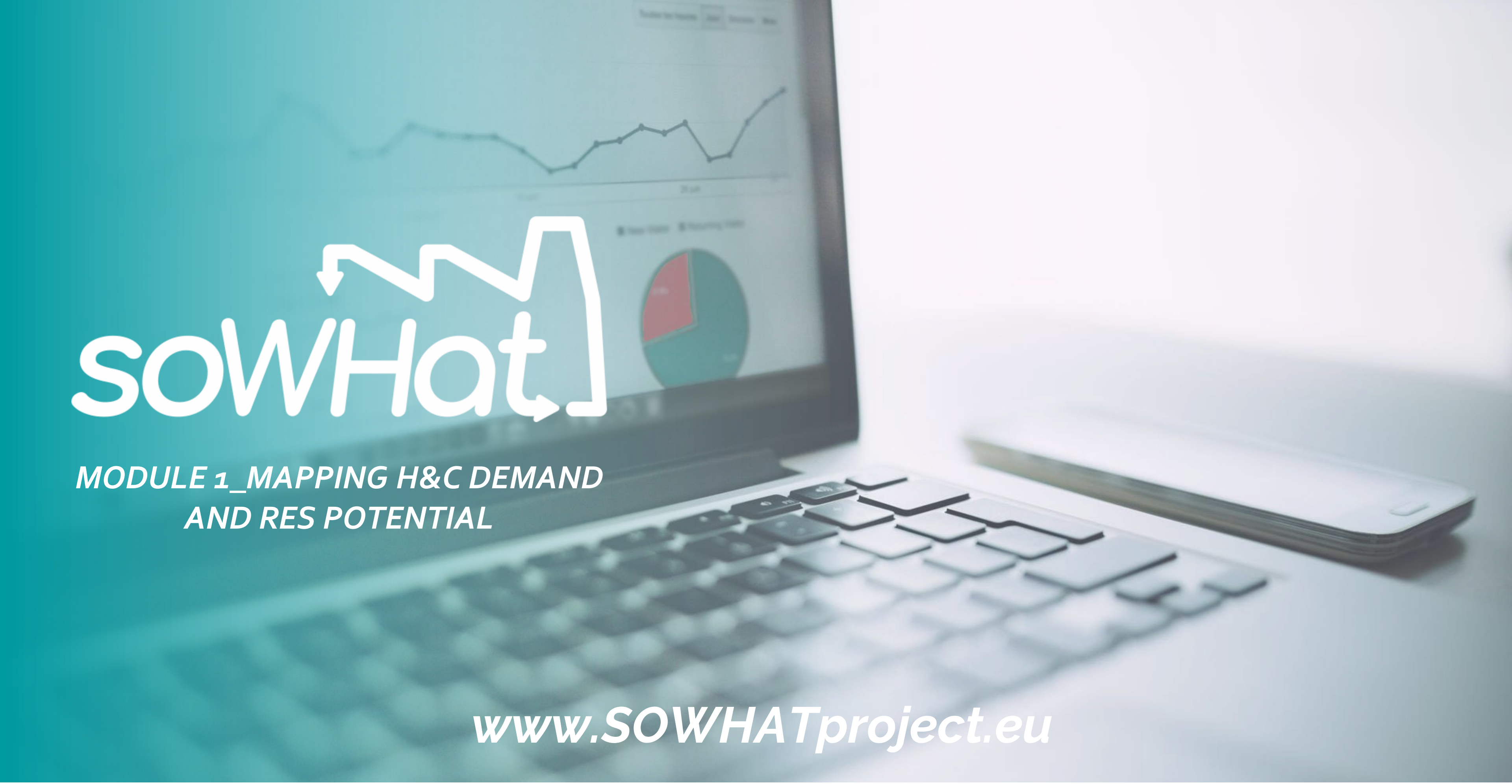

MODULE 1_MAPPING H&C DEMAND AND RES POTENTIAL

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This Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement N. 847097

Summary

- Introduction to Mapping
- Mapping Heating and Cooling Demand
  - Top-Down Approach
  - Bottom-Up Approach
- Mapping Renewable Energy Sources Potential
  - Thermal RES
  - Electrical RES

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Introduction to Mapping

- Georeferenced data are an important tool for city- and district-level energy planning
- They allow matching energy demand with potential supply from renewable or sustainable sources in a specific area
- They are particularly useful for high-level planning since they allow identifying areas with a good potential for action but additional evaluations are always needed

