINI-E3 (<http://gemini-e3.epfl.ch>). Better consistency with the GDP growth



Impact on future emissions

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Planning

- **Fall 2008:** Official ETSAP-TIAM-15R
- **Spring 2009:** Intermediate version, 15R, adjusted GDP (but not the industrial outputs), emissions, exogenous forcing, new technologies. Not disseminated except to UK, since it remains intermediate
- **Summer 2009:** ETSAP-TIAM-16R.

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Appendix

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Definition of each region (1/2)

Code	Name	Countries
AFR	Africa	Algeria, Angola, Benin, Botswana, Cameroon, Congo, Democratic Republic of Congo, Côte d'Ivoire, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Libya, Morocco, Mozambique, Namibia, Nigeria, Senegal, South Africa, Sudan, United Republic of Tanzania, Togo, Tunisia, Zambia, Zimbabwe, and Other Africa*.
AUS	Australia, New-Zealand, Oceania	Australia, New-Zealand, Oceania
CAC	CentralAsia&Caucase	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Armenia, Azerbaidjian, Georgia
CAN	Canada	Canada
CHI	China	China
CSA	Central & South America	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, Venezuela and Other Latin America.
IND	India	India
JPN	Japan	Japan
MEA	Middle East	Bahrain, Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen, and Turkey, Cyprus.
MEX	Mexico	Mexico
ODA	Other Developing Asia	Bangladesh, Brunei Darussalam, Cambodia, Chinese Taipei, Indonesia, DPR of Korea, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, Vietnam and Other Asia**

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Definition of each region (2/2)

OEE	Other Eastern Europe	Belarus, Moldova, Ukraine Albania, Bosnia-Herzegovina, Croatia, Macedonia, Montenegro, Serbia (Kosovo)
RUS	Russian Federation	Russian Federation
SKO	South Korea	South Korea
USA	USA	USA
EUR	Europe 27+	Austria, Belgium, Bulgaria, Cyprus, Switzerland, Czech Republic, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, United Kingdom

* Other Africa includes:

Burkina Faso, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Djibouti, Equatorial Guinea, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Niger, Reunion, Rwanda, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia, Swaziland and Uganda.

** Other Asia includes:

Afghanistan, Bhutan, Cook Islands, East Timor, Fiji, French Polynesia, Kiribati, Laos, Macau, Maldives, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu.

