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Assessing macro-economic effects of climate impacts on energy demand in EU sub-national regions

Draft Version (Please do not quote)

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Abstract

Energy demand is rising globally and future climatic conditions are likely to change the demands for different energy carriers required for different sectors of the economy. European policy makers are increasingly interested in having a more detailed spatial representation about the future macro-economic impacts coming from these climatic shifts in the energy consumption patterns. In this work we try to meet these policy needs by carrying out a macro-economic assessment of energy demand impacts at the sub-national level for the EU regions. We use the Inter-temporal Computable Equilibrium System (ICES) model, a neoclassical CGE whose regional coverage has been extended to the sub-county NUTS2 and NUTS1 EU regions.

To control for climatic and socio-economic uncertainty we have examined nine RCP-SSP combinations. As inputs for the CGE assessment we have included twelve types of energy demands impacts consisting in three carriers (oil, gas and electricity) times four sectors (agriculture, industry, services and residentials).

Results shows that negative macroeconomic effects may not be negligible in regions located in Southern Europe. By 2070 especially in SSP5-RCP8.5 and SSP3-RCP4.5 these negative effects can be

bigger than 1% of GDP with a peak of -7.5% in Cyprus. The analysis also shows the importance of mitigation policies to reduce the adverse macro-economic effects.

1. Introduction

Energy demand is increasing globally, causing greenhouse gas emissions from the energy sector also to increase. In the EEA countries energy consumption rose by 7.5% between 1990 and 2016 (Eurostat, 2018). The energy sector is also heavily affected by climatic stressors and future climatic conditions are likely to increase demands for energy required for cooling services through a higher number of extreme temperature events, however, demand for heating services might decrease due to the fewer low temperature extremes (De Cian and Wing, 2017; Mideksa and Kallbekken, 2010). Combined with changes in economic growth and the rising population, the mix of fuel in energy demand by various sectors is likely to change as well. It is also important to investigate the future impacts of climate change on energy demand to develop appropriate adaptation and mitigation policies (Damm et al., 2017 and Eskeland and Mideksa, 2010).

Temperature is one of the major drivers of energy demand in Europe, affecting summer cooling and winter heating for households, industry, and service sectors. Higher temperatures are expected to raise electricity demand for cooling, decrease demand for heating, and to reduce electricity production from thermal power plants (Mideksa and Kallbekken, 2010). These responses are largely autonomous and can therefore be considered as an impact or an adaptation. However, cooling is predominantly powered by electricity (which is more expensive), while heating uses a wider mix of energy sources.

The impact of climatic stressors on energy demand have been rather extensively researched (De Cian and Wing, 2017; De Cian et al., 2013; Howell and Rogner, 2014; Schaeffer, 2012; Bazilian et al., 2011). However, sub-national estimates of future climate change on energy demand in Europe is lacking in the existing literature. Kitous and Després (2018) provide aggregated results for EU-28 with a focus on selected regions. The authors find that heating needs decline by 27% by the end of the century but cooling needs increase significantly. According to EC (2018), final energy consumption in the EU is expected to decrease by 26% by 2050, with energy demand declining in the residential, industrial, transport, and the tertiary sectors. However, these results are also at the aggregate level with no spatial disaggregation. Pilli-Sihvola et al. (2010), using an econometric methodology, found that demand for heating will likely decline in Central and Northern Europe due to future warming. However, due to increasing temperature, cooling demand is likely to increase in Southern Europe. Eskeland and Mideksa (2010) estimated a decrease in electricity consumption in the northern European countries but an increase in demand the southern due to increased warming.

European policy makers are increasingly interested in having a more detailed spatial representation about the future macro-economic impacts coming from these climatic shifts in the energy consumption patterns. In this work we try to meet these policy needs by carrying out a macro-economic assessment of energy demand impacts at the sub-national level for the Nomenclature of Territorial Units for Statistics (NUTS) EU regions. For the macro-economic evaluation we start from the Inter-temporal Computable Equilibrium System (ICES) model (Parrado and DeCian, 2014). ICES is a neo-classical Computable General Equilibrium (CGE) model whose regional coverage has been extended to the sub-county NUTS2 and NUTS1 EU regions for this work[1].

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[1] This assessment has been performed in the context of the H2020 European project COACCH (CO-designing the Assessment of Climate CHange costs) - https://www.coacch.eu/

The current literature also provides limited information on the combinations of sectors and fuels with much of the literature focusing on electricity and the residential sector (Schaeffer, 2012). We combine econometric estimates with high-resolution climatic data from Regional Climate Models (RCMs) to estimate the impact of future climate change at the NUTS-2 level in the EU under various warming scenarios. Projections are computed for electricity, petroleum products, and natural gas, in four economic sectors (agriculture, industry, residential, and commercial). This allows us to consider up to twelve fuel/sector combinations which makes the final macro-economic assessment more comprehensive. Moreover, we build nine baselines based on different SSP/RCP combinations. This also enrich substantially the spectrum of possible future scenarios both from a socio-economic and climatic point of view.

The paper develops as follows. Section 2 presents the data and the methodology used to regionalize the Social Accounting Matrices (SAMs) at the sub-country level. Section 3 explains the main elements of the theoretical structure of the CGE model. Section 4 describes the baseline scenarios. Section 5 examines the inputs for the CGE analysis stemming from the econometric analysis and how these inputs have been introduced in the model. Sections 6 shows results and section 7 concludes.

2. Data

We start from the Global Trade Analysis Project (GTAP) 8 database (Narayanan et al., 2012) version 8.1 consisting of a collection of Social Accounting Matrices (SAMs) for 57 sectors covering all the economic system and 134 countries or groups of countries in the world. The reference year is 2007. The EU regional detail has been extended considering 138 territorial units. Starting from the national SAMs of the European Union available in the GTAP data, we use sub-national information from Eurostat (Economic Accounts for Agriculture, 2018; Structural Business Statistics, 2018; Gross value added at basic prices by NUTS 3 regions, 2018) to get a regionalized database at the NUTS2-1 level. For the fishery sector we also used information from the Regional Dependency on Fisheries report (EU, 2007) and for forestry data from the Global Forest model (Di Fulvio et al., 2016).

2.1 Creating and balancing the sub-national EU SAMs

The sub-subnational information is only a preliminary step to obtain the final database. We use the methodology of Bosello and Standardi (2018) to obtain and balance the regionalized SAMs. The methodology is applied in the following steps. In the CGE model, the production side is the sum of value added and intermediate goods. The two are linked by a Leontief technology (perfect complementarity). The value added is the sum of primary factors remuneration (labour, capital, land, natural resources). Therefore, the next step of the process consists in detailing the value added, originally available at the country level in the GTAP database, to the new regional scale. To do this, first, we match the GTAP sectors with those of our data sources. Then, in each sector the regional shares of valued added, labour, capital, land and natural resources are computed from the sub-national data and used to distribute the respective GTAP data across the sub-national units.

One of the most challenging tasks in the database construction is the derivation of the sub-national domestic demand and trade with other regions within and outside the country. This is because these data are often missing and need to be computed using different techniques. The derivation of intra-national trade is particularly important. In this case we rely on the so-called Simple Locations Quotients (SLQs) (Miller and Blair, 1985; Bonfiglio and Chelli, 2008; Bonfiglio, 2008). The formula for the SLQs is the following:

$$\mathrm{SLQ}_{\mathrm{i,r}} = \frac{X_{\mathrm{i,r}}/\mathrm{X}_r}{X_{\mathrm{i,c}}/\mathrm{X}_c} \qquad (1)$$

where i is the sector and X the output, r and c represent the regional and national indexes, respectively. SLQ gives a measure of the regional specialization in the economic activity. When SLQ is equal to zero the region will need to import intermediate and final goods from other regions. In the other extreme case, the sectoral production in the region is equal to the national one and this means that the region will tend to export the good for intermediate or final consumption. Clearly in almost all the cases the SLQ values will be in between the two extreme cases. The sub-country shares of domestic and imported demand will be given by multiplying the national shares times SLQs and then normalizing these shares.

The final step consists in the determination of the bilateral trade flows across sub-national regions. The procedure usually adopted is the so-called gravitational approach as in Horridge and Wittwer (2010) and Dixon et al. (2012). By this method, the bilateral intra-country trade flows are estimated using a gravity equation as in the Newtonian physics. We also follow a gravitational approach based on the kilometric road distance between each couple of capital cities for the regions within the country. We adjust the trade flows across sub-national regions by using the RAS statistical method (Bacharach, 1970) to make them consistent with the aggregate intra-national exports and imports obtained through the SLQs.