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Mapping in SO WHAT

- The SO WHAT tool includes mapping of geographical distribution of the heating and cooling demand and of the potential energy production from renewable energy sources
- Indeed, mapping these two distributions is important in order to evaluate:
  - the possibility of feeding the recovered heat to residential/tertiary buildings through district heating/cooling networks
  - the possibility to integrate the recovered energy with potential further heat or electricity produced from a renewable source

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Mapping H&C Demand

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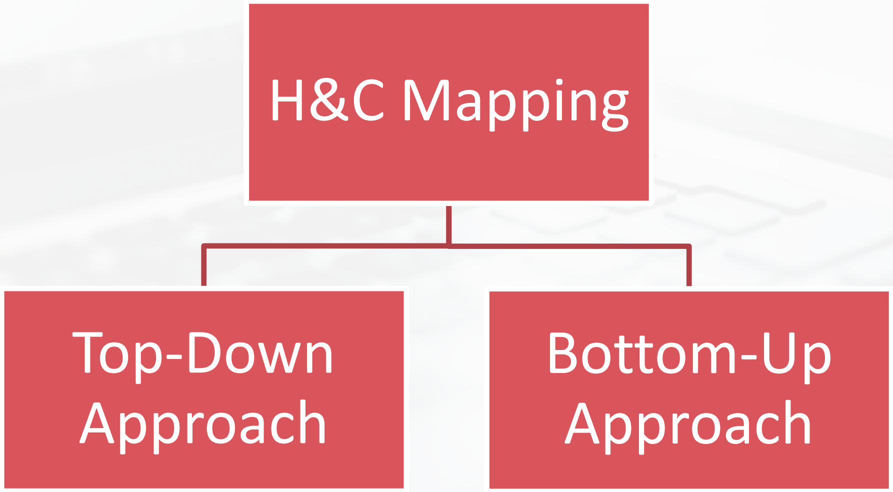
- It is needed to determine the space distribution of heating, cooling and domestic hot water demand over a given area, and its time distribution
- Two approaches are available



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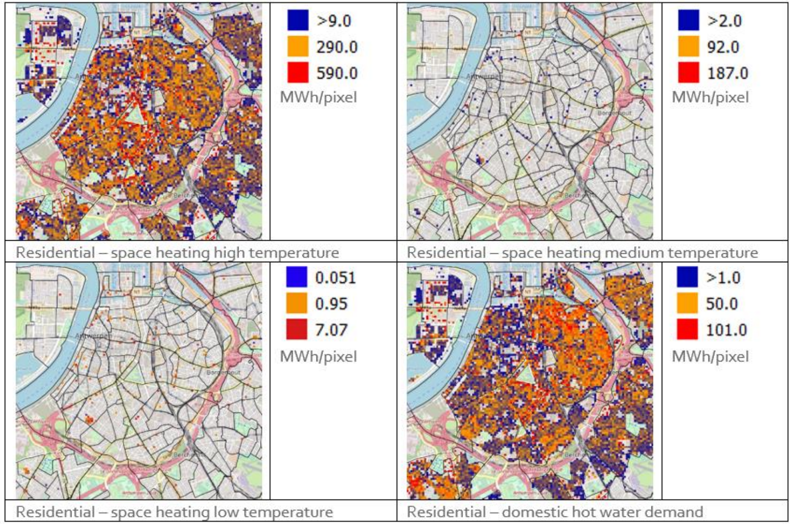
Top-Down Approach

- Works at pixel level
- Maps current annual H&C-DHW useful energy demand
- Requires aggregated input data (at city or district scale)
- Disaggregates the total value based on building/population density data
- Monthly/daily distribution of annual demand can be calculated based on Heating and Cooling Degree Days



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Bottom-Up Approach

- Works at building level
- Maps hourly and annual profile of H&C-DHW useful energy demand
- Requires input data at building level (cadaster or similar)
- Available in a simplified and in a complete version, depending on available information