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Growths of GDP and POP

	↳-2005	↳-2010	↳-2015	↳-2020	↳-2025	↳-2030	↳-2035	↳-2040	↳-2045	↳-2050	↳-2055	↳-2060	↳-2065	↳-2070	↳-2075	↳-2080	↳-2085	↳-2090	↳-2095	↳-2100
AFR GDP	1.30	1.66	2.06	2.53	3.01	3.54	4.15	4.88	5.76	6.72	7.65	8.58	9.63	10.66	11.79	12.87	13.93	14.90	15.80	16.61
AUS GDP	1.15	1.33	1.49	1.67	1.82	1.97	2.07	2.20	2.31	2.44	2.51	2.59	2.67	2.76	2.86	2.97	3.07	3.17	3.25	3.33
CAC GDP	1.00	1.45	1.79	2.12	2.46	2.79	3.13	3.52	3.94	4.40	4.76	5.10	5.41	5.73	6.06	6.39	6.66	6.93	7.14	7.33
CAN GDP	1.15	1.33	1.47	1.64	1.72	1.80	1.86	1.95	2.01	2.10	2.14	2.19	2.24	2.31	2.39	2.47	2.55	2.63	2.70	2.77
CHI GDP	1.77	2.80	3.82	5.17	6.72	8.80	10.97	13.35	16.45	19.72	21.77	23.80	25.86	27.93	29.98	31.98	33.90	35.72	37.40	38.92
CSA GDP	1.24	1.52	1.83	2.18	2.53	2.94	3.38	3.93	4.61	5.36	6.06	6.78	7.53	8.28	9.08	9.86	10.59	11.27	11.92	12.49
FSU GDP	1.36	1.70	2.09	2.46	2.93	3.40	3.99	4.58	5.29	5.98	6.75	7.44	8.13	8.77	9.42	10.02	10.61	11.15	11.64	12.08
IND GDP	1.40	2.12	3.12	4.53	6.45	8.99	12.08	14.63	17.94	21.40	23.63	25.84	28.07	30.32	32.54	34.71	36.80	38.77	40.60	42.25
JPN GDP	1.12	1.25	1.34	1.44	1.47	1.51	1.54	1.60	1.66	1.74	1.78	1.83	1.88	1.95	2.02	2.10	2.17	2.24	2.30	2.35
MEA GDP	1.32	1.71	2.10	2.56	3.01	3.52	4.04	4.67	5.36	6.13	6.83	7.55	8.31	9.07	9.95	10.80	11.64	12.42	13.18	13.84
MEX GDP	1.22	1.48	1.84	2.25	2.73	3.25	3.84	4.55	5.37	6.26	7.09	7.93	8.81	9.69	10.62	11.53	12.38	13.18	13.90	14.54
ODA GDP	1.29	1.62	1.99	2.41	2.82	3.25	3.69	4.21	4.76	5.37	5.91	6.44	7.00	7.57	8.18	8.77	9.37	9.92	10.47	10.96
OEE GDP	1.00	1.17	1.20	1.22	1.25	1.27	1.31	1.35	1.44	1.48	1.54	1.60	1.66	1.70	1.74	1.78	1.82	1.86	1.91	1.95
RUS GDP	1.00	1.33	1.80	2.26	3.05	3.84	4.32	4.86	5.44	6.07	6.57	7.04	7.46	7.91	8.36	8.81	9.19	9.56	9.84	10.11
SKO GDP	1.18	1.38	1.56	1.76	1.88	2.02	2.14	2.30	2.45	2.64	2.74	2.86	2.98	3.12	3.27	3.41	3.55	3.68	3.79	3.89
USA GDP	1.19	1.42	1.65	1.92	2.17	2.42	2.60	2.81	2.98	3.18	3.30	3.43	3.55	3.69	3.82	3.97	4.10	4.23	4.35	4.45
EUR GDP	1.00	1.15	1.28	1.42	1.57	1.73	1.82	1.95	2.06	2.21	2.29	2.38	2.46	2.56	2.65	2.75	2.84	2.94	3.01	3.09
AFR POP	1.13	1.26	1.40	1.55	1.69	1.84	1.97	2.09	2.21	2.31	2.41	2.50	2.59	2.66	2.73	2.79	2.84	2.89	2.92	2.95
AUS POP	1.06	1.12	1.16	1.21	1.26	1.29	1.30	1.30	1.28	1.28	1.27	1.26	1.25	1.24	1.23	1.23	1.22	1.22	1.21	1.21
CAC POP	1.00	1.05	1.11	1.15	1.19	1.22	1.24	1.26	1.27	1.28	1.26	1.25	1.23	1.22	1.21	1.21	1.20	1.19	1.19	1.19
CAN POP	1.06	1.10	1.14	1.19	1.22	1.25	1.26	1.26	1.24	1.23	1.22	1.22	1.21	1.20	1.19	1.19	1.18	1.18	1.17	1.17
CHI POP	1.05	1.09	1.13	1.16	1.18	1.20	1.22	1.24	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
CSA POP	1.09	1.17	1.24	1.32	1.38	1.45	1.52	1.60	1.69	1.76	1.84	1.91	1.98	2.04	2.09	2.13	2.17	2.20	2.23	2.26
FSU POP	0.99	0.98	0.97	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.85	0.85	0.84
IND POP	1.10	1.18	1.26	1.34	1.40	1.47	1.51	1.55	1.57	1.60	1.62	1.63	1.65	1.66	1.67	1.67	1.68	1.69	1.69	1.70
JPN POP	1.02	1.03	1.03	1.03	1.01	1.00	0.99	0.98	0.97	0.96	0.95	0.95	0.94	0.93	0.93	0.92	0.92	0.91	0.91	0.91
MEA POP	1.12	1.24	1.37	1.50	1.62	1.74	1.85	1.96	2.07	2.16	2.26	2.35	2.43	2.50	2.56	2.62	2.66	2.70	2.74	2.77
MEX POP	1.09	1.17	1.24	1.31	1.37	1.44	1.50	1.58	1.66	1.74	1.82	1.89	1.95	2.01	2.06	2.10	2.14	2.17	2.20	2.22
ODA POP	1.08	1.14	1.19	1.25	1.30	1.34	1.37	1.40	1.43	1.45	1.47	1.48	1.49	1.50	1.51	1.52	1.52	1.53	1.54	1.54
OEE POP	1.00	0.97	0.95	0.92	0.89	0.86	0.83	0.80	0.78	0.75	0.74	0.73	0.73	0.72	0.71	0.71	0.70	0.70	0.70	0.70
RUS POP	1.00	0.97	0.95	0.92	0.89	0.86	0.83	0.80	0.78	0.75	0.74	0.73	0.73	0.72	0.71	0.71	0.70	0.70	0.70	0.70
SKO POP	1.08	1.14	1.19	1.25	1.30	1.34	1.37	1.40	1.43	1.45	1.47	1.48	1.49	1.50	1.51	1.52	1.52	1.53	1.54	1.54
USA POP	1.06	1.11	1.17	1.22	1.28	1.32	1.34	1.34	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.27	1.26	1.26	1.25	1.25
EUR POP	1.00	1.01	1.02	1.02	1.02	1.01	1.01	1.00	0.99	0.98	0.98	0.97	0.96	0.96	0.95	0.94	0.94	0.94	0.94	0.93