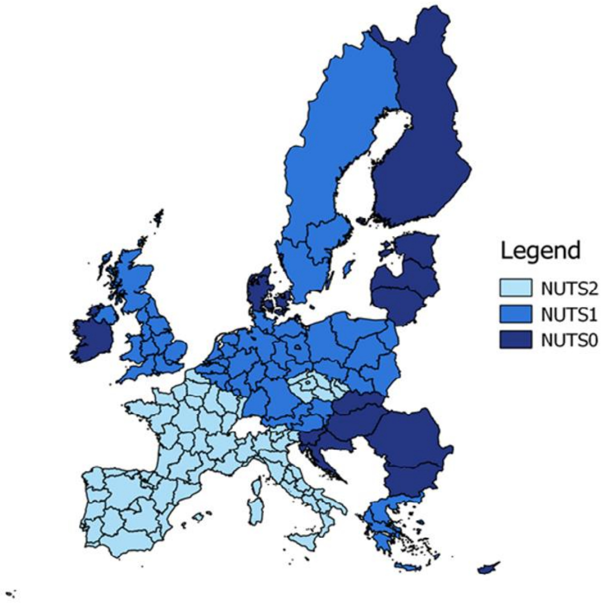
2.2 Splitting the EU electricity sector at the sub-national level

In the construction of the socio-economic scenarios it is important to represent the electricity sector in a more sophisticated way because electricity will develop differently according to the SSP and this will have relevant economic implications for the macro-economic assessment. For example, in SSP 1 we can expect a strong development of the renewables-based power generation sector while in SSP5 fossils fuels will remain important sources also for the electricity sector. Therefore, we decided to increase the detail of the electricity sector at the sub-national level. We use then information from the World Electric Power Plants Database (WEPP) (PLATTS, 2014) to increase the technological detail in the electricity sector at the NUTS-1/2 level. WEPP is a global inventory of electric power generating units managed by the S&P Global. It provides information on more than 107,500 plant sites in more than 230 countries and territories and details on plant operators, geographic location, capacity (MW), age, technology, fuels, and boiler, turbine, and generator manufacturers, emissions control equipment, renewable energy units and more. Using the WEPP information we were able to split the electricity sector in the 7 new sectors: transmission & distribution, nuclear, fossil power generation, wind, hydropower, solar, other renewables.

2.3 Final sectoral and regional details

The final sectoral aggregation is displayed in

Table **1. Final sectoral aggregation**, while **Errore. L'origine riferimento non è stata trovata.** presents the regional aggregation for the EU, and **Errore. L'origine riferimento non è stata trovata.** shows the macro regions representing the rest of the world. The full list of NUTS regions and the mapping between EU regions of the ICES model and NUTS 2013 code is reported in Annex 1.



Country	Number of Regions	NUTS level
Austria	3	NUTS1
Belgium	3	NUTS1
Bulgaria	1	NUTS0
Cyprus	1	NUTS0
Czech Republic	8	NUTS2
Germany	16	NUTS1
Denmark	1	NUTS0
Estonia	1	NUTS0
Spain	17	NUTS2
Finland	1	NUTS0
France	22	NUTS2
Greece	4	NUTS1
Hungary	1	NUTS0
Croatia	1	NUTS0
Ireland	1	NUTS0
Italy	20	NUTS2
Lithuania	1	NUTS0
Luxembourg	1	NUTS0
Latvia	1	NUTS0
Malta	1	NUTS0
Netherlands	4	NUTS1
Poland	6	NUTS1
Portugal	5	NUTS2
Romania	1	NUTS0
Sweden	3	NUTS1
Slovenia	1	NUTS0
Slovakia	1	NUTS0
United Kingdom	12	NUTS1
Total	**138**	

Figure 1: NUTS regions in ICES

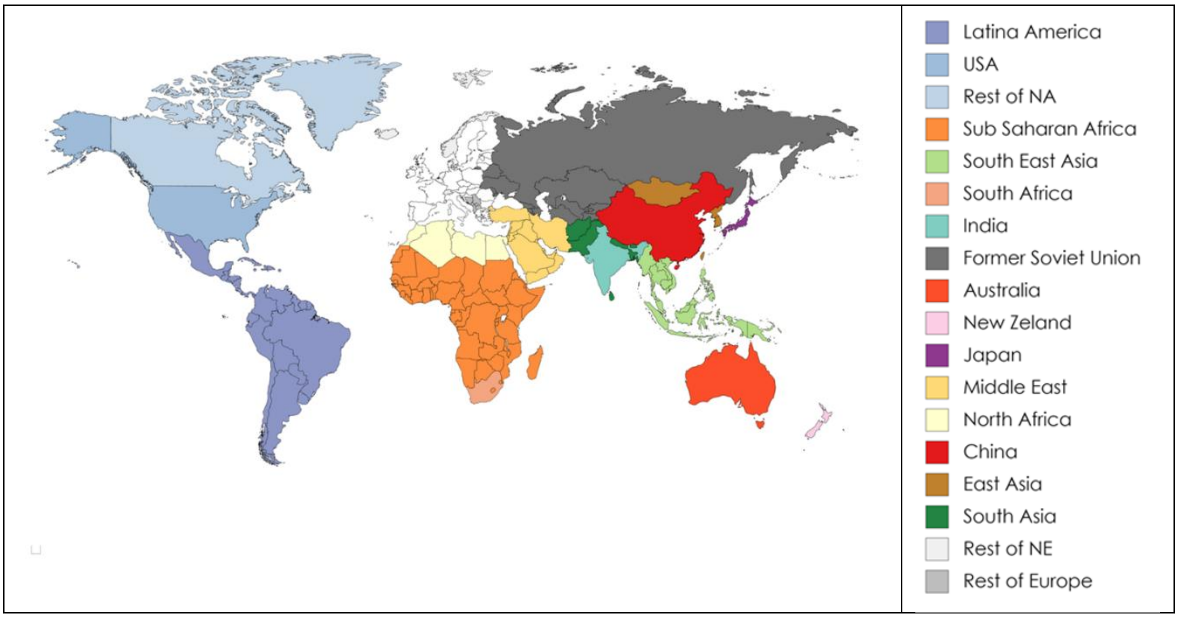


Figure 2: Rest of the world regions

Table 1. Final sectoral aggregation

1	Veg. & Fruits	13	Wind
2	Other Crops	14	Hydropower
3	Livestock	15	Solar
4	Timber	16	Oth. Renewabl.
5	Fishery	17	Heavy industry
6	Coal	18	Construction
7	Oil	19	Light indusry
8	Gas	20	Transport Road
9	Oil Products	21	Transport Water
10	Tr. & Dist.	22	Transport Air
11	Nuclear	23	Services
12	Fossil Power	24	Public Services

3. Model

The theoretical structure of the model is very similar to that one of GTAP-E model (Burniaux and Truong, 2002) but is enriched by the introduction of renewables energy sources at the EU sub-country level. In the next sections we will examine the main elements of the theoretical framework which are important in our analysis.

3.1 Production side: technology nests in ICES

The supply side is mainly based on GTAP-E model which, in turn, extends the GTAP supply structure (Hertel, 1997) to allow for mitigation policy and to take into account Co2 emissions. The GTAP-E supply structure is summarized in Figure 3**: GTAP-E supply structure**. The emission reduction taking place after the introduction of a climate policy can happen through substitution between energy and capital, electricity and non electricity and/or between different fossil fuels.

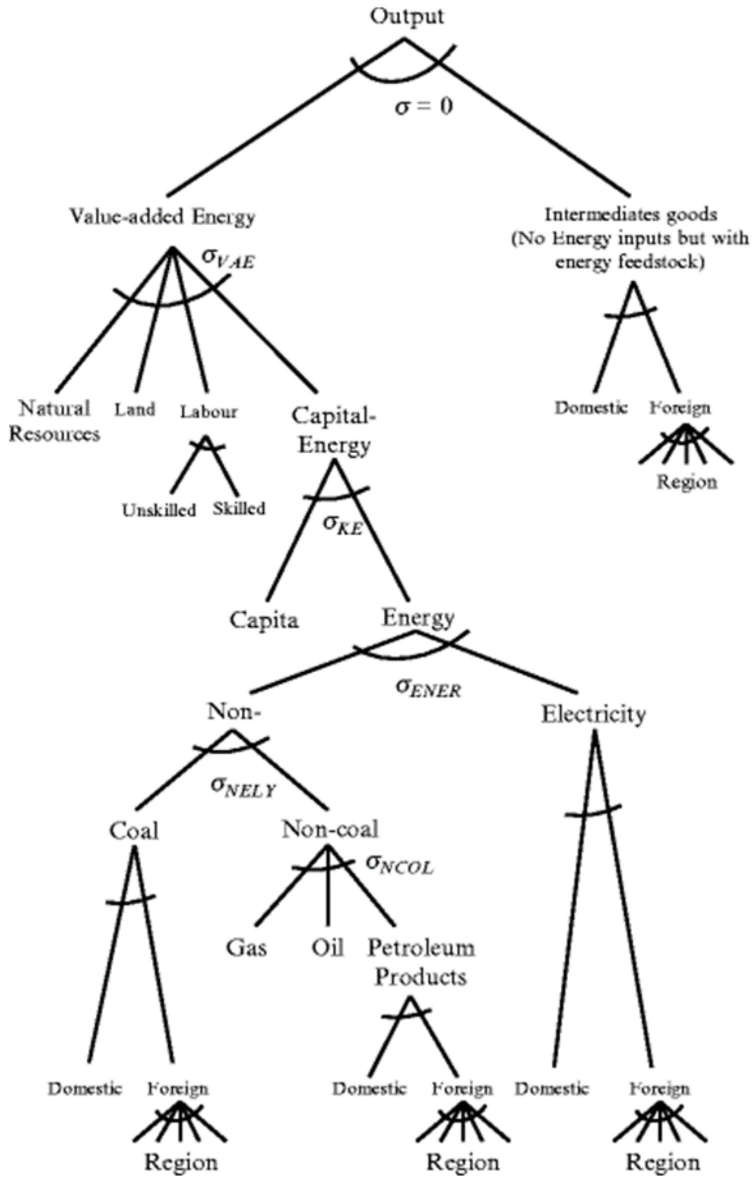


Figure 3: GTAP-E supply structure

In ICES the structure of Figure 3 remains unchanged. However, we further detail the part related to the electricity tree. This is done cconsistently with the database expansion for the power generation sector and create additional opportunities for substitution between clean and polluting technologies within the electricity sector. The tree is summarized in Figure 4.

