

INFORSE-Europe Sustainable Energy Seminar
August 21-24, 2017
Nordic Folkecenter for Renewable Energy, Denmark

INFORSE-EUROPE
International Network for Sustainable Energy

Transition Towards Sustainable Energy – Ukraine

by Olexandra Tryboi; August 21, 2017
Renewable Energy Agency



See the Program and the Proceedings at: http://www.inforse.org/europe/seminar_17_DK.htm



Transition of Ukrainian energy sector towards 100% RES in 2050

Project: Advocate for Sustainable Energy Transition
2016-2017

Armenia - Belarus - Macedonia - Serbia - Ukraine

INFORSE Denmark - NGO REA Ukraine
Coordinator: Gunnar Boye Olsen



Short about Ukraine



Area: 603,550 sq km (14 times bigger than Denmark)

Population: 44,209,733 (July 2016 est.)

Capital: Kiev (Kyiv)

TPES in 2015: 90 090 ktoe

TFC in 2015: 50 831 ktoe

Total Primary Energy Supply (TPES) in Ukraine for 2012-2015 (ktoe)

	2012		2013		2014		2015	
	TPES	%	TPES	%	TPES	%	TPES	%
Coal & peat	42545	34.7	41427	35.7	35576	33.7	27344	30
Crude oil & oil products	11632	9.5	9906	8.5	10688	10	10551	12
Natural gas	43019	35	39444	34	33412	31.6	26055	29
Nuclear	23653	19.3	21848	19	23191	22	22985	26
Hydro	901	0.7	1187	1	729	0.7	464	0.5
Geothermal, solar etc.	53	0.04	104	0.1	134	0.2	134	0.2
Biofuels and waste	1695	1.4	1875	1.6	1934	1.8	2102	2.3
Total	122512	100	115940	100	105683	100	90090	100

Total Final Consumption (TFC) of energy in Ukraine for 2012-2015, (ktoe)

	2012		2013		2014		2015	
	TFC	%	TFC	%	TFC	%	TFC	%
Coal & peat	8717	12	8698	12.5	9180	14.9	6302	12.4
Crude oil & Oil products	12490	17.2	11284	16.2	10149	16.5	9463	18.6
Natural gas	26605	36.7	24926	35.8	20955	34	16022	31.5
Electricity	11839	16.3	11828	17	11041	18	10233	20.1
Heat	11865	16.4	11702	16.8	8933	14.5	7527	14.8
Biofuels and waste	1030	1.4	1118	1.6	1201	2	1283	2.5
Total	72 548	100	69 557	100	61 460	100	50 831	100

Renewable energy sources potential in Ukraine, 2015 (ktoe)

RES type	TWh/yr	Mtoe/yr
Wind	60	15
Solar	38.2	4.2 (11.34*)
Electricity	5.7	1.4
Thermal	32.5	2.8
Hydro	28.7	7
Small	8.6	2.1
Large	20.1	4.9
Bioenergy	178	21.7
Electricity	27	7.2
Thermal	151	14.5
Geothermal	97.6	8.4
Energy of environment	146.3	12.6
Total	548.8	68.9

* - according to IRENA REMAP 2030 data

Source: <http://sae.gov.ua/uk/activity/vidnovlyuvana-enerhetyka/potentsial>



Background & prerequisites

Starting from 2012 Ukrainian energy sector is on the way of transition from fossil fuels to renewable energy

Global integration processes:

2011-p.t. – member and contracting Party of Energy Community

2012-p.t. – GDP “decoupling”

2014 – signing of EU-UA Association Agreement

2015 – Ukraine becomes a Party of Paris Agreement

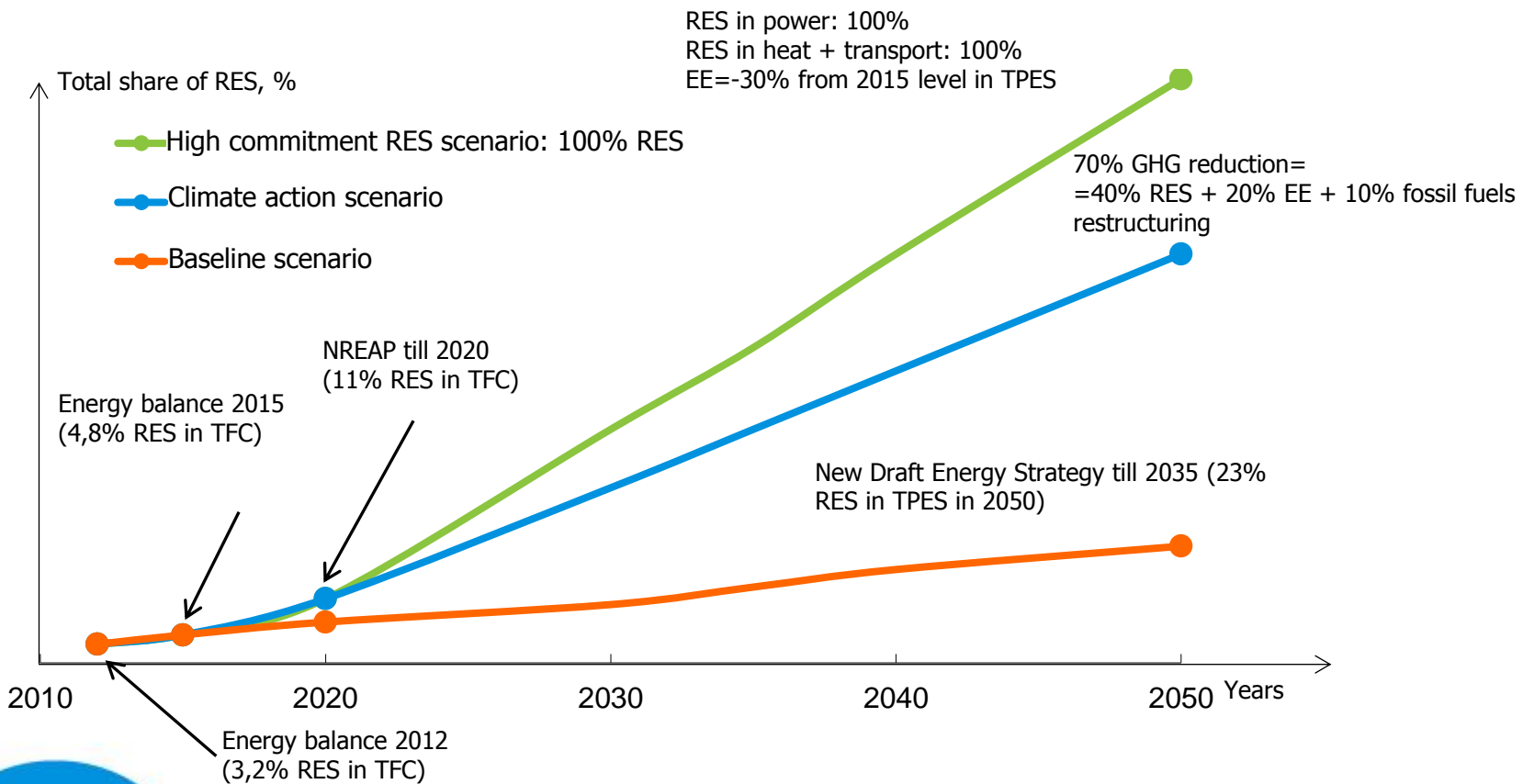
Active reforms in energy sector:

- ✓ equalization of natural gas prices for all consumer categories
- ✓ restructuring of gas and electricity markets
- ✓ massive implementation of energy resources monitoring
- ✓ law on ESCO
- ✓ first steps in implementation of sustainability criteria, competitiveness in heat market, biomass stock exchange

