

# Zero-waste initiatives

## – waste geothermal water as a source of medicinal raw material and drinking water

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# Welcome to Krakow!



## Outline:

1. Why we need save water resources?
2. Why we should recycling waste geothermal water?
3. How we can recycling waste geothermal water?
4. Tests of Mszczonów geothermal water
5. Results and conclusions

# Why we need save water resources?

*Wastewater from our homes, cities, industry and agriculture flows back to nature without being treated or reused – polluting the environment, and losing valuable nutrients and other recoverable materials!*

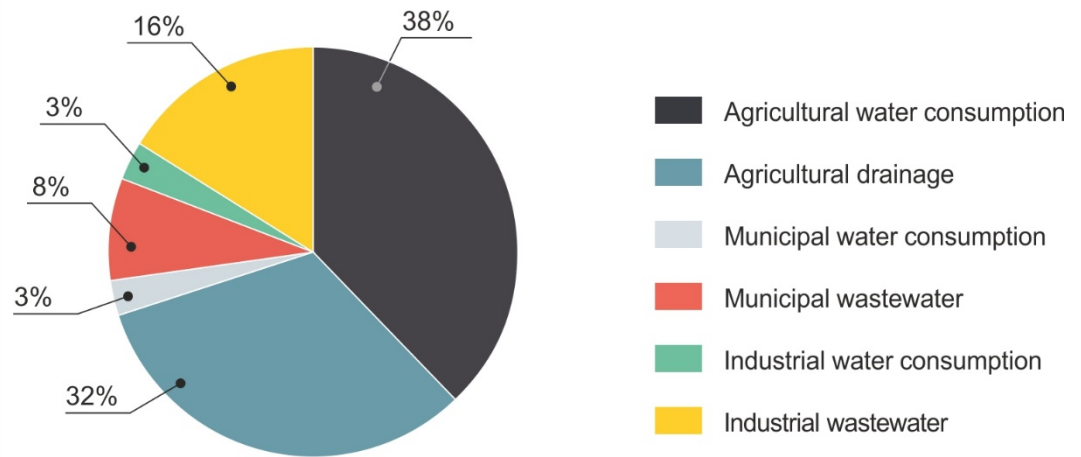
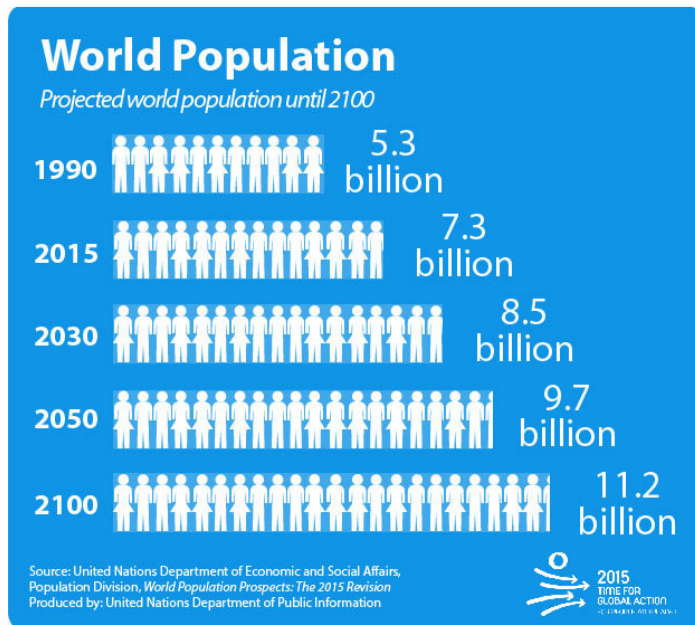


Fig. 1 Fate of freshwater withdrawals: Global consumption and wastewater production by major water use sector (UNWWDR, 2017. The United Nations World Water Development Report)