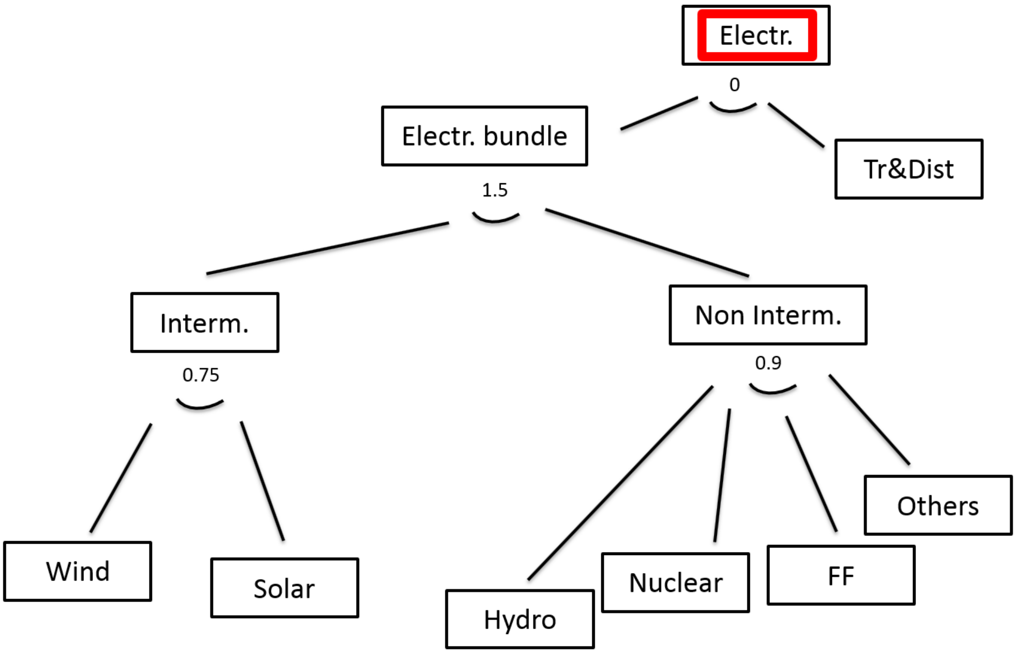


Figure 4: ICES supply structure for the electricity sector

3.2 Demand side: Armington structure in ICES

In the CGE framework the Armington assumption (imperfect substitution between domestic and imported goods) is usually made to model the trade relationships from the demand side. The GTAP model (Hertel, 1997) uses a double nest which first link domestic goods and aggregate imports and then break the aggregate imports according to the different country-source of the product. Essentially, we follow this double nest approach but we employ in the lower nest a Cresh function (Hanoch, 1971; Pant, 2007) which allows for more flexibility in the choice of the bi-lateral substitution for each couple of spatial units. Figure 5 represents our trade structure.
For countries or group of countries we keep the original values of the Armington elasticities in the GTAP database. For sub-country regions we increase the GTAP elasticities by 50%. This modelling choice tries to capture the greater fluidity of trade when sub-national units are involved.

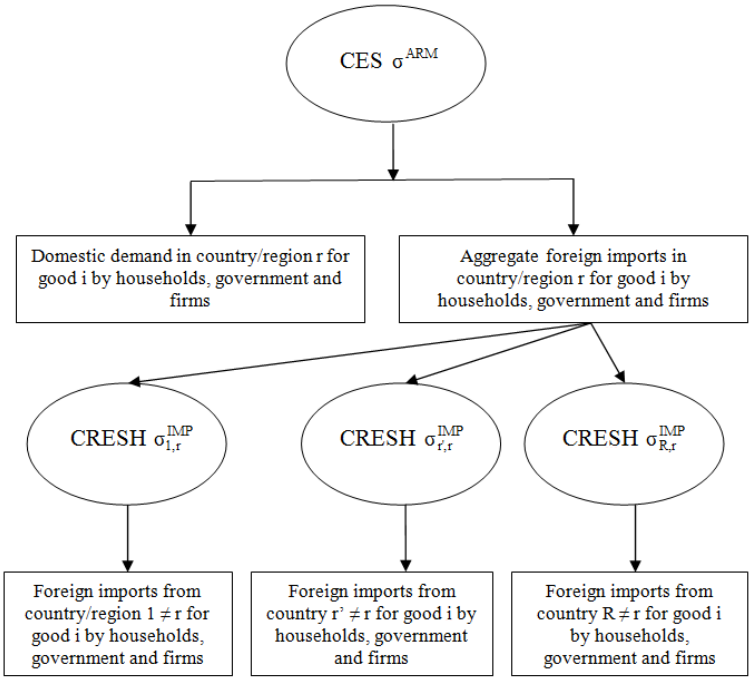


Figure 5: Armignton demand structure in the ICES model

4. Baseline scenarios

To examine a wide spectrum of socio-economic and climatic characteristics, the macroeconomic assessment has been performed using nine baseline scenarios based on combinations of the Representative Concentration Pathways (RCP) and the Shared Socioeconomic Pathways (SSP) which are reported in Table 2. All baselines cover the period 2007-2070 integrating together different socio-economic and climate assumptions, while the impact assessment is run from 2015 to 2070.
The SSPs show different pictures about demographic and economic development, but also sectoral composition, trade openness, technology and energy prices. The socio-economic characteristics, in turn, interact with different emission profiles which are given by the RCPs. Replicating specific social economic storylines (i.e. the SSPs) in combination with chosen emission patterns is not an easy task especially in a model specified at the sub-country level.
We assume that sub-national regions follow the country projections available from the SSP database (https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10). The source for GDP projections is the OECD while for population we use projections from IIASA. The purpose of having different SSPs in the assessment is that of disentangling the role of social economic development in influencing the final impacts of climate change. Accordingly, first we replicate the SSPs in their main social and economic components (GDP and population). Then, we focus on the other socio-economic and technological features implicit in each SSP. For example, trade openness is modelled using Armington elasticities which make the trade more or less fluid depending on the SSP. The

development of renewables especially in SSP1 is driven mainly by the efficiency of wind, solar and hydro power production. The dynamics of fossil fuels prices is consistent with the SSP storylines and is based on the WEO 2018 projections (IEA, 2018). Finally, the global Co2 emissions are calibrated according to each RCP. This is not trivial because GDP targets from OECD do not necessarily match the emission profiles implied by the RCP. For this reason, we use a mix of instruments which help us to replicate the specific SSP-RCP combination. The instruments are substitution parameters (e.g. the elasticity of substitution between capital and energy, the elasticity of substitution between electricity and fossil fuels) and a carbon tax applied as a policy in certain cases. We implement these instruments consistently with the narrative within each SSP and the corresponding RCP. The main features of the calibrated SSPs-RCPs combinations are summarized in Table 2 where the higher the number of asterisks the higher the level of the associated variable.

Table 2. Main modelled features of the scenarios (SSPs-RCPs combinations)

	Fossil fuel prices	Efficiency in clean energy production	Substitutability between electric and non-electric	Trade openness (Armington)	Climate policy (carbon tax)
SSP1-RCP2.6	*	******	****	**	****
SSP1-RCP4.5	*	****	****	**	-
SSP2-RCP2.6	**	*****	****	**	***
SSP2-RCP4.5	**	***	***	**	-
SSP2-RCP6.0	**	**	**	**	-
SSP3-RCP2.6	***	***	**	*	**
SSP3-RCP4.5	***	**	*	*	-
SSP5-RCP4.5	****	**	*	**	*
SSP5-RCP8.5	****	*	*	**	-