Additional incentives in place:

- ✓ privileged credit lines, co-financing programs, “warm” credits (2013-p.t.)
- ✓ improvements in law on “green” tariff (2015)
- ✓ VAT redemption for equipment and materials used for energy production from RES
- ✓ “stimulating” tariff in heating from non-gas sources (2017)

Key assumptions and trajectories





Baseline

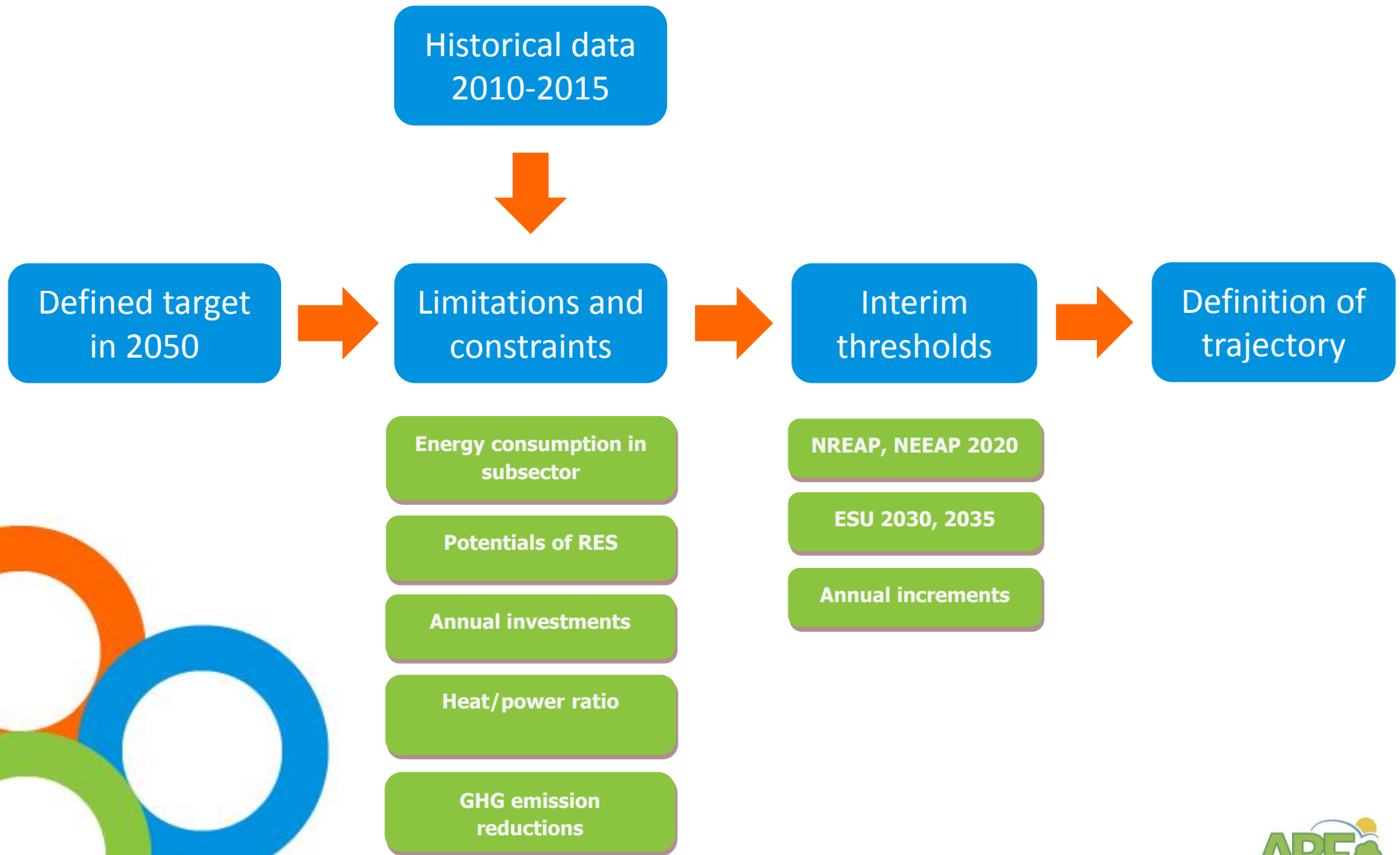


-70% GHG



100% RES

Methodology: Solving of reverse problem



National strategic documents taken into account

No	Name	Status	Developer	Date of adoption/publication
1.	Energy Strategy of Ukraine till 2035 (2016)	Draft	Razumkov Centre	December 2016
2.	Energy Strategy of Ukraine till 2035 (2014)	Draft	National Institute for Strategic Studies, under edition of Sukhodolya O.M.	June 2014
3.	Energy Strategy of Ukraine till 2030	In effect	Institute for economics and forecasting of NASU	July 2013
4.	Strategy on Agriculture and Rural Development 2015-2020	In effect	Ministry of Agrarian Policy and Food of Ukraine	September 2015
5.	National Strategy of Regional Development for the period till 2020	In effect	Ministry of Economic Development and Trade of Ukraine	August 2014
6.	Ukrainian INDC 2015 edition	In effect	Ministry of Environment and Natural Resources of Ukraine	September 2015
7.	National Concept of Climate Policy Realization in Ukraine till 2030	In effect	Ministry of Environment and Natural Resources of Ukraine	December 2016
8.	National Energy Efficiency Action Plan till 2020	In effect	State Agency on Energy Efficiency and Energy Saving of Ukraine	November 2015
9.	National Renewable Energy Action Plan till 2020	In effect	State Agency on Energy Efficiency and Energy Saving of Ukraine	October 2014
10.	Concept of Sustainable Development "Ukraine 2020"	In effect	Administration of the President of Ukraine	January 2015
11.	Ukrainian Low Emission Development Strategy and Low Carbon Development Strategy	In progress of implementation	International project USAID MERP	

