FLORENCE SCHOOL OF REGULATION

ROBERT SCHUMAN CENTRE

POLICY BRIEF

Financing energy system integration in Europe: The state of play and future prospects

Highlights

- Energy system integration (ESI) is the process of coordinating the planning and operation of the energy system as a whole, addressing different sectors, their markets and infrastructure as interconnected and complementary pillars.
- In a transition to a decarbonised and decentralised energy mix characterised by predominantly variable renewable energy sources, ESI is key to minimising cost and maximising efficiency.
- The European Union (EU) has indicated its strong support for ESI through the European Energy System Integration Strategy. However, since its publication in July 2020 there has been no announcement of a dedicated ESI fund or any concrete plans to finance it.
- To date, current non-specific financing mechanisms have provided relatively little support for ESI in the EU. A new approach is required to leverage the benefits of ESI and align it with the level of support in other areas of the energy transition.
- A dedicated ESI fund should be created at the EU level utilising an approach similar to that of the Connecting Europe Facility (CEF) and Projects of Common Interest (PCIs).

Issue 2021/43
September 2021

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1 The views expressed here do not represent the official view of the European Court of Auditors.

Introduction

The process of energy system integration (ESI) is one of coordinated planning and operation of the energy system as a whole linking different sectors, markets and infrastructure. The concept has recently emerged as a paradigm shift in how we look at the energy sector, which has traditionally followed the value chains of single commodities (electricity, oil, gas, coal etc.). The change in approach is necessitated by technological evolution from fossil-fuel dominated highly centralised production to more decentralised renewable sources with interdependencies and variable operating conditions.

ESI is a key component of the energy transition as it can reduce the time and financial investment required to achieve decarbonisation compared to separately planning for each sub-sector.[1] As the EU's Energy System Integration Strategy acknowledges,[2] ESI will be needed to achieve deep decarbonisation of the European economy in line with the bloc's climate ambitions and obligations.[3]

Nevertheless, despite the financial advantages and the political mandate there remains little dedicated support for relevant technologies and infrastructure at the EU level compared to other aspects of the energy transition such as renewable energy production.[4] This policy brief highlights the gap between ESI political ambitions at the EU level and the allocation of dedicated funds to support these ambitions. The analysis covers existing financing sources and then proposes an alternative approach to better support ESI building on established and proven structures in other areas.

1.The current approach to ESI in the EU

1.1 EU Energy Sector Integration Strategy

The EU strategy for ESI builds on 6 action lines:

1. Applying the 'energy efficiency first' principle.[5]
2. Accelerating the electrification of energy demand.
3. Promoting renewable fuels, including decarbonised hydrogen (H_2), for hard-to-abate sectors.
4. Making energy markets fit for decarbonisation through alignment of taxation.
5. Planning and financing more integrated energy infrastructure.
6. Promoting the digitalisation and interoperability of the energy system.

The ESI strategy is a first step towards establishing a framework to support sector coupling. However, it arguably lacks the requisite definition and quantification of financing needs and sources to implement its ambitions. As a result, the majority of network innovation projects involve 'ESI-enabling' technologies such as storage and smart grids rather than ESI-specific technologies like power-to-X (P2X) and X-to-power (X2P).[6] Figure 1 provides an ESI perspective on some of the main energy transformation processes leading to the supply of final energy demand, illustrating how P2X and X2P work in practice.

1 Van Nuffel, "Sector coupling: how can it be enhanced in the EU to foster grid stability and decarbonize?" Study requested by the ITRE committee of the European Parliament, 2018; Cambini, Congiu, Jamasb, Llorca and Soroush, "Energy System Integration: Implications for public policy," Energy Policy 143 (2020) 111609.

2 European Commission, "Powering a climate-neutral economy: An EU Strategy for Energy System Integration," COM (2020) 299 final.