5. Impact modelling

Input data for the macro-economic assessment of climate change impacts on energy demand have been computed starting from the econometric estimates of demand to temperature elasticity (De Cian and Sue Wing, 2017). The study determines the elasticity for electricity, petroleum products, and natural gas demand for four different uses (agriculture, industry, services and residential).
Future trends in regional energy demand are obtained combining these elasticities with high-resolution ensemble-mean temperature projections from four Regional Climate Models (RCMs): KNMI RACMO22E, IPSL-CM5A-MR, MPI-ESM-LR, and CNRM-CM5. In the CGE model this translates in implementing 12 different impacts, i.e. the number of energy carriers times the number of economic activities. This has been done for each RCP scenario.
To implement changes in energy demand in the agriculture, industry and services sectors in ICES we acted on the energy efficiency in those sectors. The underlying assumption is that the representative firm is in a better (worse) economic position if climate change will reduce (increase) the energy demand for a given energy input and will satisfy a given amount of energy demand using less (more) energy input. Accordingly, in the CGE we imposed a lower (higher) efficiency in the use of a given

energy input in a given sector if the energy demand coming from the statistical analysis reduces (increases).
A different procedure has been used in the case of the residential sector. In fact, this does not exist in the CGE model. It has been approximated by the representative regional household that is a component of the final demand. Energy demand shifts are obtained imposing exogenous shocks to household energy expenditure while keeping fixed the household budget constraint. This implies a re-adjustment of household consumption across all consumption items.
It is clear that the first kind of shock has a direct impact on production and GDP because it affects the productive capacity of an economic activity while the second type of shock is more re-distributive because the overall spending capacity of the household is not altered.
According to the projections from the econometric estimates the industrial, agricultural, and commercial activities are expected to increase substantively their electricity demand, the industrial sector also natural gas demand, especially in RCP8.5. Increases in electricity demand, along with declines in oil and gas demand are foreseen for the residential sector.
In Table 3 we report the main trends of energy demands coming from the econometric analysis and the application of the regional climate models. These trends are inputs for our CGE model and they depend on a specific RCP. We do not show all the inputs because this risks to be too much cumbersome as we have 4 RCPs, 156 regions and 12 combinations of energy carrier/sector. Therefore, we focus on the extreme RCPs (2.6 and 8.5) and the most significant combination of carrier/sector (gas/industry, electricity/services and oil/services) which can be representative of more general economic and climatic mechanisms[2].
From Table 3 we note that the demand of electricity in the service sector is expected to grow both in RCP 2.6 and 8.5 because of changes in temperature, the most pronounced increases occur in RCP 8.5. On the other hand, the demand of oil in services is expected to decrease in Europe in RCP 2.6 and 8.5, in this case the most pronounced reductions occur in RCP 8.5. These different trends could represent a more general dynamics where cooling energy needs mostly represented by the electricity/services combination increase while the heating needs mostly represented by the oil/ services combination decrease. In the CGE this translates in an augmented energy efficiency in oil/services combination and a reduced energy efficiency in the electricity/services combination because firms will require less and more inputs to satisfy the energy demand.
We notice that impacts for the gas/industry combination are in general very small. However, there are relevant exceptions in some regions of southern Europe (Italy, Spain, Portugal and Greece). Moreover, some EU southern islands such as Malta and Cypurs experience a very strong rise in the gas requirement for the industrial sector. As we will see in the next section, also these trends will be important to understand the macro-economic winner/looser patterns at the geographical level.

[2] We do not report inputs for residential sector because these inputs have mainly a re-allocative effect on the private household's budget constraint. Also, some impacts involving agriculture are very low and not very interesting. RCPs 4.5 and 6.0 are somewhat in between RCPs 2.6 and 8.5.

Table 3. Per cent changes of energy demand over the period 2015-2070 (input for the ICES model)

ICES Region	Gas Ind RCP 2.6	Gas Ind RCP 8.5	Elect Serv RCP 2.6	Elect Serv RCP 8.5	Oil Serv RCP 2.6	Oil Serv RCP 8.5
Australia	4.63	21.22	21.63	49.85	1.14	3.00
New Zeland	0.00	0.00	2.56	6.15	-0.46	-1.23
China	-0.78	-2.14	45.26	123.76	-11.22	-28.31
jpn	-2.31	-5.06	5.32	10.29	-7.56	-13.97
EastAsia	-0.58	-1.45	10.07	31.68	-7.93	-19.95
SouthEastAs	0.58	1.66	4.68	12.35	0.52	1.51
SouthAsia	2.60	7.16	13.17	25.14	2.11	4.29
India	6.91	14.66	50.70	119.19	8.05	14.89
Rest of NA	6.39	13.96	12.94	40.62	-0.31	-0.89
usa	4.88	11.08	14.15	33.48	-1.43	-4.01
Latin America	0.30	0.78	1.16	2.29	0.14	0.40
EastAustria	0.19	0.56	4.53	12.75	-5.95	-19.40
SouthAustria	0.09	0.00	7.38	16.93	-13.86	-25.93
WestAustria	0.09	0.00	4.46	13.80	-7.71	-21.83
Brussels	0.00	0.00	6.02	14.69	-12.01	-23.16
Flanders	0.00	0.00	6.41	15.00	-11.70	-23.56
Wallonia	0.00	0.00	7.67	16.31	-13.79	-25.19
cyp	38.29	324.19	85.14	836.56	-10.52	-33.81
Prague	0.00	0.00	3.23	11.07	-6.23	-18.28
CentBoemia	0.25	0.00	5.10	10.97	-7.95	-18.14
Souwestcze	0.00	0.00	3.87	12.31	-8.96	-20.00
Norwestcze	0.00	0.00	4.36	11.97	-7.70	-19.53
Noreastcze	0.00	0.00	3.26	11.31	-5.57	-18.62
Soueastcze	0.00	0.00	4.65	12.00	-8.28	-19.58
CentMoravia	0.00	0.00	3.50	11.48	-6.82	-18.86
MoraviaSil	0.00	0.00	4.12	11.62	-8.21	-19.05
dnk	0.00	0.00	9.09	16.66	-14.18	-25.63
est	0.00	0.00	7.84	11.55	-10.35	-18.96
fin	0.00	0.00	7.01	15.18	-13.24	-23.66
IleFrance	0.00	0.00	7.18	14.69	-12.99	-23.16
ChamArde	0.00	0.00	4.75	15.72	-10.50	-24.47
Picardie	0.00	0.00	5.22	16.11	-13.80	-24.96
HautNorm	0.00	0.00	9.57	17.01	-12.89	-26.06
Centre	0.00	0.00	7.19	15.82	-14.45	-24.60
BasseNorm	0.00	0.00	9.37	20.33	-13.94	-29.94
Bourgogne	0.00	0.00	8.30	18.46	-16.33	-27.79
NordPCalais	0.00	0.00	8.84	16.43	-14.54	-25.36
Lorraine	0.00	0.00	7.38	16.29	-8.72	-25.18
Alsace	0.00	0.00	5.65	15.97	-13.59	-24.78
FranComte	0.00	0.00	7.72	16.97	-11.65	-26.02
PaysLoire	0.00	0.00	6.44	15.08	-13.08	-23.66
Bretagne	0.00	0.00	10.60	19.48	-13.06	-28.98
PoitouChar	0.00	0.00	6.84	16.61	-14.06	-25.58

ICES Region	Gas Ind RCP 2.6	Gas Ind RCP 8.5	Elect Serv RCP 2.6	Elect Serv RCP 8.5	Oil Serv RCP 2.6	Oil Serv RCP 8.5
Aquitaine	0.00	0.17	11.15	19.28	-13.56	-28.43
MidiPyren	0.29	0.33	7.61	19.60	-14.55	-28.47
Limousin	0.00	0.00	9.08	20.41	-13.19	-30.02
RhoneAlp	0.00	0.00	10.01	18.06	-15.23	-27.32
Auvergne	0.00	0.00	11.26	19.48	-15.94	-28.98
LangRouss	0.00	0.67	9.92	19.97	-11.47	-28.26
Provence	0.00	0.00	7.66	16.93	-13.00	-25.97
Corse	0.00	0.00	7.45	19.34	-13.35	-28.81
BadenWur	0.01	0.00	4.93	14.79	-12.39	-23.27
Bavaria	0.01	0.00	3.95	14.10	-8.36	-22.37
Berlin	0.01	0.00	6.83	10.46	-7.46	-17.41
Branden	0.01	0.00	5.72	14.23	-10.14	-22.57
Bremen	0.01	0.00	5.89	13.49	-11.22	-21.60
Hamburg	0.01	0.00	6.03	13.89	-7.43	-22.12
Hessen	0.01	0.00	5.76	14.79	-9.63	-23.30
MeklenVor	0.01	0.00	5.26	14.61	-12.44	-23.06
LowSaxony	0.01	0.00	6.18	14.66	-12.58	-23.12
NorRenoWes	0.01	0.00	5.10	16.07	-11.08	-24.91
RenoPala	0.01	0.00	3.38	15.54	-11.53	-24.24
Saarland	0.01	0.00	4.36	12.01	-6.55	-19.59
Saxony	0.01	0.00	6.69	12.35	-7.38	-20.05
SaxonyAnh	0.01	0.00	5.62	16.29	-11.74	-25.18
SchHol	0.01	0.00	6.34	13.56	-7.83	-21.69
Turingia	0.01	0.00	6.95	14.08	-11.31	-22.32
Voreia	4.02	56.84	19.64	133.36	-11.76	-25.19
Kentriki	3.17	54.76	25.51	138.83	-12.12	-30.12
Attiki	2.47	167.20	40.28	382.96	-7.70	-31.82
Nisia	2.22	76.27	27.62	204.81	-13.36	-36.68
hun	1.86	6.94	8.31	22.75	-7.71	-19.08
irl	0.00	0.00	11.34	22.32	-15.26	-32.11
Piemonte	0.00	0.00	5.97	14.69	-7.61	-23.16
ValAosta	0.00	0.00	0.00	0.00	0.00	0.00
Lombardia	0.00	4.09	8.17	19.89	-10.16	-21.41
TrentAdige	0.00	0.00	8.08	20.33	-13.80	-29.83
Veneto	2.41	7.98	10.56	24.89	-9.30	-19.81
FriuliGiulia	-0.13	0.17	4.35	14.21	-10.00	-22.20
Liguria	0.00	0.00	6.99	19.59	-11.99	-29.11
EmiRom	1.54	7.98	11.12	28.44	-12.66	-24.02
Toscana	0.00	0.67	4.83	18.03	-9.60	-25.97
Umbria	0.62	2.53	7.90	21.59	-9.04	-26.54
Marche	0.13	0.17	9.37	19.47	-11.61	-28.64
Lazio	2.01	5.84	10.73	27.73	-9.46	-27.23
Abruzzo	0.00	0.00	4.39	18.09	-9.20	-27.36
Molise	0.00	0.00	5.24	18.09	-9.76	-27.36
Campania	0.23	0.50	8.00	21.33	-10.63	-30.11