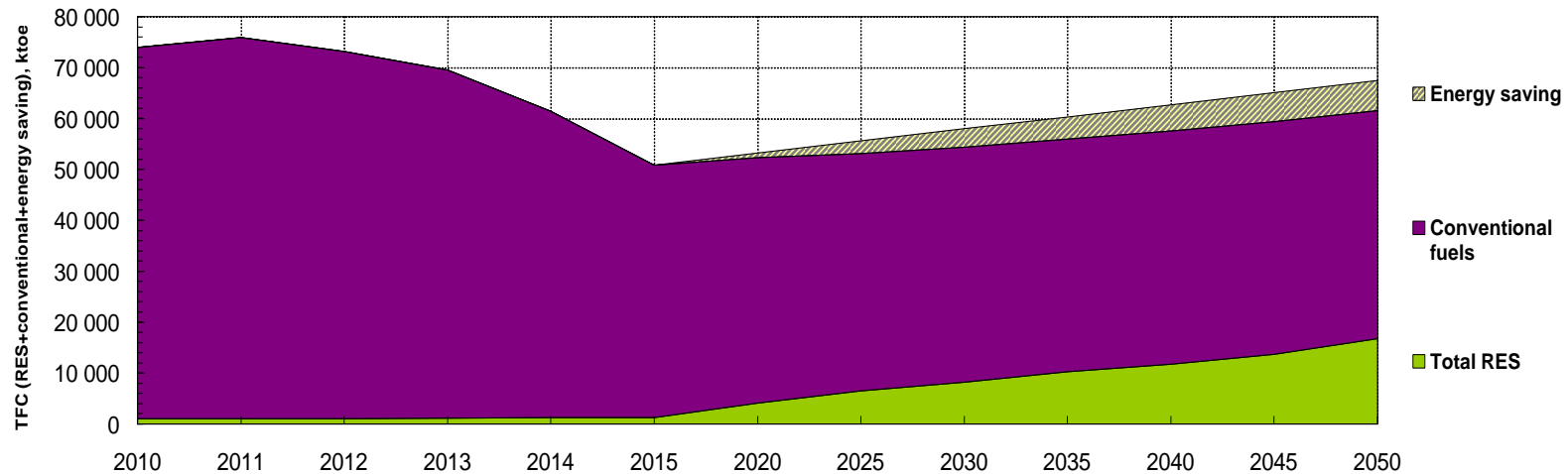
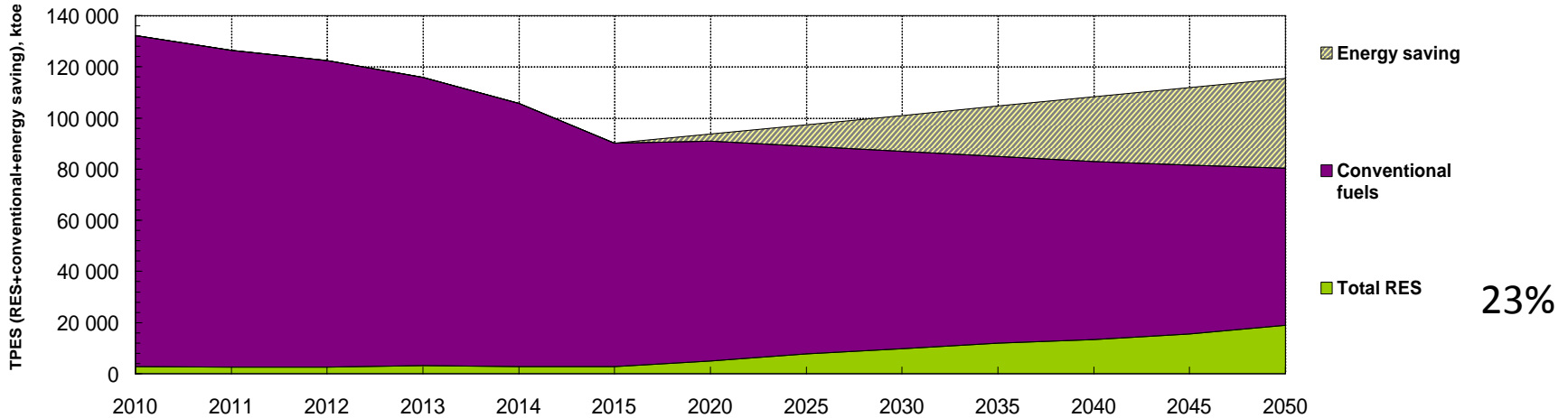
Scenario 1 – Baseline. Assumptions

- ✓ National Renewable Action Plan: 50% fulfillment for RES targets (without biomass) in TFC in 2020 and 100% fulfilled in biomass part in 2050, ;
- ✓ Energy efficiency: 9 % decreasing of TFC in 2050 in comparison with average 2010-2015 level.
- ✓ Suspended fulfillment of New Draft Energy Strategy till 2035: 23% RES share in TFC in 2050 (in comparison with 2015 level);
- ✓ Current INDC target: 40% GHG emission reduction shall not be exceeded in 2050.
- ✓ Liquid biofuels share in transport: 5% in 2050 (bearing in mind transport energy consumption in 2015=2050).
- ✓ Solar energy potential utilization: 100% in 2050 according to IRENA REMAP 2030 data (4.2 Mtoe);
- ✓ Biomass as the leading source of renewable energy for all points 2015-2050



Baseline

Baseline scenario: RES and energy efficiency in TPES and TFC comparing with traditional fuels, ktoe/year



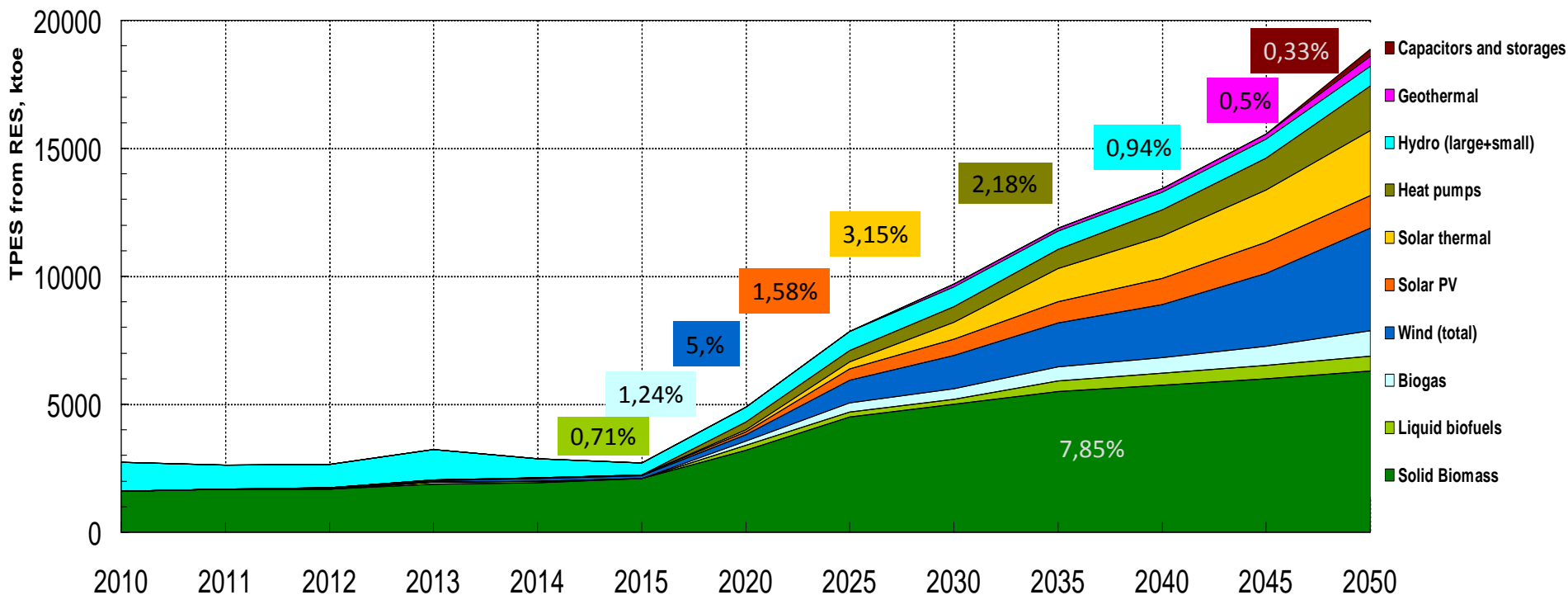
TPES in 2050 is 10.8% less in comparison with 2015 (80,328 against 90,090 ktoe),
TFC is 9% less in comparison with average level of 2010-2015.