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Growths of GDP and POP

Annual growths					Annual growths				
		2005-2030	2030-2050	2050-2100			2005-2030	2030-2050	2050-2100
AFR	GDP	4.1%	3.3%	1.8%	AFR	POP	2.0%	1.1%	0.5%
AUS	GDP	2.2%	1.1%	0.6%	AUS	POP	0.8%	-0.1%	-0.1%
CAC	GDP	4.2%	2.3%	1.0%	CAC	POP	0.8%	0.2%	-0.1%
CAN	GDP	1.8%	0.8%	0.6%	CAN	POP	0.7%	-0.1%	-0.1%
CHI	GDP	6.6%	4.1%	1.4%	CHI	POP	0.5%	0.1%	0.0%
CSA	GDP	3.5%	3.0%	1.7%	CSA	POP	1.2%	1.0%	0.5%
IND	GDP	7.7%	4.4%	1.4%	IND	POP	1.2%	0.4%	0.1%
JPN	GDP	1.2%	0.7%	0.6%	JPN	POP	-0.1%	-0.2%	-0.1%
MEA	GDP	4.0%	2.8%	1.6%	MEA	POP	1.8%	1.1%	0.5%
MEX	GDP	4.0%	3.3%	1.7%	MEX	POP	1.1%	1.0%	0.5%
ODA	GDP	3.8%	2.5%	1.4%	ODA	POP	0.9%	0.4%	0.1%
OEE	GDP	1.0%	0.8%	0.5%	OEE	POP	-0.6%	-0.7%	-0.1%
RUS	GDP	5.5%	2.3%	1.0%	RUS	POP	-0.6%	-0.7%	-0.1%
SKO	GDP	2.2%	1.3%	0.8%	SKO	POP	0.9%	0.4%	0.1%
USA	GDP	2.9%	1.4%	0.7%	USA	POP	0.9%	0.0%	-0.1%
EUR	GDP	2.2%	1.2%	0.7%	EUR	POP	0.1%	-0.2%	-0.1%