ICES Region	Gas Ind RCP 2.6	Gas Ind RCP 8.5	Elect Serv RCP 2.6	Elect Serv RCP 8.5	Oil Serv RCP 2.6	Oil Serv RCP 8.5
Puglia	2.62	19.15	14.05	51.79	-14.36	-28.18
Basilicata	0.00	0.00	6.63	19.48	-11.42	-28.98
Calabria	0.00	0.00	7.90	21.82	-9.28	-31.58
Sicilia	1.88	21.36	10.51	57.97	-10.81	-30.11
Sardegna	0.90	1.68	10.29	24.66	-13.77	-31.54
lva	0.00	0.00	3.98	10.94	-8.65	-18.09
ltu	0.00	0.00	3.33	10.70	-6.45	-17.75
lux	0.00	0.00	7.98	16.75	-13.15	-25.75
mlt	4.13	63.87	19.92	161.36	-22.16	-40.43
NorthNether	0.00	0.00	6.08	16.17	-9.68	-25.03
EastNether	0.00	0.00	6.82	14.95	-10.03	-23.49
WestNether	0.00	0.00	7.22	15.43	-9.07	-24.11
SouthNether	0.00	0.00	6.38	14.63	-10.68	-23.09
CentPol	0.01	0.25	6.99	10.08	-10.50	-16.29
SouthPol	0.01	0.00	5.39	10.75	-8.61	-17.82
EastPol	0.01	0.00	6.32	10.99	-13.11	-18.16
NorWestPol	0.01	0.00	7.43	11.78	-8.85	-19.27
SouWestPol	0.01	0.00	2.64	11.24	-7.45	-18.52
NorthPol	0.01	0.00	3.19	12.13	-11.44	-19.75
Norte	0.00	0.00	8.29	24.94	-20.11	-34.82
Algarve	5.24	25.89	20.65	85.56	-17.52	-43.39
Centro	0.00	0.33	9.80	24.14	-13.86	-33.42
Lisboa	0.69	0.84	12.42	33.90	-23.54	-41.65
Alentejo	8.78	28.44	27.53	80.10	-20.66	-36.72
svk	0.00	0.17	3.43	11.71	-7.82	-18.80
svn	0.00	0.00	4.68	14.98	-8.79	-23.52
Galicia	0.00	0.00	12.30	26.64	-18.21	-36.50
Asturias	0.00	0.00	15.31	28.77	-22.79	-38.50
Cantabria	0.00	0.00	14.36	30.00	-20.41	-39.61
PaisVasco	0.00	0.00	14.93	24.40	-20.69	-34.28
Navarra	0.00	0.00	10.98	22.31	-16.46	-32.10
LaRioja	0.00	0.00	13.95	26.45	-15.57	-36.31
Aragon	2.31	6.37	11.07	31.35	-14.14	-30.11
Madrid	5.85	18.75	18.01	51.93	-13.43	-28.94
CastLeon	0.00	0.50	12.55	24.58	-21.48	-33.57
CastMancha	3.20	15.43	14.23	46.69	-13.56	-29.57
Extremadura	20.65	84.79	35.10	191.10	-15.70	-33.10
Cataluna	0.00	0.00	6.42	19.26	-12.35	-28.73
Valencia	0.69	4.43	10.25	34.90	-13.84	-36.80
Balears	0.30	8.34	9.63	43.20	-17.55	-37.80
Andalucia	8.19	38.96	24.25	105.32	-16.41	-31.57
Murcia	2.31	12.02	13.79	46.44	-14.23	-34.82
Canarias	0.00	0.00	0.00	0.00	0.00	0.00
EastSweden	0.00	0.00	7.70	14.88	-12.07	-23.41
SouthSweden	0.00	0.00	7.20	15.26	-13.36	-23.87

ICES Region	Gas Ind RCP 2.6	Gas Ind RCP 8.5	Elect Serv RCP 2.6	Elect Serv RCP 8.5	Oil Serv RCP 2.6	Oil Serv RCP 8.5
NorthSweden	0.00	0.00	9.63	18.35	-13.64	-27.56
NorEastEng	0.00	0.00	8.86	19.98	-17.04	-29.54
NorWestEng	0.00	0.00	9.09	19.07	-15.56	-28.49
YorkHumber	0.00	0.00	9.58	19.39	-20.71	-28.87
EastMidEng	0.00	0.00	11.11	19.05	-16.12	-28.49
WestMidEng	0.00	0.00	8.37	19.72	-18.30	-29.24
EastofEng	0.00	0.00	10.39	17.33	-12.76	-26.45
London	0.00	0.00	7.80	15.81	-14.29	-24.58
SouEastEng	0.00	0.00	12.89	18.32	-19.10	-27.63
SouWestEng	0.00	0.00	10.85	20.40	-16.57	-30.00
Wales	0.00	0.00	8.93	20.91	-14.54	-30.57
Scotland	0.00	0.00	6.20	18.34	-12.39	-27.58
NorthIre	0.00	0.00	8.09	20.63	-13.75	-30.27
RoNoEu	0.00	0.00	5.28	11.23	-0.30	-0.68
RoEu	-0.19	-0.42	3.96	7.59	-1.93	-3.71
bgr	2.16	18.78	9.95	48.07	-8.45	-23.63
hrv	0.22	2.40	6.20	17.47	-10.15	-21.79
rou	5.32	27.89	12.63	61.38	-7.38	-20.80
Former Soviet	0.02	0.05	3.34	7.10	-1.63	-3.19
MiddleEast	0.75	2.14	4.19	8.16	0.40	1.20
NorthAfrica	1.39	2.99	8.95	21.72	-0.89	-2.25
SSA	1.11	2.56	2.50	6.88	0.46	1.39
South Africa	3.31	8.65	27.21	71.96	-7.38	-15.31

6. Simulation results

GDP consequences of climate induced shifts on energy demand in Europe may not be negligible. These effects, induced primarily by cooling needs, represent an increase in the production costs for firms particularly felt in Southern European regions (Spain, Italy Greece, Portugal) but also in Romania, Bulgaria and Croatia (Figure 6). By 2070 especially in SSP5-RCP 8.5 and SSP3-RCP4.5 these cost increases could induce macroeconomic losses larger than the 1% of GDP in many southern EU regions with a peak of -7.5% in Cyprus (Figure 7)[3]. Cyprus seems particularly vulnerable with possible losses in the order of 1.8% of GDP already in 2030 in RCP8.5 (Figure 7).
By moving form RCP 2.6 to RCP 8.5 and from SSP1 to SSP5, following all the SSP-RCP combinations in Figure 6, we can understand that mitigation is really key to reduce the negative macro-economic effects of energy demand impacts. Moreover, even if energy climate impacts are essentially linked to a specific RCP, they interact with the socio-economic dimension represented by the SSP. We can appreciate this by examining Figure 6 and Figure 8 where the combination SSP3-RCP4.5 shows the most negative performance on average together with SSP5-RCP8.5. This could depend on the fact the SSP3 is characterized by a smaller degree of trade fluidity which makes harder the substitution

[3] In Figure 7 and 8 the following abbreviations have been adopted for the SSP-RCP combinations: SSP1-RCP2.6 (s1r26), SSP1-RCP4.5 (s1r45), SSP2-RCP2.6 (s2r26), SSP2-RCP4.5 (s2r45), SSP2-RCP6.0 (s2r60), SSP3-RCP2.6 (s3r26), SSP3-RCP4.5 (s3r45), SSP5-RCP4.5 (s5r45), SSP5-RCP8.5 (s5r85).

of energy inputs through the export/import mechanisms. Therefore, SSP3-RCP4.5 shows worse economic outcomes than other scenario combinations in which the climate signal is stronger such as SSP2-RCP 6.0.
The sub-national CGE detail is also worthy in our experiment because we can observe heterogenous macro-economic effects within countries.