Baseline scenario: TPES and TFC in 2010-2050 ktoe



2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Total primary energy supply												
132308	126438	122488	115940	105683	90090	91000	89000	87000	85000	83000	81500	80328
Fossil fuels and nuclear energy												
129576	123805	119839	112697	102822	87390	86112	81142	77306	73130	69569	65941	61470
Energy efficiency												
-	-	-	-	-	-	24491	26491	28491	30491	32491	33991	35163
Solid biomass												
1597	1682	1695	1879	1934	2102	3200	4500	5000	5500	5750	6000	6302
Biogas												
-	-	-	-	-	14,3	162	350	400	550	600	750	1000
Wind												
4,29	7,63	24,69	54,77	96,86	93,2	253,5	890	1305	1700	2075	2853	4016
Solar PV												
0,09	2,57	28,54	48,86	36,77	40,97	104	445	653	850	1037,5	1222,5	1269,2
Solar thermal												
-	-	-	-	-	-	100	267	653	1275	1660	2038	2530
Heat pumps												
-	-	-	-	-	-	300	450	600	750	1000	1250	1750
Hydro (large + small)												
1131	941	901	1187	729	464	573,5	761	789	728	696	733	756
Geothermal												
-	-	-	-	-	-	-	-	100	100	150	200	400
Liquid biofuels												
-	-	-	48,4	42,4	35,1	195	195	195	416	463	514	571
Capacitors and storages												
-	-	-	-	-	-	-	-	-	-	-	-	263
2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Total final consumption												
74004	75852	73107	69557	61460	50831	52273	53155	54382	55964	57540	59423	61561

Baseline scenario



Share of biomass and other renewables in total RES (TPES) in Baseline scenario, %

RES types	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Biomass + Biogas + Biofuels	58,4	63,9	64	59,9	69,7	78,3	72,8	64,2	57,7	54,5	50,7	46,7	41,7
Wind	0,2	0,3	0,9	1,7	3,4	3,5	5,2	11,3	13,5	14,3	15,4	18,3	21,3
Solar PV + thermal	-	0,1	1,1	1,5	1,3	1,3	4,2	9,1	13,5	17,9	20,1	21,0	20,1
Heat pumps	-	-	-	-	-	-	6,1	5,7	6,2	6,3	7,4	8,0	9,3
Hydro	41,4	35,7	34,0	36,9	25,6	16,9	11,7	9,7	8,1	6,1	5,2	4,7	4,0
Geothermal	-	-	-	-	-	-	-	-	1,0	0,8	1,1	1,3	2,1

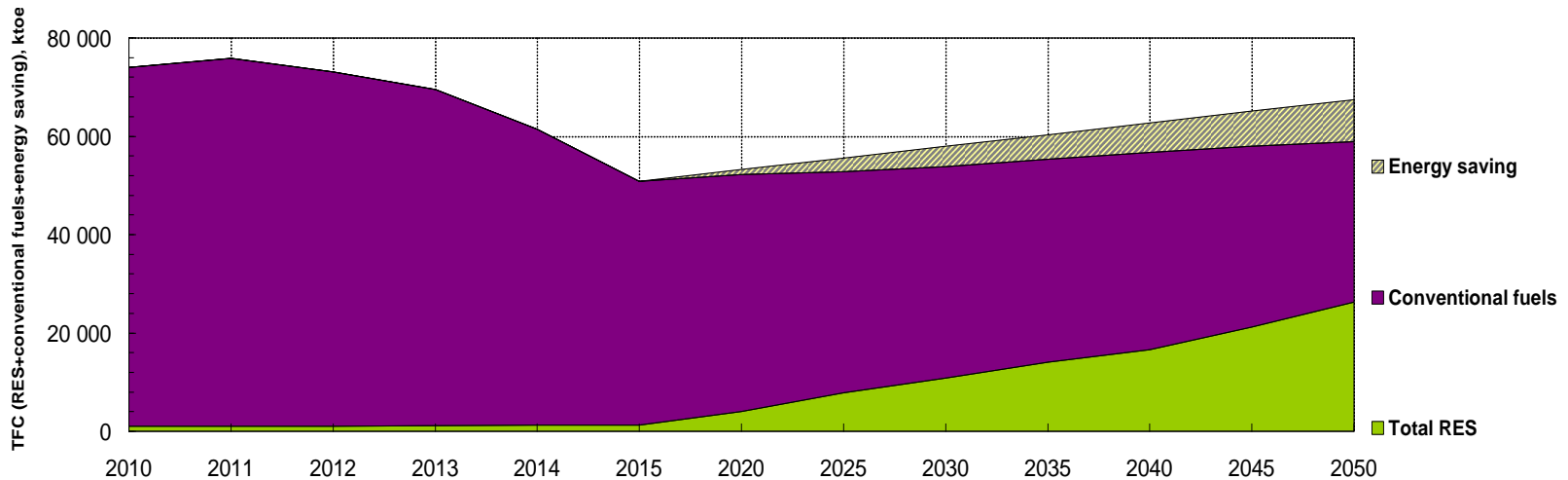
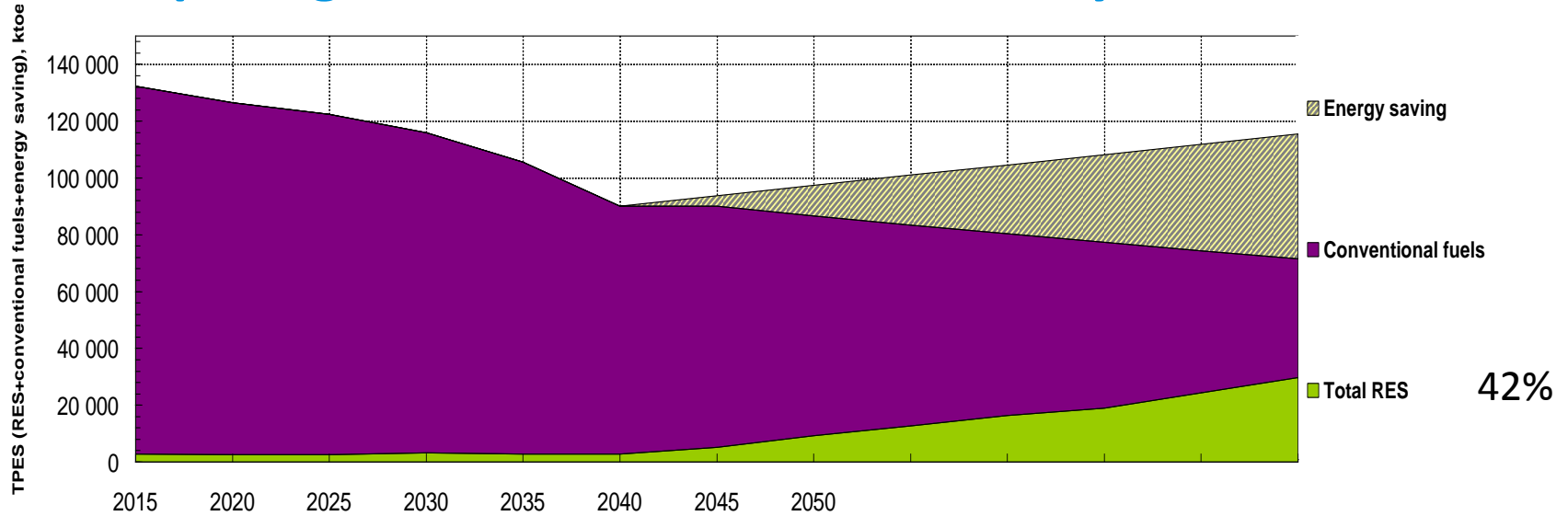
Scenario 2 – Climate action. Assumptions

- ✓ National Renewable Energy Action Plan: 50% fulfillment of all targets in 2020;
- ✓ Energy efficiency: 13 % decreasing of TFC in 2050 in comparison with average 2010-2015 level
- ✓ 40% RES share in 2050 to average 2010-2015 TPES levels;
- ✓ New Draft Energy Strategy till 2035: 23% RES share in TFC in between 2030-2035 period;
- ✓ Revised GHG emission reduction target: 70% GHG emission reduction in 2050 in comparison with 2015;
- ✓ Implementation and fulfillment of Directives #2009/75/EC (on particle matters, SO_x, NO_x emissions from LCP) and Directive # 2009/87/EC aimed on UA ETS implementation.
- ✓ Liquid biofuels share in transport: 10% in 2050 (bearing in mind transport energy consumption 2015=2050).