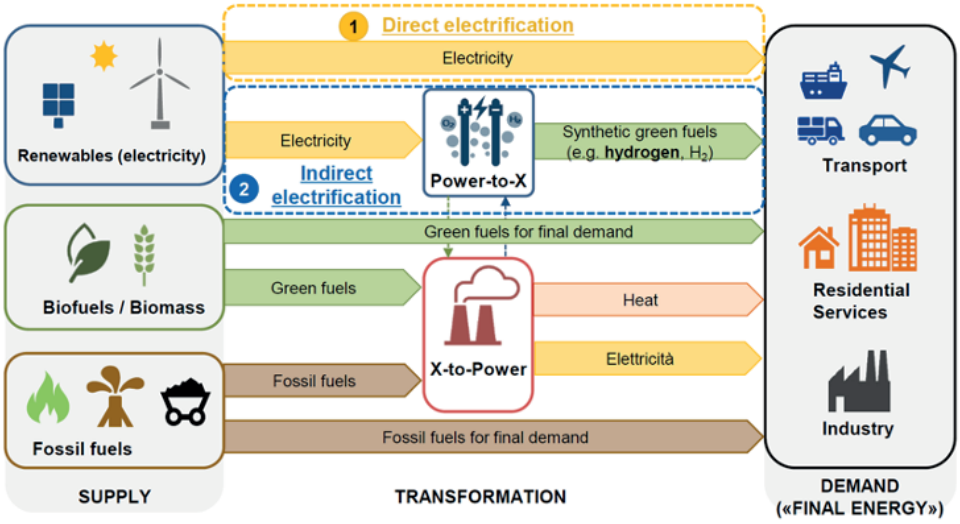
3 https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement , https://sdgs.un.org/2030agenda , https://ec.europa.eu/clima/policies/eu-climate-action/law_en

4 Bauman et al., "Economic potential of power-to-gas energy storages," 10th International Conference on the European Energy Market, 2013; Budny et al., "Economic feasibility of pipe storage and underground reservoir storage options for power-to-gas load balancing," 2015; Lambert, "Power-to-Gas: Linking Electricity and Gas in a Decarbonising World?" Oxford Energy Insight 39 (2018); Cambini, Congiu and Soroush, "Regulation, Innovation and Systems Integration: Evidence from the EU," Energies, 2020, 13.

5 According to Regulation (EU) 2018/1999, the energy efficiency first principle means "…to consider, before taking energy planning, policy and investment decisions, whether cost-efficient, technically, economically and environmentally sound alternative energy efficiency measures could replace in whole or in part the envisaged planning, policy and investment measures, whilst still achieving the objectives of the respective decisions."

6 Cambini, Congiu and Soroush, "Regulation, Innovation and Systems Integration: Evidence from the EU," Energies, 2020, 13; Van Nuffel, "Sector coupling: how can it be enhanced in the EU to foster grid stability and decarbonise," Study requested by the ITRE Committee of the European Parliament, 2018.

Figure 1: Schematic overview of direct electrification versus P2X and X2P (Genoese, 2020).



1.2 Existing funding mechanisms

Horizon 2020 is one of the EU's key innovation funds. In this initiative, the European Commission granted €152 million across 24 projects in the 'A single, smart European electricity grid' category.[7] These projects deal specifically with ESI and aim to develop and demonstrate innovative technologies to increase the share of renewables and their overall operating efficiency in the wider network. More broadly, Horizon 2020 has contributed €2.8 billion of funding across 399 projects dealing in some way with ESI[8] and €9 billion across 2152 projects dealing indirectly with ESI (see Figure 2 below).

Although Horizon 2020 has provided projects with a loose focus on ESI with considerable funding, there is relatively little financing of ESI-specific technologies.[9] This is emblematic of a wider trend in investment patterns in this area.