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Fossil potentials

Cumulative resources EJ	AFR	AUS	CAC	CAN	CHI	CSA	IND	JPN	MEA
<i>Total coal</i>	4235	6050	837	1343	24820	1467	2649	3919	263
Total oil conventional	1450	72	241	533	318	2749	70	1	6880
Total very heavy oil	245	0	201	2466	3	1610	0	0	0
Total oil shale	370	72	126	35	36	187	0	0	97
<i>Total oil</i>	2066	144	569	3035	357	4546	70	1	6977
Total gas conventional	1326	365	973	749	200	968	86	5	5527
Total gas unconventional	1901	1840	333	1869	1433	3069	562	2	2002
<i>Total gas</i>	3227	2205	1306	2618	1633	4037	648	7	7529

	MEX	ODA	OEE	RUS	SKO	USA	EUR	World
	73	5670	4312	41689	2	20152	1538	119020
	323	250	60	1565	0	598	673	15783
	0	3	0	200	0	1	4	4734
	0	20	15	443	0	6045	299	7746
	323	273	75	2208	0	6644	976	28262
	104	759	160	4280	0	1291	914	17708
	2	1485	145	3941	2	1833	704	21123
	106	2244	305	8221	2	3124	1618	38831

LITERATURE	ETSAP-TIAM	IPCC	USGS MEAN	USGS F95	USGS F50	USGS F5	MERGE
TOTAL COAL (EJ)	119020	142351					261518
TOTAL GAS (EJ)	38821	36020					35294
Conventional	17708	17179	14395	9001	13111	20258	10086
Unconventional / Undiscovered	21123	18841					25208
TOTAL OIL (EJ)	28262	35576					20027
Conventional	15783	13562	15281	9647	14008	21224	8828
Unconventional	12480	22014					11199

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Potentials for renewable

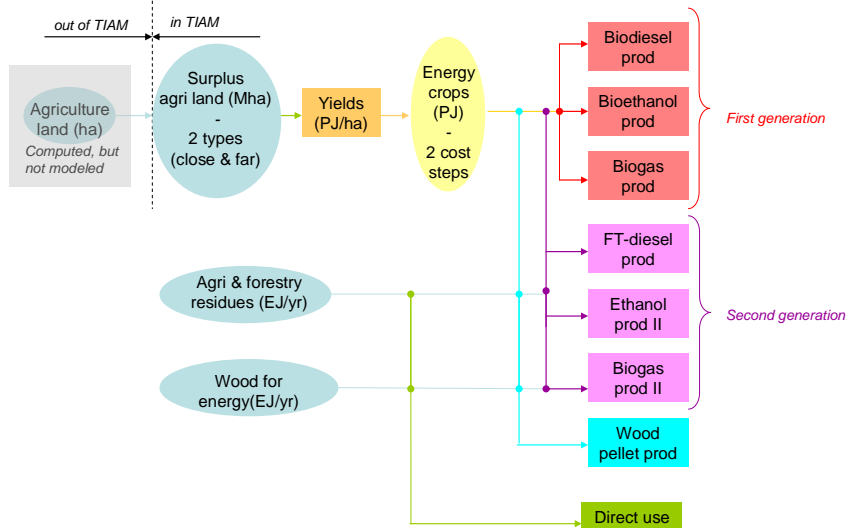
		AFR	AUS	CAC	CAN	CHI	CSA	EUR
Geothermal	2050 GW	36	48	0	0	7	68	113
	2100 GW	36	48	0	0	7	68	113
Hydro	2050 TWh	1011	13	416	176	1013	1100	138
	2100 TWh	1668	31	493	868	2454	3124	873
Wind	2050 GW	75	300	120	360	456	300	653
	2100 GW	75	300	120	360	456	300	653
+ backstop (constant) GW		946	321	4680	944	0	684	826