Use	Construction Period	Number of Buildings	GFA (m²)	Heating Demand (kWh/year)	Cooling Demand (kWh/year)	DHW Demand (kWh/year)
Residential	Pre-1945	534	279,772	20,346,771	473,960	3,888,831
Residential	1945-1969	71	59,463	4,000,259	86,496	826,536
Residential	1970-1979	32	29,703	1,689,811	71,039	412,872
Residential	1980-1989	97	61,734	3,760,774	218,466	858,103
Residential	1990-1999	52	87,441	3,499,476	259,553	1,215,430
Residential	2000-2010	34	37,487	951,556	138,860	521,069
Residential	Post-2010	14	19,677	500,967	67,495	273,510

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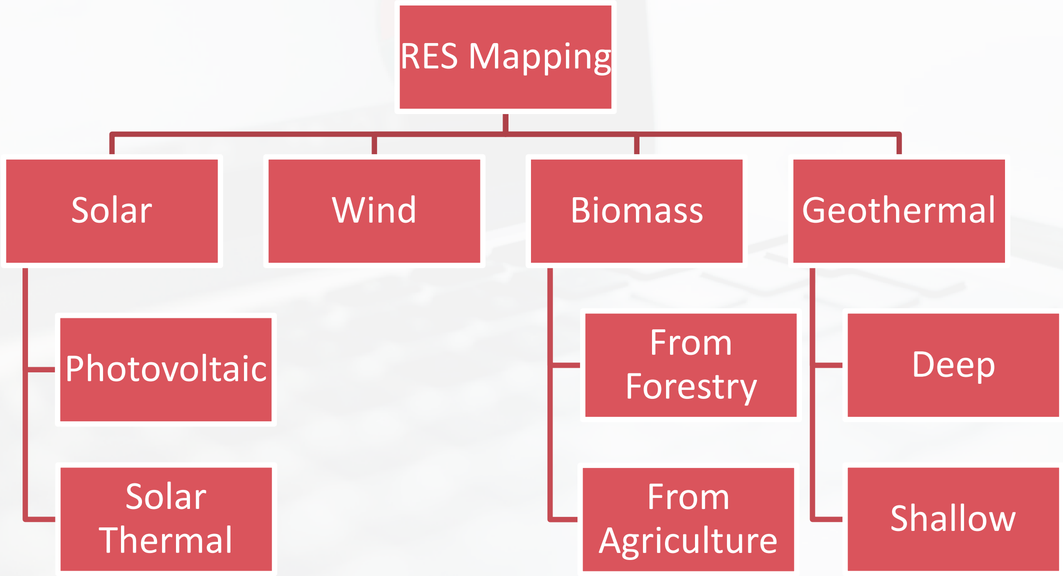
Mapping RES Potential

- Determining spatial distribution of renewable source availability
- For sources with significant variability in time (e.g. solar, wind), determining also time distribution



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What is RES Potential

- Physical Potential
- Geographical Potential
- Technical Potential
- Local Potential

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Mapping Thermal RES Potential

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Energy source's type	Algorithms [unit]	Inputs [unit]	External database [unit] to provide default values for algorithms' input
Solar thermal energy $E_{pot,solar}$	$E_{pot,solar} = Ir \times Technical\ suitability \times Efficiency \times Available\ Area$ [MWh/yr]	• Ir =Total solar irradiance under flat plane angle [kWh/m^2] • Technical suitability [-]: assumed 40% (1); • Efficiency [-]: assumed 75% (2); • Available area= ○ Footprint of buildings [m²], ○ Other suitable area [m²].	• Ir [kWh/m^2]: PVGIS database (https://re.jrc.ec.europa.eu/pvg_tools/it/tools.html#MR); • Footprint of buildings [m²]: cadaster database or OpenStreetMap (http://www.openstreetmap.org) as an open data alternative; • Other suitable area [m²]: Corine Land cover (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018).

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Mapping Thermal RES Potential

Energy source	Algorithms [unit]	Inputs [unit]	External database [unit] to provide default values for algorithms' input
Biomass energy from forestry PE_{FT}	$PE_{FT} = FA \times NAI_{reg} \times PE$ [MWh/yr]	• FA = Forest area of specific forest type: ○ Forest cover [ha], ○ Protected areas or other spatial constrains [ha], ○ Global ecological zones [ha]; • NAI_{reg} = Average stem-wood net annual increment per region [$tonnes_{DM}$/(ha yr)]: GEZ – Temperate forests: 3.0 to 4.0 • GEZ – Boreal forests: 1.5 to 2.5 • GEZ – Subtropical forests: 0.9 • PE = Primary energy production for every type of forest [MWh/ton_{DM}]: 19.0 to 19.2	• Forest cover [ha]: Corine Land cover (2018) (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018); • Protected areas or other spatial constrains [ha]: Natura2000 areas (2016) (http://ftp.eea.europa.eu/www/natura2000/Natura2000_end2016_Shapefile.zip); • Global ecological zones [ha]: Global ecological zones (2010) (http://www.fao.org/geonetwork/srv/en/main.home?uuid=2fb209d0-fd34-4e5e-a3d8-a13c241eb61b);