- 70% GHG

Climate action scenario: RES and energy efficiency in TPES and TFC comparing with traditional fuels, ktoe/year



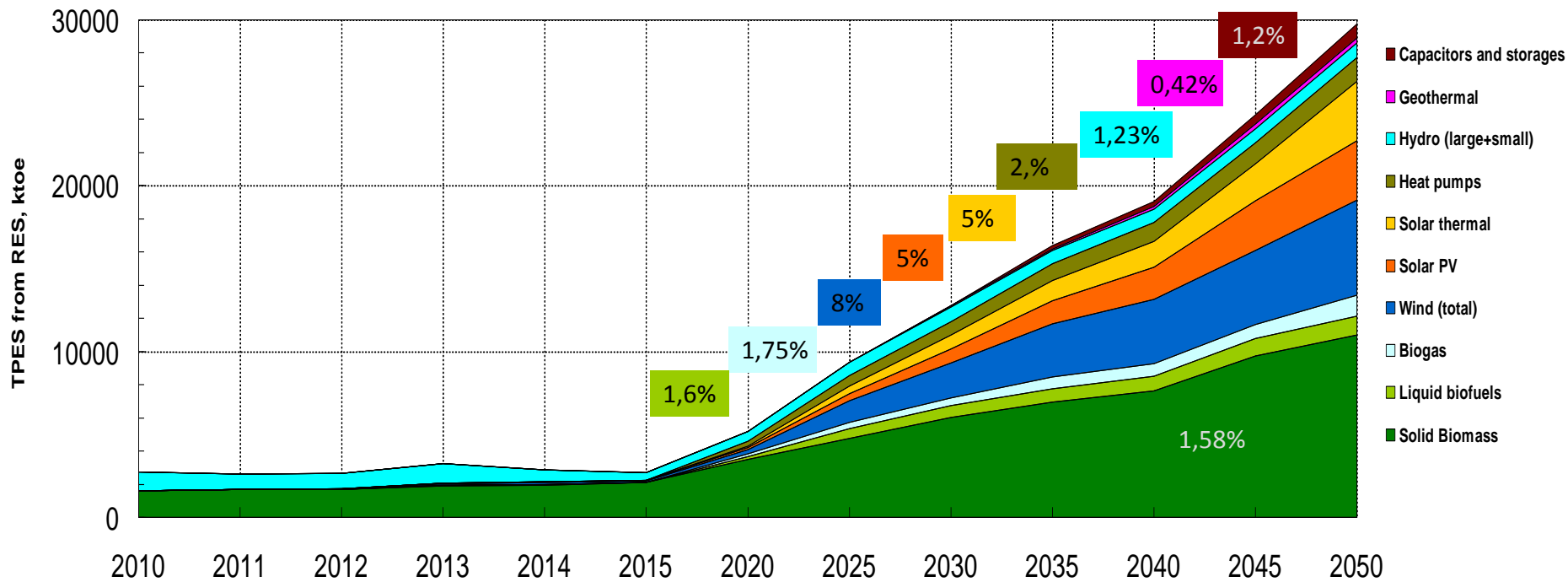
TPES in 2050 is 20% less in comparison with 2015 (71,629 against 90,090 ktoe),
 TFC is 13% less in comparison with 2010-2015 TFC average.

Climate action scenario: TPES and TFC 2010-2050, ktoe



2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Total primary energy supply												
132308	126438	122488	115940	105683	90090	90090	86712	83460	80330	77318	74418	71629
Fossil fuels and nuclear energy												
129576	123805	119839	112697	102822	87390	84912	77354	70698	63957	58264	50163	41871
Energy efficiency												
-	-	-	-	-	-	25401	28780	32031	35161	38173	41073	43863
Solid Biomass												
1597	1682	1695	1879	1934	2102	3489	4769	6039	6952	7616	9750	11000
Biogas												
-	-	-	-	-	14,3	162	400	500	700	750	850	1250
Wind												
4,29	7,63	24,69	54,77	96,86	93,2	254	1301	2087	3213	3866	4465	5730
Solar PV												
0,09	2,57	28,54	48,86	36,77	40,97	104	434	835	1406	1933	2977	3581
Solar thermal												
-	-	-	-	-	-	100	434	835	1205	1546	2233	3581
Heat pumps												
-	-	-	-	-	-	300	650	835	1004	1160	1302	1433
Hydro (large + small)												
1131	941	901	1187	729	464	574	799	847	795	775	834	881
Geothermal												
-	-	-	-	-	-	-	-	100	100	200	300	300
Liquid Biofuels												
-	-	-	48,4	42,4	35,1	195	571	686	800	914	1028	1143
Capacitors and storages												
-	-	-	-	-	-	-	-	-	198	294	516	858
2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Total final consumption												
74004	75852	73107	69557	61460	50831	52273	52765	53874	55385	56718	57996	58927

Scenario 2 – Climate action



Share of biomass and other renewables in total RES (TPES) in Climate action scenario, %

RES types	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Biomass + Biogas + Biofuels	58,4	63,9	64	59,9	69,7	78,3	74,3	61,3	56,6	51,6	48,7	47,9	45,0
Wind	0,2	0,3	0,9	1,7	3,4	3,5	4,9	13,9	16,3	19,6	20,3	18,4	19,3
Solar PV + thermal	-	0,1	1,1	1,5	1,3	1,3	3,9	9,3	13,1	15,9	18,3	21,5	24,1
Heat pumps	-	-	-	-	-	-	5,8	6,9	6,5	6,1	6,1	5,4	4,8
Hydro	41,4	35,7	34,0	36,9	25,6	16,9	11,1	8,5	6,6	4,9	4,1	3,4	3,0
Geothermal	-	-	-	-	-	-	-	-	0,8	0,6	1,0	1,2	1,0

Scenario 3 – High commitment 100% RES.