# SUSTAINABLE DEVELOPMENT GOALS

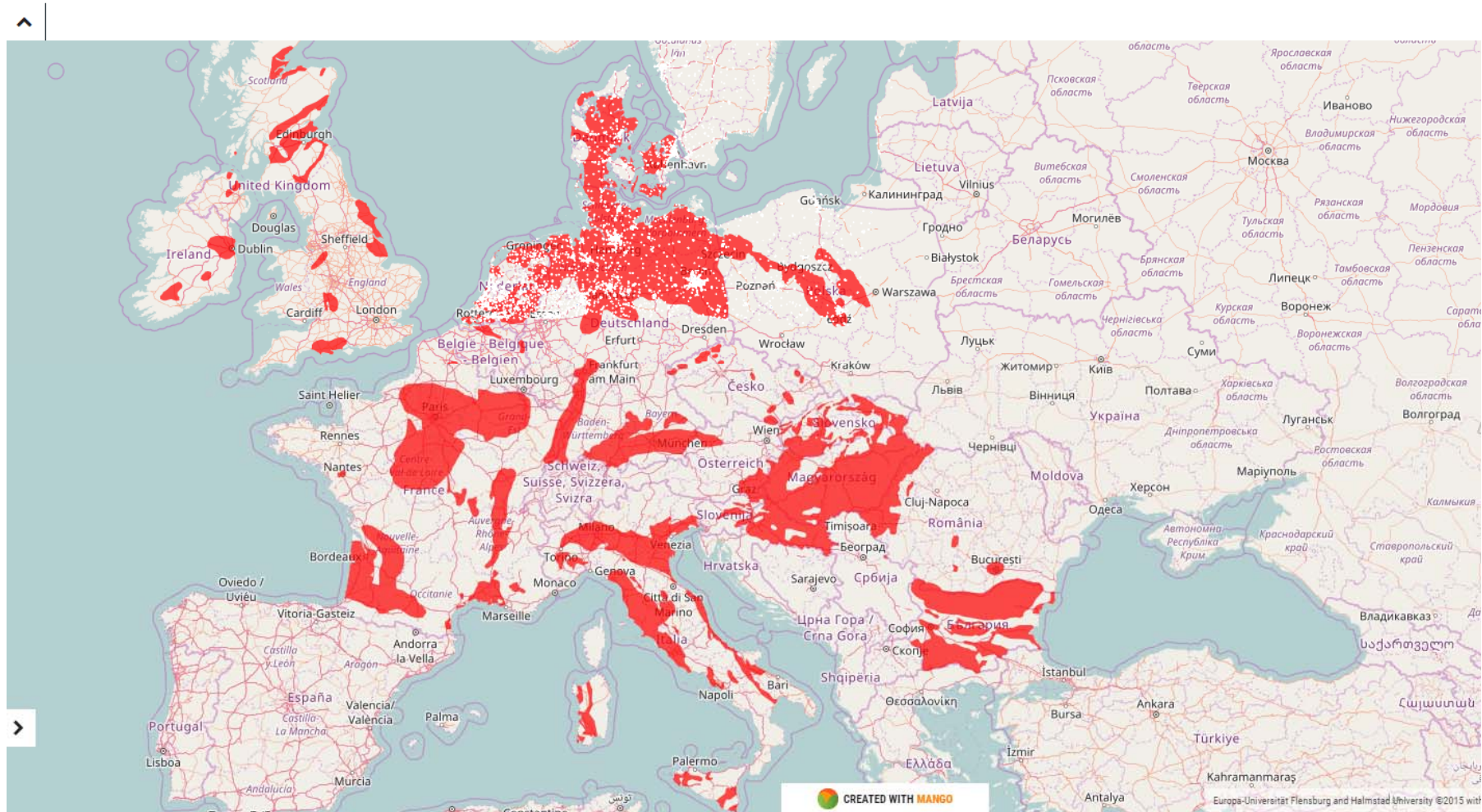


# Why we should recycling waste geothermal water?



Peta, the Pan-European Thermal Atlas: renewable energy

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## Use of geothermal waters in Poland