Similar correlations for biomass energy from agriculture

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Mapping Thermal RES Potential

Energy source	Algorithms [unit]	Inputs [unit]	External database [unit] to provide default values for algorithms' input
Deep geothermal energy **$H_{tech,heat,x\,km}$** (150m-7km)	$P_{tech,heat,x\,km} = \frac{T_{x\,km} - T_r}{T_{7km} - T_r} P_{tech,heat,7km}$ [W] $H_{tech,heat,x\,km} = P_{theory} \times lifetime$ [J]	• $T_{x\,km}$ = Rocks' temperature at a specific depth [°C]; • $T_{7\,km}$ = Rocks' temperature at 7 km of depth [°C]; • T_r = Temperature of reinjected water [°C]; • *Lifetime*: assumed 8760 hours a year;	• Spatial constrains: EES-Natura200 areas (http://ftp.eea.europa.eu/www/natura2000 /Natura2000_end2016_Shapefile.zip) ; • Technical potential deep geothermal energy: database from https://www.thermogis.nl/en/map-viewer; • https://map.mbfsz.gov.hu/geo_DH/ • $T_{x\,km}$, $T_{7\,km}$ [°C]: database from https://www.thermogis.nl/en/map-viewer.

Similar correlations for shallow geothermal energy

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Mapping Electrical RES Potential

Energy source	Algorithms [unit]	Inputs [unit]	External database [unit] to provide default values for algorithms' input

Photovoltaic energy $E_{pot,ph}$	$E_{pot,ph} = Ir \times Technical\ suitability \times Panel\ Efficiency \times Electrical\ Efficiency \times Available\ Area$
	
	[kWh/yr]
		• Ir =Total solar irradiance under flat plane angle [kWh/m^2]
		• Technical suitability [-]: assumed equal to 40% (1);
		• Panel Efficiency [-]: assumed equal to 30% Invalid source specified.;
		• $Electrical\ Efficiency$ [-]: assumed to be equal to 17%
		• Available area=
		  ○ Footprint of buildings [m²],
		  ○ Other suitable area [m²].
			• Ir [kWh/m^2]: PVGIS database (http://re.jrc.ec.europa.eu/PVGIS5-release.html);
			• Footprint of buildings [m²]: cadaster database or OpenStreetMap (http://www.openstreetmap.org) as an open data alternative;
			• Other suitable area [m²]: Corine Land cover (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018).

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Mapping Electrical RES Potential

Energy source	Algorithms [unit]	Inputs [unit]	External database [unit] to provide default values for algorithms' input
Wind energy at a specific height h E_h	$E_h = 8760\,\eta_m\,\eta_{el}\,\eta_{aux} \sum_{w=w_{low}}^{w_{high}} P_h(w) f(w)$ [kWh/yr] $f(w) = \left(\frac{\beta}{\eta}\right)\left(\frac{w}{\eta}\right)^{\beta-1} e^{-\left(\frac{w}{\eta}\right)^{\beta}}$ [-]	• 8760 yearly operative hours of the aerogenerator [h]; • ρ = air density [kg/m³]; • A = area of the aerogenerator that is orthogonal to wind's direction [m²]; • w = wind speed [m/s]; • C_p = power coefficient [-]; • $f(w)$ = Weibull distribution [-]; • β = shape parameter [-]; • η = scale parameter [-]. • Height at which the wind turbine is placed; • η_m mechanical efficiency of the device [-]; • η_{el} electrical efficiency of the device [-]; • η_{aux} auxiliaries' efficiency [-].	• β and η [-]: CENER database (https://globalwindatlas.info/) • Spatial constrains: EES-Natura200 areas (https://www.eea.europa.eu/data-and-maps/data/natura-9/natura-2000-spatial-data/natura-2000-shapefile-1).

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