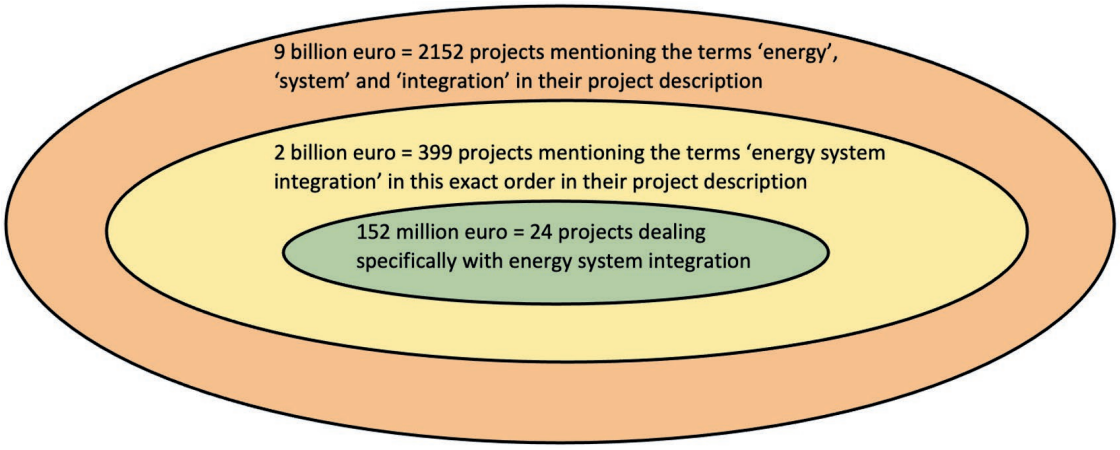
The **Connecting Europe Facility for Energy (CEF-E)** aims to accelerate investment in the field of trans-European networks for energy (TEN-E). This initiative groups projects by their energy sector (gas, electricity, smart grids etc.), reflecting traditional vertical energy value chains rather than the integrated energy system we are moving towards. Only one CEF-E project is specifically related to energy system integration: TSO 2020.[10] This project received €7 million of the roughly €5.35 billion funding allocated to projects by the initiative. The revised TEN-E regulation[11] extends the definition of energy infrastructure to include energy system integration projects within the scope of TEN-E and CEF-E. However, the revision of the TEN-E and the revised project list might only materialise after 2023.

Like CEF-E, the **European Structural and Investment Funds** group projects by their energy sector (gas, electricity, renewables etc.) following the traditional silos logic. The budget allocated for energy infrastructure projects in electricity and gas networks is around €2.3 billion. However, the system for categorising spending does not allow ESI-related investments to be captured.

The **European Local ENergy Assistance (ELENA)** service takes an approach different to the previous mechanisms. ELENA provides grants and loans to support the ambitions of the Renovation Wave strategy, including through the use of combined heat and power (CHP) infrastructure, such as €2.7 million in direct financing to two district heating projects in the Netherlands.[12] However, beyond direct financing ELENA also offers financial guarantees to protect against investor risk, as well as financial advisory services. These other mechanisms

7 https://cordis.europa.eu/programme/id/H2020_LCE-02-2016 and https://cordis.europa.eu/programme/id/H2020_LCE-01-2016-2017
8 These figures represent the numbers of projects exactly mentioning the phrase 'energy system integration' as revealed by a text mining analysis of their project descriptions.
9 For details of Horizon 2020 projects, see Annex I.
10 For details of TSO 2020, see Annex II.
11 https://ec.europa.eu/commission/presscorner/detail/en/IP_20_2394
12 For more details on these projects, see Annex III.

Figure 2: Breakdown of Horizon 2020 funding for ESI projects (Authors, 2021)



have facilitated the mobilisation of €6.6 billion in private sector energy efficiency and renewable energy investments since 2009.[13]

In addition to EU funding, several countries have committed to finance ESI projects with national budgets. Such cases will not be discussed here as they fall outside the focus of this paper. Moreover, many of these projects typically have a hydrogen focus, i.e. they aim to develop hydrogen capacity or infrastructure and are therefore included in the national hydrogen strategies.[14]

1.3. The prospects for ESI financing at the EU level

At the time of publication, the European Commission does not yet have a plan for an EU budget contribution to energy system integration.

Outside a dedicated budget, the European Commission is looking to support ESI in the field of hydrogen through the **European Clean Hydrogen Alliance (ECHA)**.[15] The aim of the ECHA is to establish a pipeline of projects by the end of 2021 that can accelerate the growth of a decarbonised hydrogen economy in Europe. It serves as a platform for industry, public authorities and civil society to work together to establish a clear vision of what the growth of the sector should look like, with a view to mapping out the next 10 years of development.