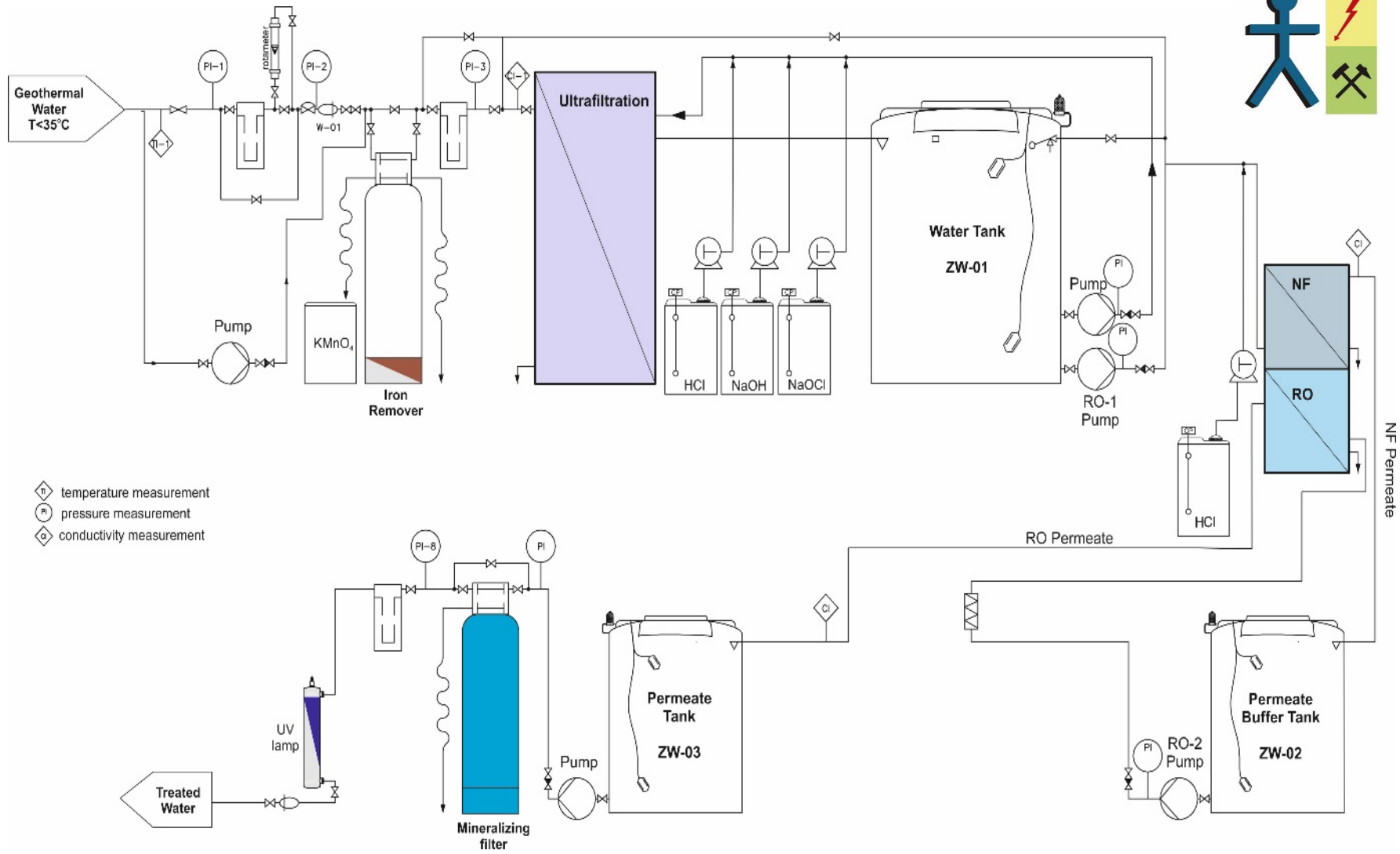
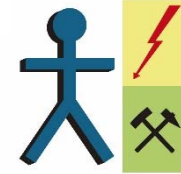


# Balneological classification of mineral waters in Poland

TOTAL DISSOLVED SOLIDS (TDS)	TEMPERATURE [°C]	PHARMACO-DYNAMIC FACTORS – SPECIFIC COMPONENTS	CHEMICAL TYPE OF WATER
		2 mg F <sup>-</sup>	Fluoride
		1 mg I <sup>-</sup>	Iodated
		1 mg S(II)	Sulfuric
≥ 1 g/L – mineral water	> 20 - geothermal water	70 mg H <sub>2</sub> SiO <sub>3</sub>	Silica
< 1 g/L – slightly mineralized	< 20 - cold water	10 mg Fe(II)	Ironic
		74 Bq	Radon or radioactive
		250 mg free CO <sub>2</sub>	Carbonate
		1000 mg free CO <sub>2</sub>	CO <sub>2</sub> -rich. carbonized



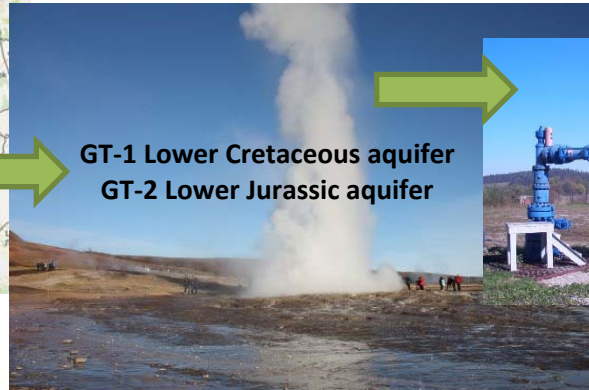
# How we can recycling waste geothermal water?