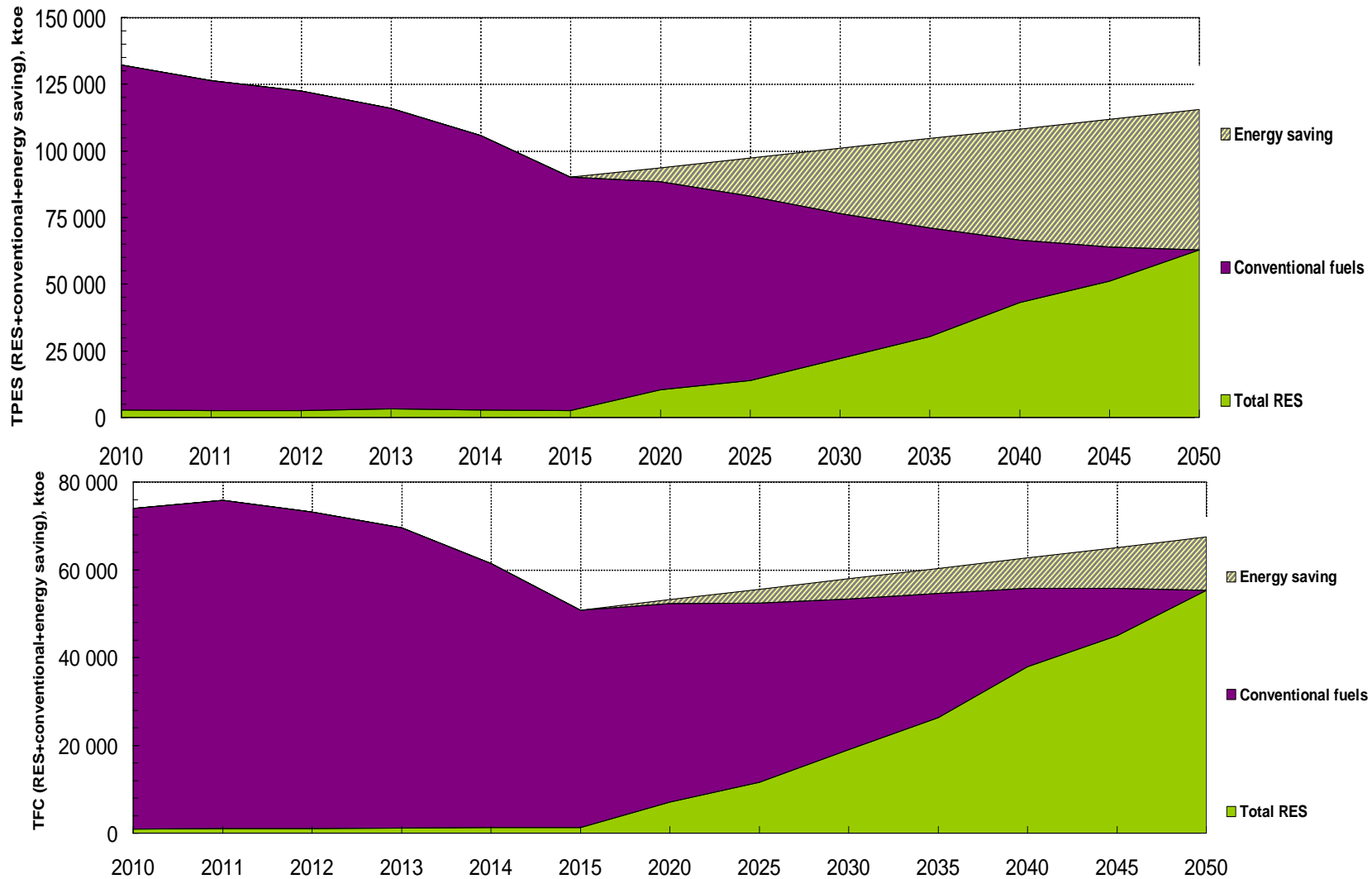
Assumptions

- ✓ National Renewable Energy Action Plan: 100% fulfillment of all targets in 2020;
- ✓ Energy efficiency: 18 % decreasing of TFC in 2050 in comparison with average 2010-2015 level;
- ✓ Trend of TPES from RES growth (average) is up to 4%/year;
- ✓ For the period 2040-2050 TFC is starting decreasing to meet 100% RES in 2050;
- ✓ 100% emission reductions in 2050;
- ✓ Liquid biofuels share in transport: 30% in 2050 (bearing in mind transport energy consumption 2015=2050).
- ✓ Solar energy potential utilization: 100% in 2050 according to LUT transition model data (11.7 Mtoe).



100% RES

Scenario 100% RES: RES and energy efficiency in TPES and TFC comparing with traditional fuels, ktoe/year



TPES in 2050 is 30% less in comparison with 2015 (62,750 against 90,090 ktoe),
TFC is 18% less.

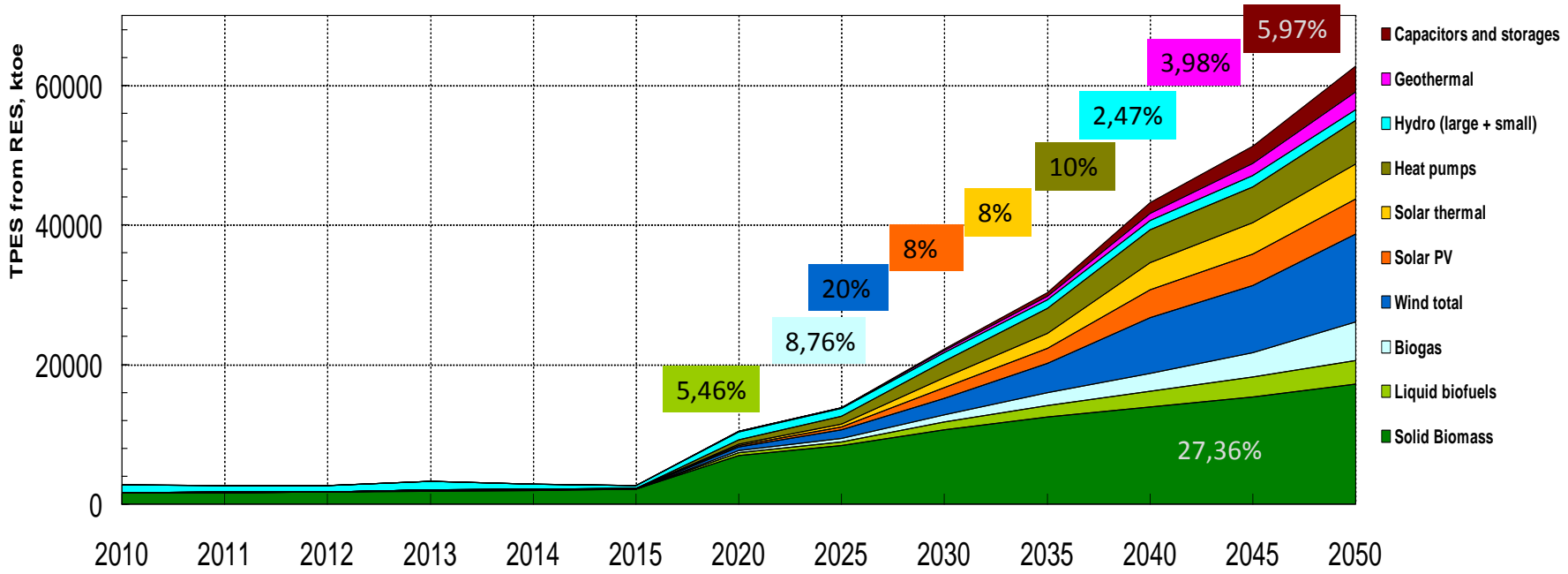
100% RES scenario: TPES and TFC in 2010-2050, ktoe



100% RES

2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Total primary energy supply												
132308	126438	122488	115940	105683	90090	88500	83000	76500	71000	66500	64000	62750
Fossil fuels and nuclear energy												
129576	123805	119839	112697	102822	87390	78084	69143	54287	40667	23268	12751	-
Energy efficiency												
-	-	-	-	-	-	26991	32491	38991	44491	48991	51491	52741
Solid Biomass												
1597	1682	1695	1879	1934	2102	6978,7	8356,4	10665	12458	13896	15383	17169
Biogas												
-	-	-	-	-	14,3	325	500	1000	1750	2500	3500	5500
Wind												
4,29	7,63	24,69	54,77	96,86	93,2	507,00	1245	2295	4260	7980	9600	12550
Solar PV												
0,09	2,57	28,54	48,86	36,77	40,97	208	415	1530	2130	3990	4480	5020
Solar thermal												
-	-	-	-	-	-	200	415	1530	2130	3990	4480	5020
Heat pumps												
-	-	-	-	-	-	600	1037,5	2295	3550	4655	5120	6275
Hydro (large + small)												
1131	941	901	1187	729	464	1147	1180	1248,2	1268,6	1375	1631,8	1547
Geothermal												
-	-	-	-	-	-	60	60	250	500	1000	1750	2500
Liquid Biofuels												
-	-	-	48,4	42,4	35,1	390	571,3	1142,6	1713,8	2285	2856,4	3427,7
Capacitors and storages												
-	-	-	-	-	-	-	76,4	257,1	572,6	1560,2	2448,6	3746
2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Total final consumption												
74004	75852	73107	69557	61460	50831	52273	52383	53290	54647	55771	55724	55 362