Although there is no public investment budget allocated to the ECHA, the European Commission offers its support in guiding projects towards existing financing mechanisms[16] through a Hydrogen Public Funding Compass,[17] which encourages projects to work together to find synergies through facilitating dialogue and offering visibility to private investors. The European Commission foresees up to €490 billion total investment in the renewable and low-carbon hydrogen space by 2050 and is using the ECHA to help guide the investment in line with the aims of the Hydrogen Strategy.[18] This includes electrolyser capacity targets of 6GW by 2024 and 40GW by 2030 and total decarbonised hydrogen production of 10 million tonnes by 2030.[19] The final list of projects eligible for inclusion under the ECHA is expected by the end of 2021.

The existing funding options described above demonstrate two key weaknesses in the current approach to financing energy system integration in the EU. First, although there are several well-resourced initiatives that in some way address the subject of ESI, they have been broadly unsuccessful in delivering support for this area relative to the level of political ambition outlined in the EU ESI strategy. This is evidenced by the small number of projects that have received financing from these funds, in the context of their overall budgets and contributions to other areas of the

13 https://www.eib.org/en/products/advising/elena/index.htm
14 See Hydrogen-Insights-2021.pdf (hydrogencouncil.com)
15 https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en
16 Examples include: Important Projects of Common European Interest (IPCEI), Next Generation EU (NGEU), National Energy and Climate Plans (NECPs), the Recovery and Resilience Facility, European Regional Development and Just Transition funds, CEF-E, the Connecting Europe Facility for Transport (CEF-T) and the EU Emission Trading System (ETS) Innovation Fund.
17 https://ec.europa.eu/growth/industry/hydrogen/funding-guide/index_en
18 For more information on the ECHA, see Annex IV.
19 https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_1257

energy transition. Second, the scope of some key financing mechanisms, such as the CEF-E, follows the value chains of specific commodities (i.e. gas, electricity, oil etc.). This outdated approach fails to account for the increasingly integrated nature of our energy systems and the need to support projects that work towards this model.

An overarching financing strategy is required for ESI which would limit the risk of fragmented and incompatible infrastructure development and provide a better overview of the ESI 'gaps,' or missing links, which warrant stronger support. We therefore propose two overarching policy recommendations to improve the ESI financing process in a more structured, tailored and transparent manner better reflecting the needs of the sector.

2. Policy recommendations

2.1.Create a dedicated Fund for Energy System Integration at the EU level

We propose a mechanism similar to the Projects of Common Interest (PCIs) [20] and Connecting Europe Facility (CEF).[21] In this format, international infrastructure projects proposed by private entities or public-private consortia can apply for PCI special status in view of their contribution to strengthening security of supply. While all PCIs are eligible for public funding, a smaller number of them are selected to receive grants via the CEF in a second stage.

Applying a similar logic, projects contributing to the EU target of an integrated energy system could be evaluated according to their sustainability, economic value and other relevant criteria. Only a selection of these projects meeting additional criteria (the number of sectors interconnected, their contribution to economy circularity etc.) would then receive dedicated ESI grants from the EU and benefit from a streamlined permitting process.

In line with the innovation literature, grant-based subsidies, carbon contracts for difference (CCfD), or other support mechanisms are likely required to decrease the cost of technologies and overcome innovation barriers related to uncertainty in the regulatory framework. Once technologies are established and the regulatory framework is better defined to create the right incentives for private investment, we can expect public funding to decline and be gradually phased out in favour of repayable grants or guarantees.

2.2. Member States and national regulators should participate in the evaluation of projects

Just like the current process for PCIs, Member States should be the main contact point for project promoters, while energy regulators should evaluate the feasibility, cost and benefits of the proposed projects. We believe this first 'check' at the national level would help the EU Commission with its evaluation and could facilitate synergies between mutual public and private interests leading to the formation of mixed consortia.

Project monitoring could be performed by the European Commission via its European Climate, Infrastructure and Environment Executive Agency (CINEA),[22] which already deals with several of the ESI-related financing instruments mentioned in the first part of this paper.