# Why Mszczonów geothermal water?



GT-1 Lower Cretaceous aquifer  
GT-2 Lower Jurassic aquifer



## Physical properties and chemical composition of Mszczonów geothermal water

ELEMENT	GT-1	GT-2
TDS [mg/L]	6,157.3	4,863.3
pH	6.41	7.67
Total hardness [mg CaCO <sub>3</sub> /L]	392.7	374
Carbonate hardness [mg CaCO <sub>3</sub> /L]	242.7	204.1
Na [mg/L]	2,178.0	1,713.81
K [mg/L]	18.7	22.66
Ca [mg/L]	120.5	99.4
Mg [mg/L]	22.39	30.627
Cl [mg/L]	3,543.0	2,645
SO <sub>4</sub> [mg/L]	84.33	68.48
As [mg/L]	0.015	0.008
F [mg/L]	0.96	0.21
Cr [mg/L]	0.011	0.01
Cd [mg/L]	<0.0003	<0.0003
Ni [mg/L]	0.002	0.002
Pb [mg/L]	0.0008	0.0024
Hg [mg/L]	<0.0001	0.0005
Al [mg/L]	<0.005	<0.005
Mn [mg/L]	0.029	0.122
Fe [mg/L]	0.12	1.38
Sr [mg/L]	4.94	2.34
H <sub>2</sub> SiO <sub>3</sub> [mg/L]	32.18	25.84
<sup>222</sup> Rn [Bq/L]	5.4	6



## Results

### – physical and chemical properties of permeate after NF and RO

ELEMENT	GT-1		GT-2	
	NF PERMEATE	RO PERMEATE	NF PERMEATE	RO PERMEATE
TDS [mg/L]	2,525.0	91	2,554.9	170.8
Total hardness [mg CaCO <sub>3</sub> /L]	8.6	0.9	183	0.7
Carbonate hardness [mg CaCO <sub>3</sub> /L]	8.6	0.9	18.9	0
Na [mg/L]	950.3	34.06	901.18	68.97
K [mg/L]	12.67	1.22	13.47	5.39
Ca [mg/L]	2.74	0.3	50.9	0.27
Mg [mg/L]	0.436	0.045	13.615	<0.1
Cl [mg/L]	1,532.0	40.7	1,510.0	76.6
SO <sub>4</sub> [mg/L]	1.33	0.49	37.81	<3.0
I [mg/L]	0.24	0.059	0.03	0.12
As [mg/L]	0.01	0.005	0.004	0.001
F [mg/L]	0.43	0.14	0.2	0.039
Cr [mg/L]	0.005	<0.005	0.008	<0.005
Cd [mg/L]	<0.0003	<0.0003	<0.0003	<0.0003
Ni [mg/L]	<0.001	<0.001	<0.001	<0.001
Pb [mg/L]	0.0024	0.0005	0.0006	0.0016
Hg [mg/L]	<0.0001	<0.0001	0.0003	<0.0001
Al [mg/L]	<0.005	<0.005	<0.005	<0.005
Mn [mg/L]	0.017	<0.005	0.022	<0.005
Fe [mg/L]	<0.01	<0.01	0.05	0.03
Sr [mg/L]	<0.20	<0.20	1.24	<0.2
H <sub>2</sub> SiO <sub>3</sub> [mg/L]	8.39	0.34	12.34	1.24
<sup>222</sup> Rn [Bq/L]	2.4	1.4	3	1.8

## Comparison of concentrate analysis results with requirement of the Polish Ministry of Health

ELEMENT	GT-1		GT-2		THE HIGHEST ADMISSIBLE CONCENTRATION		
	NF CONCENTRATE	RO CONCENTRATE	NF CONCENTRATE	RO CONCENTRATE	DRINKING CURE	INHALATION	BATH
TDS [mg/L]	12,792.9	6,289.7	10,498.5	4,628.2	-	-	-
Total hardness [mg CaCO <sub>3</sub> /L]	1.083.8	51.9	910.2	703.5	-	-	-
Carbonate hardness [mg CaCO <sub>3</sub> /L]	84	51.9	128.5	0	-	-	-
Na [mg/L]	4,327.0	2,349	3,699.15	1,417.80	-	-	-
K [mg/L]	41.46	37.57	51.98	39.8	-	-	-
Ca [mg/L]	333.8	16.27	245.48	207.46	-	-	-
Mg [mg/L]	60.98	2.749	72.341	45.167	-	-	-
Cl [mg/L]	7,490.0	3,752.0	6.002.0	2.520.0	-	-	-
SO <sub>4</sub> [mg/L]	316.6	41.03	260.95	316.95	-	-	-
I [mg/L]	1.41	0.034	0.06	0.13	-	-	-
As [mg/L]	0.029	0.02	0.02	0.012	-	-	-
F [mg/L]	1.4	1.2	0.065	0.15	-	-	-
Cr [mg/L]	0.019	0.011	0.024	0.027	0.01	0.01	-
Cd [mg/L]	<0.0003	<0.0003	<0.0003	<0.0003	0.003	0.003	-
Ni [mg/L]	0.003	0.002	0.003	0.05	0.03	0.03	-
Pb [mg/L]	0.0085	0.0018	0.0048	0.0214	0.01	0.01	-
Hg [mg/L]	<0.0001	<0.0001	0.0004	0.0003	0.001	0.001	-
Al [mg/L]	<0.005	0.009	<0.005	0.006	0.1	0.1	-
Mn [mg/L]	3.444	0.241	0.119	0.299	-	-	-
Fe [mg/L]	1.83	0.07	0.13	1.02	-	-	-
Sr [mg/L]	12.97	0.56	6.18	5.17	-	-	-
H <sub>2</sub> SiO <sub>3</sub> [mg/L]	93.73	26.12	73.48	54.1	-	-	-
<sup>222</sup> Rn [Bq/L]	<0.5	<0.5	<0.5	<0.5	-	-	-