Scenario 3 – High commitment 100% RES



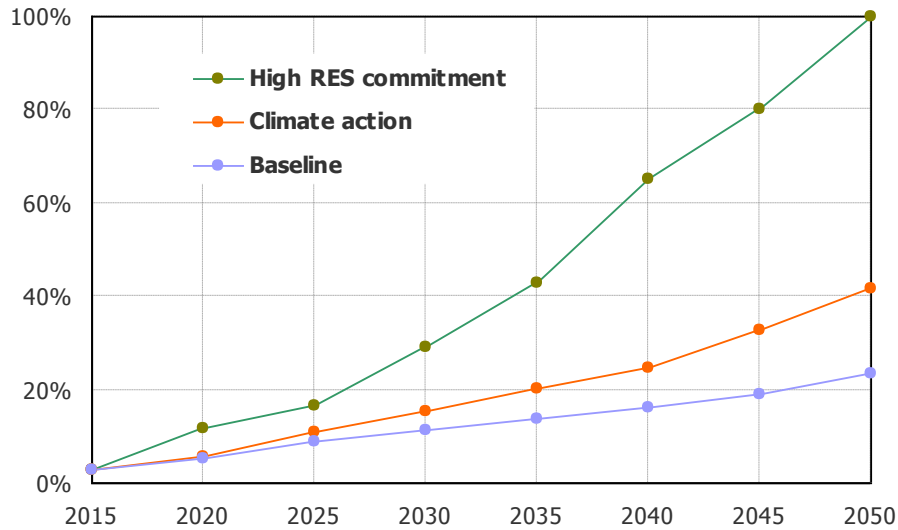
Share of biomass and other renewables in total RES (TPES) in 100% RES scenario, %

RES types	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035	2040	2045	2050
Biomass + Biogas + Biofuels	58,4	63,9	64,0	59,9	69,7	78,3	73,9	68,0	57,7	52,5	43,2	42,4	41,6
Wind	0,16	0,29	0,93	1,70	3,41	3,52	4,87	8,98	10,33	14,04	18,46	18,73	20,0
Solar PV + thermal	-	0,10	1,08	1,52	1,29	1,34	3,92	5,99	13,78	14,04	18,46	17,48	16,0
Heat pumps	-	-	-	-	-	-	5,76	7,49	10,33	11,70	10,77	9,99	10,0
Hydro	41,39	35,74	34,01	36,86	25,65	16,88	11,01	8,52	5,62	4,18	3,18	3,18	2,47
Geothermal	-	-	-	-	-	-	0,58	0,43	1,13	1,65	2,31	3,41	3,98

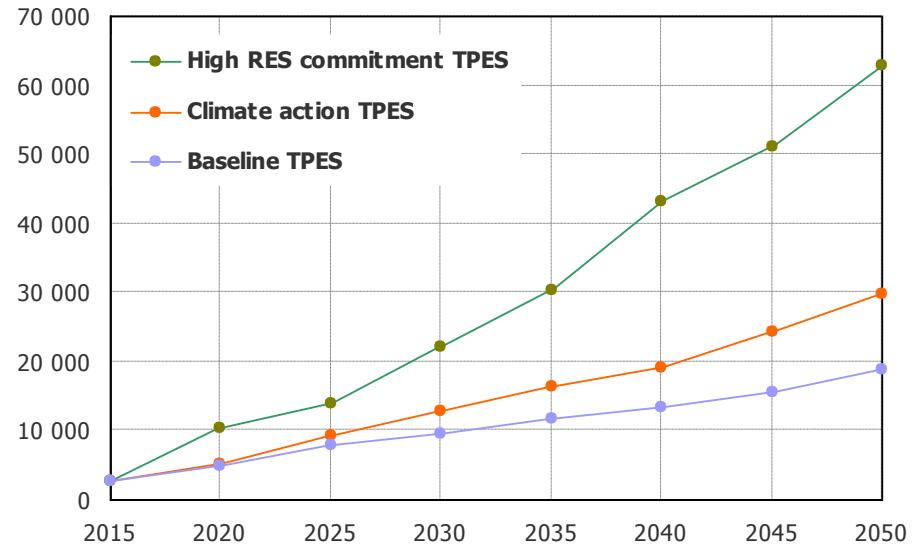


Scenario comparison

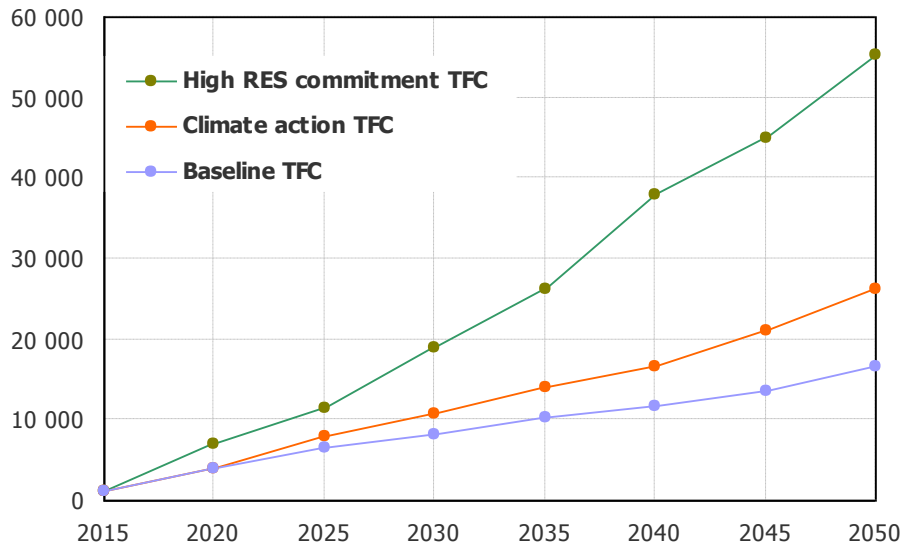
RES share in TPES for three scenarios, %



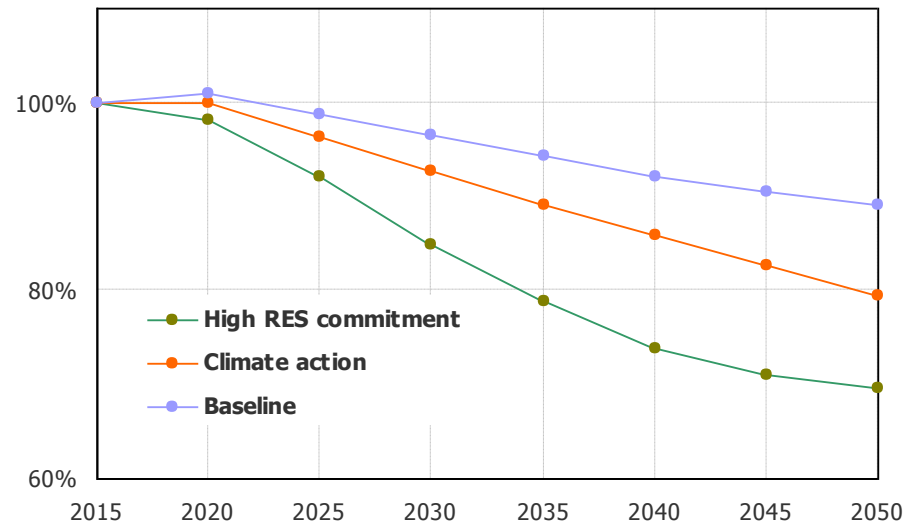
TPES from RES for three scenarios, ktoe/year