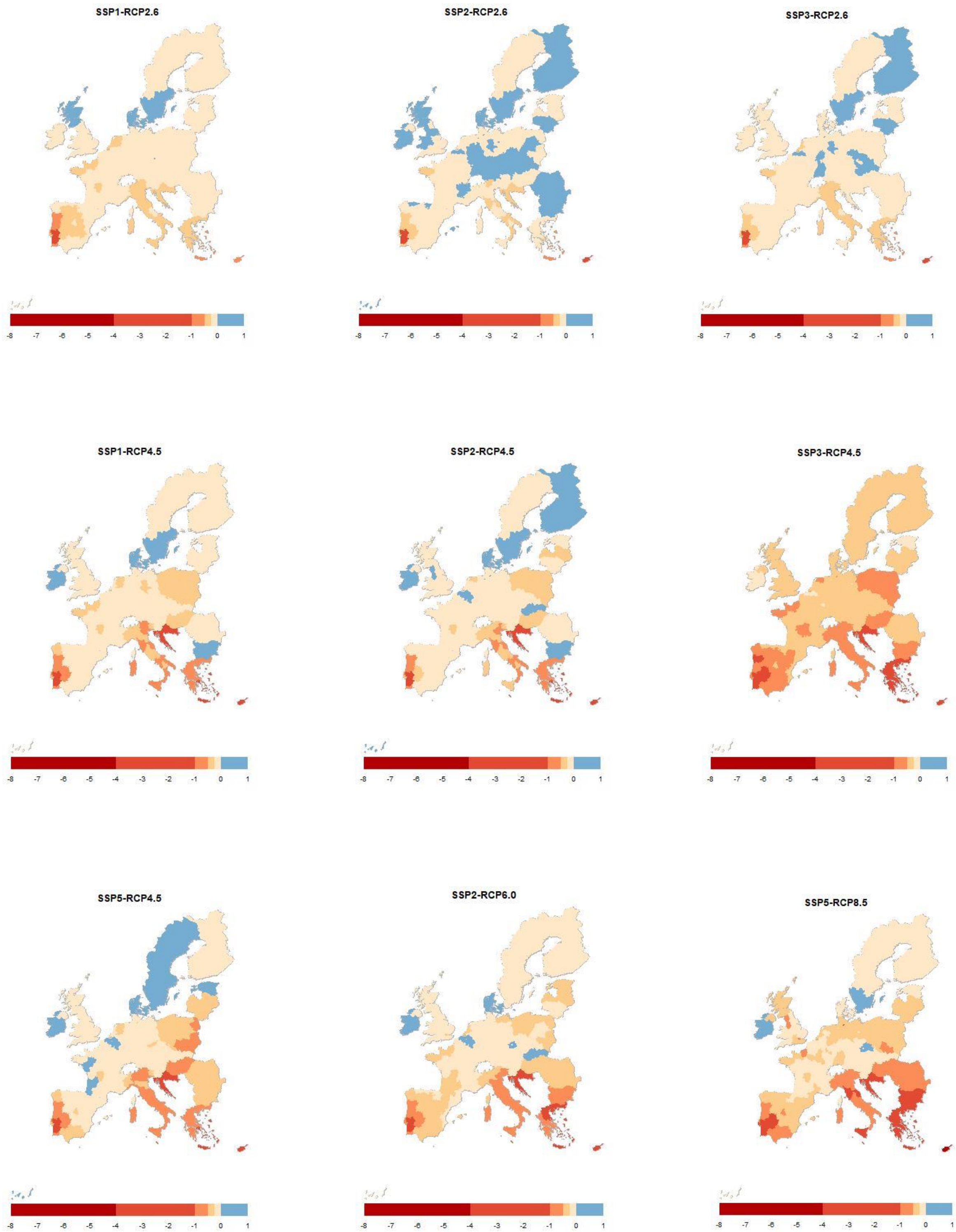


Figure 6. Climate change impacts on energy demand in the EU: GDP effects by region and scenario combination for year 2070. Values in percentage changes from the baseline

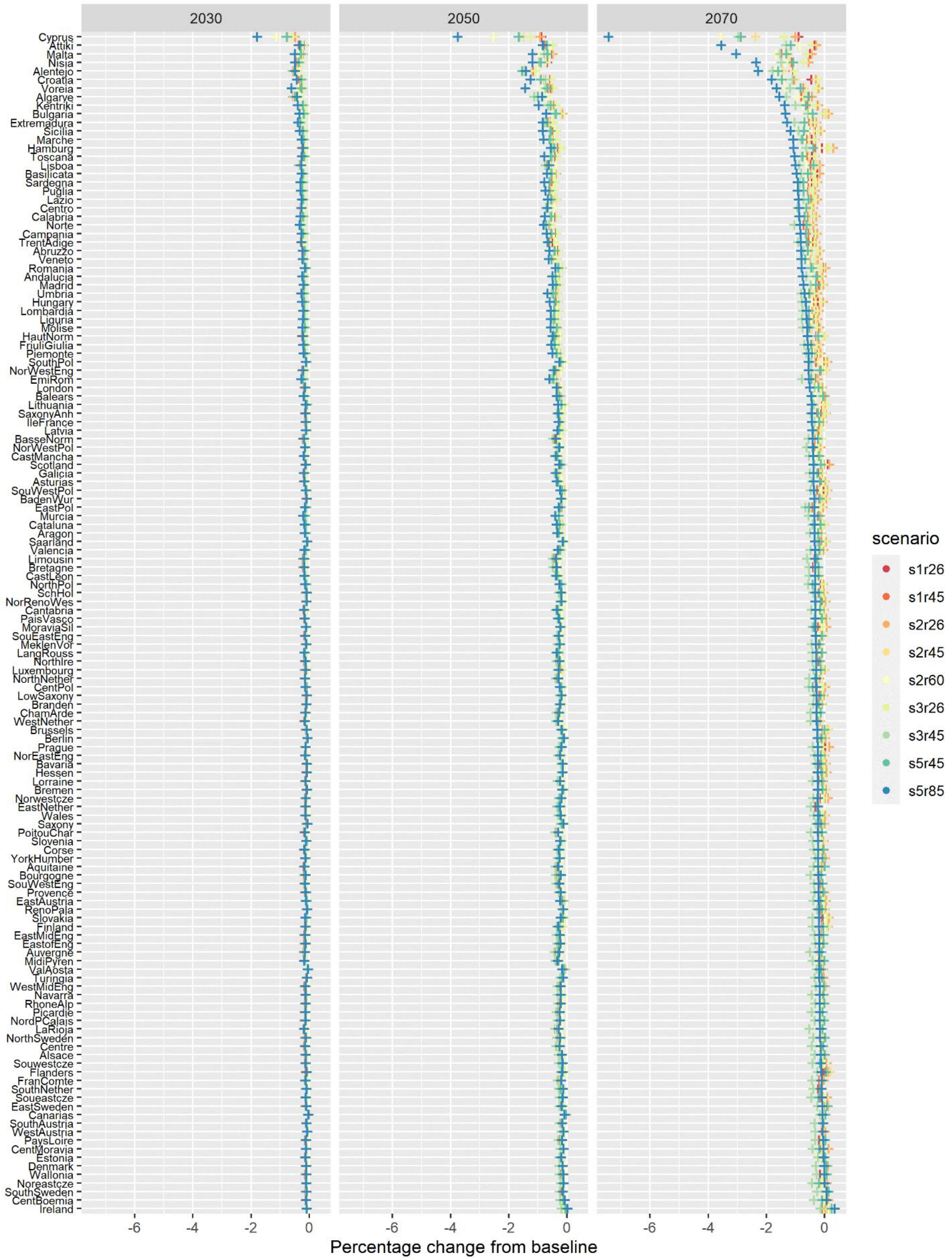


Figure 7. Climate change impacts on energy demand: GDP effects by region and scenario combination in years 2030, 2050 and 2070. Values in percentage change from the baseline