## Conclusions:

- Waste geothermal water can be purified by membrane processes (nanofiltration/reverse osmosis) and after that re-used as drinking water
- This solution can be implement especially in areas with problems of lack or deficit of water
- The most important application of research is micro- and macroelements content valorisation of geothermal water, which caused good quality and lack of salinity components
- Results of tests show compatibility between parameters of concentrate and requirements of Polish national criteria for the assesment of the medicinal raw materials



## Source of pictures:

Slide 2:

- [http://www.poland24h.pl/files/Klienci/atr/krakow/pol\\_krakow.jpg](http://www.poland24h.pl/files/Klienci/atr/krakow/pol_krakow.jpg)
- <http://u.profitroom.pl/2015.hotel-logos.pl/uploads/krakow-z-lotu.jpg>
- [https://d-nm.ppstatic.pl/k/r/a1/96/551998ea9995a\\_o.jpg?1488287148](https://d-nm.ppstatic.pl/k/r/a1/96/551998ea9995a_o.jpg?1488287148)
- [http://encyklopediaksiazek.cba.pl/Wiki/images/7/7b/Smok\\_wawelski.jpg](http://encyklopediaksiazek.cba.pl/Wiki/images/7/7b/Smok_wawelski.jpg)

Slide 4:

- [https://assets.weforum.org/editor/8doM1NP9hnXC\\_Hxyihd3lVnAmrYI9oQGTJdbMKUr6tk.jpg](https://assets.weforum.org/editor/8doM1NP9hnXC_Hxyihd3lVnAmrYI9oQGTJdbMKUr6tk.jpg)

Slide 5:

- <http://www.un.org/en/zerohunger/img/challenge/UN%20Sustainable%20Development%20Goals%20icons.jpg>

Slide 6:

- <http://maps.heatroadmap.eu/berndmoller/maps/31157/Renewable-Resources-Map-for-EU28?#>

Slide 7:

- <https://www.min-pan.krakow.pl/Wydawnictwa/TPG2016/02-Kepi.pdf>
- [http://termy-mszczonow.eu//cache/images/text\\_pages/10f0c61445f67d85f17ef1a7fa433ab9.jpg](http://termy-mszczonow.eu//cache/images/text_pages/10f0c61445f67d85f17ef1a7fa433ab9.jpg)

Slide 10:

- <https://www.google.pl/maps/place/Mszczon%C3%B3w>
- <http://www.geotermia.com.pl/galeria.php>
- [http://termy-mszczonow.eu/termy\\_latem.html](http://termy-mszczonow.eu/termy_latem.html)
- [https://www.pgi.gov.pl/images/wody-mineralne/Zdjecia\\_do\\_artykulow/PA150399.JPG](https://www.pgi.gov.pl/images/wody-mineralne/Zdjecia_do_artykulow/PA150399.JPG)
- [http://www.pzw.org.pl/pliki/prezentacje/38/wiadomosci/66360/sam\\_1529.jpg](http://www.pzw.org.pl/pliki/prezentacje/38/wiadomosci/66360/sam_1529.jpg)

## References:

Fig. 1. UNESCO, 2017. UNESCO and Sustainable Development Goals. Available from: <http://en.unesco.org/sdgs> (accessed February 2017).

Fig. 2. Kępińska B., 2016. Przegląd stanu wykorzystania energii geotermalnej w Polsce w latach 2013–2015. A Review Of Geothermal Energy Uses In Poland In 2013–2015. Technika Poszukiwań Geologicznych. Geotermia. Zrównoważony Rozwój. 1-2/2016.

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