20 https://ec.europa.eu/energy/topics/infrastructure/projects-common-interest_en
21 https://ec.europa.eu/inea/en/connecting-europe-facility
22 https://cinea.ec.europa.eu/index_en

Conclusion

The publication of the Energy System Integration Strategy in July 2020 was an important and welcome first step in shaping the transition of European energy markets towards 2050. The strategy made a significant contribution to clarifying the EU approach to key issues such as electrification, the role of gas in the future energy mix and energy infrastructure. This clarity has gone a long way towards informing private investors about the landscape of future EU energy markets. However, the strategy lacks concrete indications of how the vision of an integrated energy system can be materialised.

At present, there are limited public financing options available for ESI at the EU level, as is evidenced by the relatively little targeted public investment in this area to date. It therefore seems that the level of political ambition regarding ESI is not matched with a comparable financial commitment. Beyond existing schemes, there is arguably a sufficiently strong scientific and political case for a public fund that is explicitly allocated to ESI. This should be coordinated at the EU level to absorb tasks efficiently into existing platforms, maximise coordination within regions and go beyond national objectives.

We believe that infrastructure integration is at the core of ESI and should therefore be the first pillar addressed in the path towards an integrated energy system. We therefore propose that a similar approach to that used for financing security of supply infrastructure be followed: the PCI and CEF-E model. Such a process should remain technology-neutral and encompass any credible decarbonised energy carrier, technology and initiative which supports the integration of the EU energy system.[23] For this reason, we believe that not only the EU Commission but also Member States and national regulators should take part in the evaluation process.

23 Initiatives of this type in support of one specific technology are not new to the European Commission. See European Battery Alliance | Internal Market, Industry, Entrepreneurship and SMEs (europa.eu

Annex I

Metabolic

The 'Metabolic'[24] research project started in 2018 with the aim of analysing the potential of smart integrated decentralised energy (SIDE) systems to contribute to the energy transition within a microgrid system. As Metabolic states, "A SIDE system is characterised by a high degree of system integration of various renewable energy technologies" and "at the root of each SIDE system is a holistic design philosophy aimed at exploiting as many synergies as possible between components." The aim of the project is to provide flexibility through a new economic model which simplifies and optimises the interactions between SIDE systems and microgrids using a bottom-up approach. In turn this can facilitate the development of integrated energy systems at the neighbourhood level. For this purpose, the project analysed the techno-economic performance of four micro-grid projects in the Netherlands: Aardehuizen, De Ceuvel, Schoonschip and Republica Papaverweg. These projects were funded by both public and private entities including community cooperatives, the joint programming initiative 'ERA-Net Smart Grids Plus' and the EU Horizon 2020 research and innovation programme.

HyBalance

'HyBalance'[25] is a demonstration project for power to gas technology in Denmark. It focuses on producing hydrogen through water electrolysis for the purpose of storing renewable electricity. The project has several industrial partners[26] which bring their technical expertise in designing and developing advanced large-scale electrolyser technology and in hydrogen infrastructure rollout in Denmark (e.g. Copenhagen Hydrogen Network (CHN)). There are also several partners experienced in energy markets which can provide ideas on how to design and integrate new markets in electricity and natural gas from hydrogen technologies (e.g. Centrica and Hydrogen Valley – previously CEMTEC). HyBalance is funded by the Horizon 2020 programme through the 'Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU).' In addition, the project has also received funding from the Danish Energy Technology Development and Demonstration Programme (EUDP).

HEAVENN

One interesting project involved in sectoral integration is 'HEAVENN'[27] in the northern Netherlands. HEAVENN stands for 'H2 Energy Applications in Valley Environments for the Northern Netherlands.' The project aims to produce green hydrogen as a raw material for industry, as a fuel for mobility purposes or for renewable electricity storage. Six European countries and thirty-one public and private entities are involved in the project. HEAVENN has a budget of €90 million that is funded by the European Commission's Fuel Cells and Hydrogen Joint Undertaking (FCH JU) and a public-private financing consortium. It designs and develops hydrogen infrastructure that can support the production and delivery of hydrogen throughout the region. It started in January 2020 and will last for 6 years.