TFC from RES for three scenarios, ktoe/year



Dynamics of TPES changing for three scenarios, 100%= average for 2010-2015



RES potential used

RES type	Total potential, 2050, ktoe	Potential used in 2050, ktoe			Potential used in 2050, %		
		Baseline	Climate action	High commitment	Baseline	Climate action	High commitment
Solid biomass+ biogas + liquid biofuels	43 420	7 873	13 392	26 097	18,10%	30,80%	60,10%
Wind (total)	19 600	4 016	5 730	12 550	20,50%	29,20%	64,00%
Solar PV	5 850	1 269	3 581	5 020	21,70%	61,20%	85,80%
Solar thermal	5 850	2 530	3 581	5 020	43,30%	61,20%	85,80%
Heat pumps	12 600	1 750	1 432	6 275	13,90%	11,40%	49,80%
Hydro (large+small)	4 900	756	881	1 547	15,40%	18,00%	31,60%
Geothermal	8 400	400	300	2 500	4,80%	3,60%	

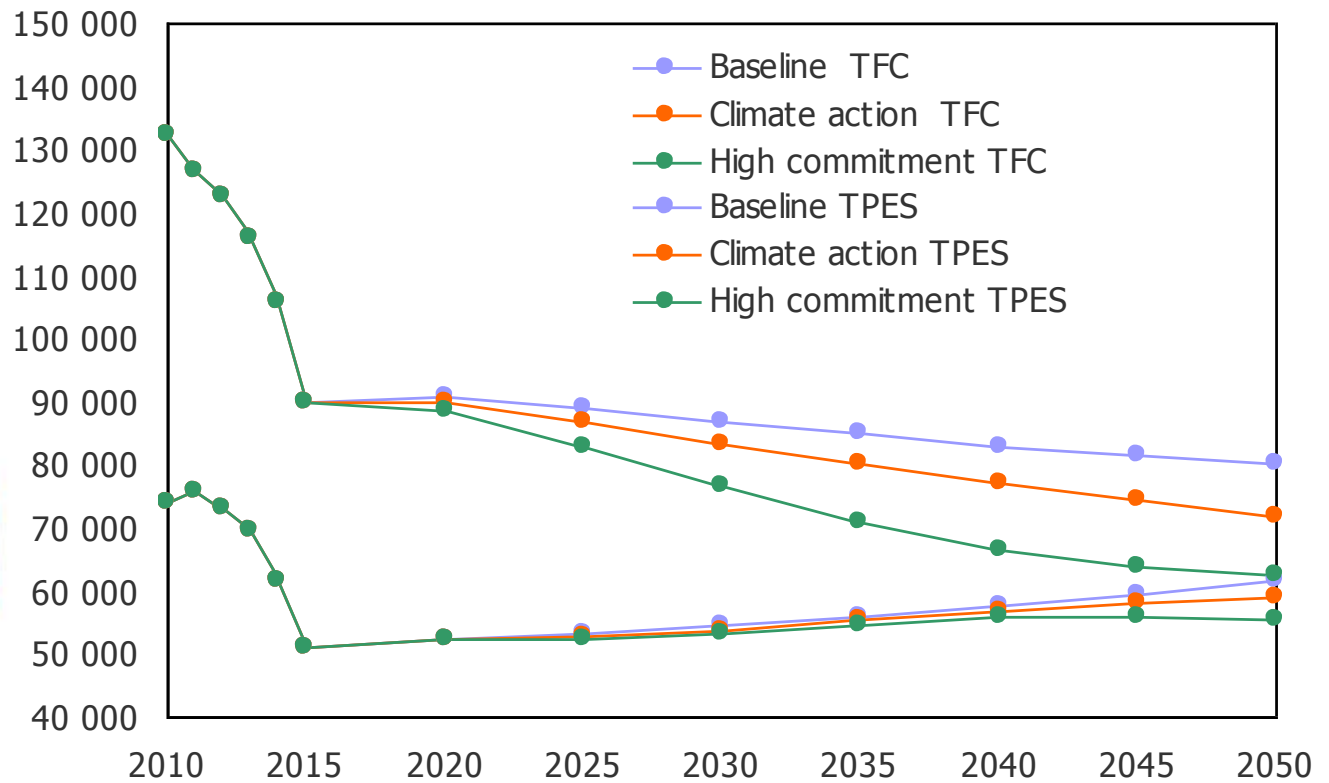


Scenario comparison

Energy efficiency in TFC for three scenarios

Energy efficiency, ktoe, (current year)/2010-2015 average	2015	2020	2025	2030	2035	2040	2045	2050
Baseline	0	935	2 429	3 579	4 374	5 175	5 669	5 907
Climate action	0	935	2 820	4 087	4 953	5 997	7 096	8 542
100% RES	0	935	3 202	4 671	5 691	6 944	9 368	12 107

Dynamics of TFC and TPES for three scenarios, 100%= average for 2010-2015



Approach to calculate jobs in RES sectors

	Number of jobs per ktoe (total)	Note
Solid Biomass	4	ktoe combined
Biogas	7	ktoe combined
Wind (total)	9	ktoe power
Solar PV	11	ktoe power
Solar thermal	4	ktoe thermal
Heat pumps	10	ktoe thermal/power
Geothermal	6	ktoe combined
Liquid biofuels	7,5	ktoe TFC

Source for data: THE STATE OF RENEWABLE ENERGIES IN EUROPE EDITION 2016
16th EurObserv'ER Report

Baseline scenario: Employment in RES sectors

RES type	2015	2020	2025	2030	2035	2040	2045	2050
Solid biomass	8408	12800	18000	20000	22000	23000	24000	25208
Biogas	100	1131	2450	2800	3850	4200	5250	7000
Wind	872	2282	8010	11745	15300	18675	25673	36148
Solar PV	404	1144	4895	7178	9350	11413	13448	13961
Solar thermal	0	400	1068	2610	5100	6640	8150	10121
Heat pumps	0	3000	4500	6000	7500	10000	12500	17500
Geothermal	0	0	0	600	600	900	1200	2400
Liquid biofuels	263	1463	1463	1463	3123	3471	3856	4285
Total in RES	10048	22219	40386	52395	66823	78298	94076	116623



Baseline

Climate action scenario: Employment in RES sectors

RES type	2015	2020	2025	2030	2035	2040	2045	2050
Solid biomass	6306	10468	14308	18117	20857	22849	29250	33000
Biogas	100	1135	2800	3500	4900	5250	5950	8750
Wind	872	2282	11706	18778	28919	34793	40186	51572
Solar PV	404	1144	4769	9181	15464	21262	32744	39395
Solar thermal	0	1500	6503	12519	18074	23195	33488	53721
Heat pumps	0	3000	6503	8346	10041	11598	13023	14326
Geothermal	0	0	0	1800	1800	3600	5400	5400
Liquid biofuels	263	1463	4285	5142	5998	6855	7712	8569
Total in RES	7946	20991	50874	77383	106053	129402	167754	214733



- 70% GHG

High commitment on 100% RES: Employment in RES sectors

RES type	2015	2020	2025	2030	2035	2040	2045	2050
Solid biomass	6306	20936	25069	31996	37373	41689	46148	51507
Biogas	100	2275	3500	7000	12250	17500	24500	38500
Wind	872	4563	11205	20655	38340	71820	86400	112950
Solar PV	404	2288	4565	16830	23430	43890	49280	55220
Solar thermal	0	3000	6225	22950	31950	59850	67200	75300
Heat pumps	0	5700	9856	21803	33725	44223	48640	59613
Geothermal	0	1080	1080	4500	9000	18000	31500	45000
Liquid biofuels	632	7020	10283	20566	30849	41132	51416	61699
Total in RES	8314	46862	71784	146299	216917	338104	405083	499788



100% RES

Thank you for your attention!

129 regions and cities already have plans
towards **100% RES** in 2050!