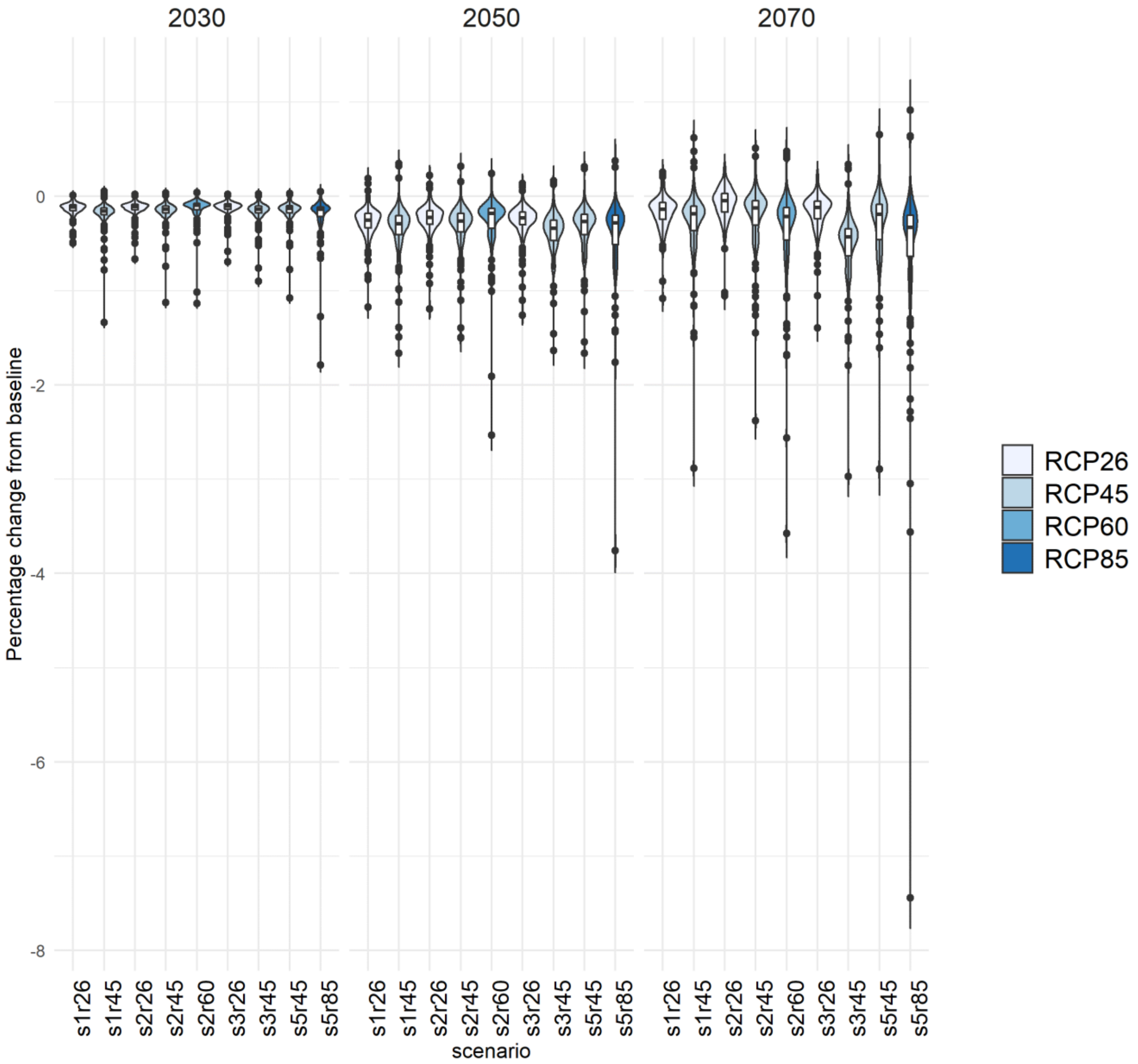


Figure 8. Climate change impacts on energy demand: distribution of GDP effects across all regions of the ICES model by year and scenario combinations. Values are percentage changes respect to the baseline

7. Conclusions

In this study we have analyzed the macro-economic effects in the EU sub-national regions following changes in energy demand due to climate change. To control for climatic and socio-economic uncertainty we have examined a wide spectrum of RCP and SSP combinations from SSP1-RCP2.6 to SSP5-RCP8.5, overall nine combinations. As inputs for the CGE assessment we have included twelve types of energy demands impacts consisting in three carriers (oil, gas and electricity) times four sectors (agriculture, industry, services and residentials).
Results shows that negative macroeconomic effects may not be negligible in regions located in Southern Europe. By 2070 especially in SSP5-RCP8.5 and SSP3-RCP4.5 these negative effects can be bigger than 1% of GDP with a peak of -7.5% in Cyprus. The analysis also shows the importance of mitigation policies to reduce the adverse macro-economic effects.
Even if the energy demand impact coming from the econometric estimation is essentially linked to a specific RCP, the socio-economic dimension is also important. For example, the combination SSP3-RCP4.5 shows worse economic outcomes than other scenario combinations in which the climate signal is stronger such as SSP2-RCP 6.0.
As a policy implication, it is important that Southern European countries immediately start to invest in more efficient cooling technologies and implement appropriate climate policy to reduce greenhouse gas emissions which can contribute to exacerbate the negative climate signal on the cooling needs in the coming decades.

References

Bacharach, M. (1970). Biproportional Matrices & Input-Output Change. Number 16 in University of Cambridge Department of Applied Economics Monographs. Cambridge University Press.

Bazilian, M. et al. (2011). "Considering the energy, water and food nexus: towards an integrated modeling approach". Energy Policy 39 (12):7896–7906, https://doi.org/10.1016/j.enpol.2011.09.039.

Bonfiglio, A. (2008). Evaluating Implications of Agricultural Policies in a Rural Region through a CGE Analysis, No 328, Working Papers, Universita' Politecnica delle Marche, Dipartimento di Scienze Economiche e Sociali.

Bonfiglio, A. & Chelli, F. (2008). Assessing the Behaviour of Non-Survey Methods for Constructing Regional Input-Output Tables through a Monte Carlo Simulation. Economic Systems Research, 20(3):243-258.

Bosello, F., Standardi, G. (2018). A Sub-national CGE Model for the European Mediterranean Countries, in F. Perali and P. L. Scandizzo (eds.), The New Generation of Computable General Equilibrium Models, Springer International.

Burniaux J.-M., Truong T. P. (2002). GTAP-E: An energy environmental version of the GTAP model. GTAP Technical Paper n. 16.

Damm, A., Köberl, J., Prettenthaler, F., Rogler, N., and Töglhofer, C. (2017). "Impacts of +2°C Global Warming on Electricity Demand in Europe", Climate Services, 7, 12–30; https://doi.org/10.1016/j.cliser.2016.07.001.

De Cian, E., Lanzi, E., Roson, R. (2013). "Seasonal temperature variations and energy demand". Climatic Change, 116, 805–825. http://dx.doi.org/10.1007/s10584-012-0514-5.

De Cian, E. and Sue Wing, I.(2017). Global energy consumption in a warming climate. Environ Resource Econ. 1–46. https://doi.org/10.1007/s10640-017-0198-4.

Di Fulvio, F., Forsell, N., Lindroos, O., Korosuo, A., Gusti, M. (2016) Spatially explicit assessment of roundwood and logging residues availability and costs for the EU28, Scandinavian Journal of Forest Research, 31:7, 691-707, DOI: 10.1080/02827581.2016.1221128.

Dixon, P., Rimmer, M., Wittwer, G. (2012). USAGE-R51, a State-level Multi-regional CGE Model of the US Economy: Presented at the 15th Annual Conference on Global Economic Analysis, Geneva, Switzerland.

Eskeland, G. S., Mideksa, T.K. (2010). "Electricity demand in a changing climate". Mitigation Adaptation Strategies Global Change, 15, 877–897. http://dx.doi.org/10.1007/s11027-010-9246-x.

European Commission (2018). In-depth analysis in support of the commission communication com:(2018) 773.

Eurostat (2018). Eurostat Database on Energy Statistics. Available: https://ec.europa.eu/eurostat/web/energy/data. [Accessed September 2019].

EU. Policy Department Structural and Cohesion Policies. (2007) Regional Dependency on Fisheries

Eurostat (2018). Gross value added at basic prices by NUTS 3 regions. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_10r_3gva&lang=en

Eurostat. Economic Accounts for Agriculture (2018). http://appsso.eurostat.ec.europa.eu/nui/show.do

Eurostat. Structural business statistics (2018). http://ec.europa.eu/eurostat/web/structural-business-statistics/data/database

Hanoch, G. (1971). CRESH production functions. Econometrica, 39: 695-712.

Hertel, T.W. (1997). Global Trade Analysis: Modeling and Applications, Cambridge: Cambridge University Press.

Howell M., Rogner H.H. (2014). "Assessing integrated systems". Nature Climate Change, 4 (4), pp. 246-247, https://doi.org/10.1038/nclimate2180.

Horridge, M., Wittwer, G. (2010). Bringing Regional Detail to a CGE Model Using CENSUS Data. Spatial Economic Analysis, 5(2), 229-255.

Kitous A., Després J., Assessment of the impact of climate change on residential energy demand for heating and cooling, EUR 29084 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-77861-2, https://doi.org/10.2760/96778, JRC108692.

IEA (2018), World Energy Outlook 2018, IEA, Paris, https://doi.org/10.1787/weo-2018-en.

Mideksa, T.K. and Kalbekken, S. (2010). "The impact of climate change on the electricity market: A review", Energy Policy, 38(7); https://doi.org/10.1016/j.enpol.2010.02.035.

Miller, R. E. & Blair, P.D. (1985). Input-Output Analysis: foundations and extensions (Prentice-Hall, Inc., Englewood Cliffs, New Jersey).

Narayanan, B., Aguiar, A. & McDougall, R. (2012). Global Trade, Assistance, and Production: The GTAP 8 Data Base. Center for Global Trade Analysis, Purdue University.

Pant, H. (2007). GTEM: Global Trade and Environment Model. ABARE Technical Report. Canberra: Australian Bureau of Agricultural and Resource Economics and Sciences.