	IND	JPN	MEA	MEX	ODA	OEE	RUS	SKO	USA	World
	0	125	0	162	649	0	1	0	125	1336
	0	125	0	162	649	0	1	0	125	1336
	256	20	108	7	464	60	380	17	237	5416
	612	133	142	47	1732	124	1261	26	1616	15205
	144	30	75	30	240	79	118	6	360	3346
	144	30	75	30	240	79	118	6	360	3346
	0	0	946	68	0	0	2346	0	949	12710

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Proposed structure of biomass resources



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Potentials – energy crops

	Agricultural surplus land (Mha)					Energy crop potential in 2050 (EJ/y)		
	Total	Ratio wrt total agri land	<200 km	>200 km		Total	<200 km	>200 km
AFR	104	10%	79.4	24.6	AFR	31	23.7	7.3
AUS	216	45%	126.4	89.6	AUS	38	22.2	15.8
CAC	58.4	20%	43.5	14.9	CAC	23.3	17.3	6.0
CAN	7.6	11%	4.5	3.1	CAN	2.8	1.7	1.1
CHI	14.9	2%	13.6	1.3	CHI	10.9	10.0	0.9
CSA	129.3	20%	93.3	36.0	CSA	40	28.9	11.1
IND	29	16%	29.0	0.0	IND	12.1	12.1	0.0
JPN	0	0%	0.0	0.0	JPN	0	0.0	0.0
MEA	23	5%	22.9	0.1	MEA	2	2.0	0.0
MEX	22.7	20%	21.8	0.9	MEX	7	6.7	0.3
ODA	7	15%	6.7	0.3	ODA	3	2.9	0.1
OEE	10.5	20%	10.5	0.0	OEE	4.2	4.2	0.0
RUS	43	20%	28.1	14.9	RUS	17.1	11.2	5.9
SKO	0	2%	0.0	0.0	SKO	0	0.0	0.0
USA	46.4	11%	35.2	11.2	USA	17.2	13.0	4.2
WEU	17.1	8%	17.1	0.0	WEU	8.4	8.4	0.0
World	728.9	15%	532.1	196.8	World	217	164.3	52.7

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 Smeets E., Faaij A., Lewandowski I. and Turkenburg W. (2007). A bottom-up assessment and review of global bio-energy potentials to 2050. Progress in Energy and Combustion Science 33,56-106.
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Potentials – crops (alternative scenario)

EJ	2010	2020	2050	2100
AFR	0.2	3.1	9	15
AUS	0	2.4	13	16.6
CAC *	0.2	6.6	28.7	29.6
CAN	0	1.4	6	9
CHI	0.2	2.1	5	6
CSA	2.7	9.6	17	22
IND	0.2	1.9	5	7
JPN	0	0	0.1	0.1
MEA	0	0.4	1	1.5
MEX	0	0.7	2	3
ODA	0.8	3.1	6	6.5
OEE *	0.0	1.2	5.2	5.3
RUS *	0.1	4.9	21.1	21.8
SKO	0	0	0.1	0.1
USA	0.7	6.9	16.4	22
EUR	0.0	0.1	0.5	0.5
Total	5.3	44.6	136	166

Reference

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Potentials – other biomass

	Agricultural and forestry residues energy potential in 2050 (EJ/y)	Total wood resources available for energy in 2050 (EJ/y)
AFR	15	4.3
AUS	2	0.1
CAC	0.7	0.0
CAN	2.4	0.6
CHI	3.8	7.3
CSA	9.9	7.9
IND	5.7	3.8
JPN	0	0.0
MEA	0	0.3
MEX	1.1	0.6
ODA	1.4	0.7
OEE	0.1	0.0
RUS	2.2	0.1
SKO	0.1	0.0
USA	4.6	0.6
WEU	4	1.6
World	53	28.0

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