Parrado R., De Cian E. (2014). Technology spillovers embodied in international trade: Intertemporal, regional and sectoral effects in a global CGE framework, Energy Economics, 41(2014): 76-89.

Pilli-Sihvola, K., Aatola, P., Ollikainen, M., Tuomenvirta, H. (2010). "Climate change and electricity consumption—Witnessing increasing or decreasing use and costs?" Energy Policy, 38, 2409–2419. http://dx.doi.org/10.1016/j.enpol.2009.12.033.

Platts (2014). UDI World Electric Power Plants Data Base (WEPP), Washington, DC.

Schaeffer, R. (2012). "Energy sector vulnerability to climate change: a review". Energy 38:1–12.

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Annex 1: mapping of EU regions and NUTS 2013 EU code

No.	**ICES EU regions**	**NUTS-Level (from level 0 country to level 2)**	**NUTS 2013 code**	**Country**
1	EastAustria	NUTS-1	AT1	Aut
2	SouthAustria	NUTS-1	AT2	Aut
3	WestAustria	NUTS-1	AT3	Aut
4	Brussels	NUTS-1	BE1	Bel
5	Flanders	NUTS-1	BE2	Bel
6	Wallonia	NUTS-1	BE3	Bel
7	cyp	NUTS-0	CY	Cyp
8	Prague	NUTS-2	CZ01	Cze
9	CentBoemia	NUTS-2	CZ02	Cze
10	Souwestcze	NUTS-2	CZ03	Cze
11	Norwestcze	NUTS-2	CZ04	Cze
12	Noreastcze	NUTS-2	CZ05	Cze
13	Soueastcze	NUTS-2	CZ06	Cze
14	CentMoravia	NUTS-2	CZ07	Cze
15	MoraviaSil	NUTS-2	CZ08	Cze
16	dnk	NUTS-0	DK	Dnk
17	est	NUTS-0	EE	Est
18	fin	NUTS-0	FI	Fin
19	IleFrance	NUTS-2	FR10	Fra
20	ChamArde	NUTS-2	FR21	Fra
21	Picardie	NUTS-2	FR22	Fra
22	HautNorm	NUTS-2	FR23	Fra
23	Centre	NUTS-2	FR24	Fra
24	BasseNorm	NUTS-2	FR25	Fra
25	Bourgogne	NUTS-2	FR26	Fra
26	NordPCalais	NUTS-2	FR30	Fra
27	Lorraine	NUTS-2	FR41	Fra
28	Alsace	NUTS-2	FR42	Fra
29	FranComte	NUTS-2	FR43	Fra
30	PaysLoire	NUTS-2	FR51	Fra
31	Bretagne	NUTS-2	FR52	Fra
32	PoitouChar	NUTS-2	FR53	Fra
33	Aquitaine	NUTS-2	FR61	Fra
34	MidiPyren	NUTS-2	FR62	Fra
35	Limousin	NUTS-2	FR63	Fra
36	RhoneAlp	NUTS-2	FR71	Fra
37	Auvergne	NUTS-2	FR72	Fra
38	LangRouss	NUTS-2	FR81	Fra
39	Provence	NUTS-2	FR82	Fra
40	Corse	NUTS-2	FR83	Fra
41	BadenWur	NUTS-2	DE1	Deu
42	Bavaria	NUTS-2	DE2	Deu
43	Berlin	NUTS-2	DE3	Deu
44	Branden	NUTS-2	DE4	Deu
45	Bremen	NUTS-2	DE5	Deu
46	Hamburg	NUTS-2	DE6	Deu
47	Hessen	NUTS-2	DE7	Deu
48	MeklenVor	NUTS-2	DE8	Deu
49	LowSaxony	NUTS-2	DE9	Deu
50	NorRenoWes	NUTS-2	DEA	Deu
51	RenoPala	NUTS-2	DEB	Deu
52	Saarland	NUTS-2	DEC	Deu
53	Saxony	NUTS-2	DED	Deu
54	SaxonyAnh	NUTS-2	DEE	Deu
55	SchHol	NUTS-2	DEF	Deu

No.	ICES EU regions	NUTS-Level (from level 0 country to level 2)	NUTS 2013 code	Country
56	Turingia	NUTS-2	DEG	Deu
57	Voreia	NUTS-1	EL5	Grc
58	Kentriki	NUTS-1	EL6	Grc
59	Attiki	NUTS-1	EL3	Grc
60	Nisia	NUTS-1	EL4	Grc
61	hun	NUTS-0	HU	Hun
62	irl	NUTS-0	IE	Irl
63	Piemonte	NUTS-2	ITC1	Ita
64	ValAosta	NUTS-2	ITC2	Ita
65	Lombardia	NUTS-2	ITC4	Ita
66	TrentAdige*	NUTS-2	ITH1-ITH2	Ita
67	Veneto	NUTS-2	ITH3	Ita
68	FriuliGiulia	NUTS-2	ITH4	Ita
69	Liguria	NUTS-2	ITC3	Ita
70	EmiRom	NUTS-2	ITH5	Ita
71	Toscana	NUTS-2	ITI1	Ita
72	Umbria	NUTS-2	ITI2	Ita
73	Marche	NUTS-2	ITI3	Ita
74	Lazio	NUTS-2	ITI4	Ita
75	Abruzzo	NUTS-2	ITF1	Ita
76	Molise	NUTS-2	ITF2	Ita
77	Campania	NUTS-2	ITF3	Ita
78	Puglia	NUTS-2	ITF4	Ita
79	Basilicata	NUTS-2	ITF5	Ita
80	Calabria	NUTS-2	ITF6	Ita
81	Sicilia	NUTS-2	ITG1	Ita
82	Sardegna	NUTS-2	ITG2	Ita
83	lva	NUTS-0	LV	Lva
84	ltu	NUTS-0	LT	Ltu
85	lux	NUTS-0	LU	Lux
86	mlt	NUTS-0	MT	Mlt
87	NorthNether	NUTS-1	NL1	Nld
88	EastNether	NUTS-1	NL2	Nld
89	WestNether	NUTS-1	NL3	Nld
90	SouthNether	NUTS-1	NL4	Nld
91	CentPol	NUTS-1	PL1	Pol
92	SouthPol	NUTS-1	PL2	Pol
93	EastPol	NUTS-1	PL3	Pol
94	NorWestPol	NUTS-1	PL4	Pol
95	SouWestPol	NUTS-1	PL5	Pol
96	NorthPol	NUTS-1	PL6	Pol
97	Norte	NUTS-2	PT11	Prt
98	Algarve	NUTS-2	PT15	Prt
99	Centro	NUTS-2	PT16	Prt
100	Lisboa	NUTS-2	PT17	Prt
101	Alentejo	NUTS-2	PT18	Prt
102	svk	NUTS-0	SK	Svk
103	svn	NUTS-0	SI	Svn
104	Galicia	NUTS-2	ES11	Esp
105	Asturias	NUTS-2	ES12	Esp
106	Cantabria	NUTS-2	ES13	Esp
107	PaisVasco	NUTS-2	ES21	Esp
108	Navarra	NUTS-2	ES22	Esp
109	LaRioja	NUTS-2	ES23	Esp
110	Aragon	NUTS-2	ES24	Esp
111	Madrid	NUTS-2	ES30	Esp
112	CastLeon	NUTS-2	ES41	Esp
113	CastMancha	NUTS-2	ES42	Esp
114	Extremadura	NUTS-2	ES43	Esp
115	Cataluna	NUTS-2	ES51	Esp

No.	**ICES EU regions**	**NUTS-Level (from level 0 country to level 2)**	**NUTS 2013 code**	**Country**
116	Valencia	NUTS-2	ES52	Esp
117	Balears	NUTS-2	ES53	Esp
118	Andalucia**	NUTS-2	ES61-ES63-ES64	Esp
119	Murcia	NUTS-2	ES62	Esp
120	Canarias	NUTS-2	ES70	Esp
121	EastSweden	NUTS-1	SE1	Swe
122	SouthSweden	NUTS-1	SE2	Swe
123	NorthSweden	NUTS-1	SE3	Swe
124	NorEastEng	NUTS-1	UKC	Gbr
125	NorWestEng	NUTS-1	UKD	Gbr
126	YorkHumber	NUTS-1	UKE	Gbr
127	EastMidEng	NUTS-1	UKF	Gbr
128	WestMidEng	NUTS-1	UKG	Gbr
129	EastofEng	NUTS-1	UKH	Gbr
130	London	NUTS-1	UKI	Gbr
131	SouEastEng	NUTS-1	UKJ	Gbr
132	SouWestEng	NUTS-1	UKK	Gbr
133	Wales	NUTS-1	UKL	Gbr
134	Scotland	NUTS-1	UKM	Gbr
135	NorthIre	NUTS-1	UKN	Gbr
136	bgr	NUTS-0	BG	Bgr
137	hrv	NUTS-0	HR	Hrv
138	rou	NUTS-0	RO	Rou

* It includes two Italian Nuts-2 regions: Provincia Autonoma di Bolzano (ITH1) and Provincia Autonoma di Trento (ITH2).
** It includes three Nuts-2 Spanish regions: Andalucia (ES61), Ceuta (ES63) and Melilla (ES64).