PlaMES

This project is carried out by one DSO, four EU universities and one spin-off company. It aims to develop an integrated planning tool for multi-energy systems on a European scale. The model considers coupling different energy sectors (electricity, heat, mobility and gas) and calculates the optimal-cost energy mix for the future European energy system up to 2050. Generation and storage systems are considered in the planning and operation stage, as are transmission and distribution grids, from an integrated perspective.

Annex II

TSO 2020

TSO 2020[28] contributes to the implementation of the TEN-E Project of Common Interest (PCI) 1.5 Interconnection between Endrup (DK) and Eemshaven (NL), known as the COBRA cable, and of the TEN-Transport core networks on the North Sea-Baltic and Rhine-Alpine corridors. The main objective of the action is to demonstrate the technical and commercial viability of

24 https://www.metabolic.nl/projects/side-systems/
25 http://hybalance.eu/
26 A list of all the partners can be found on the project's website.
27 https://www.newenergycoalition.org/en/hydrogen-valley/
28 https://ec.europa.eu/inea/en/node/11820

power to hydrogen solutions in the Groningen region (NL) and to assess the replicability of solutions in other regions. These solutions simultaneously balance the intermittent power input from the COBRA cable and develop the use of hydrogen for transport applications along the TEN-T corridors. The project received €7 million of EU funding in 2016 and was completed in June 2021.

Annex III

District Heating 2.0 Stadsverwarming Purmerend

The first of the two ELENA-funded district heating projects aimed to modernise outdated fossil gas heating infrastructure by converting it to biomass and to eliminate inefficiencies in the supply chain (i.e. by removing additional unnecessary loops in transportation infrastructure and improving the dispatchability of heating services). The district heating network is situated in Purmerend, North Holland, and the new 44 MWh biomass heat plant utilises biomass supplied by a subsidiary of the Staatsbosbeheer, the national forest administration of the Netherlands. The initiative saves an estimated 40 GWh/y and avoids 39,100 t CO_2 /y compared to the previous infrastructure.[29] [30] The project was completed in 2013.

Rotterdam-Leiden Heat Infrastructure

The second project, completed in 2019, uses a heat exchanger to recover waste heat from the Shell refinery at the Port of Rotterdam and feeds it into the main district heating network. Funding from ELENA assisted with the technical, financial and legal studies required for the relevant permit requests. It also facilitated the identification of potential investors to further support the financing of the €17.7 million project. The establishment of this district heating infrastructure is estimated to save 42 GWh/y and avoid 9,114 t CO_2/y.[31] This case is an example of how support from ELENA goes beyond direct financing to also provide services that can attract private-sector investment, thus multiplying the impact of the mechanism.

Annex IV

The European Clean Hydrogen Alliance (ECHA) was announced in the new Industrial Strategy for Europe[32] in March 2020 and began work in February 2021. The ECHA has six thematic roundtables covering the entire sector, including P2X, storage and X2P.

Consistent with the framework of the EU Hydrogen Strategy, projects must meet several key criteria to be included in the final project pipeline, which were established by the roundtables. Emission intensity is a key metric, with the Sustainable Investment Taxonomy threshold of 3 tonnes (t) of CO_2/ t of H_2[33] serving as a minimum benchmark limiting projects to decarbonised and renewable hydrogen. The project collection closed in May 2021 with more than 1,000 project submissions accounting for well over the electrolyser and decarbonised production ambitions in the EU Hydrogen Strategy.

29 https://www.eib.org/attachments/documents/elena-completed-purmerend-en.pdf
30 https://www.rvo.nl/initiatieven/financieringsvoorbeelden/stadsverwarming-purmerend
31 https://www.eib.org/attachments/documents/completed-project-factsheet-rotterdam-leiden-heat.pdf
32 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593086905382&uri=CELEX:52020DC0102
33 https://ec.europa.eu/finance/docs/level-2-measures/taxonomy-regulation-delegated-act-2021-2800-annex-2_en.pdf

The Florence School of Regulation

The Florence School of Regulation (FSR) was founded in 2004 as a partnership between the Council of the European Energy Regulators (CEER) and the European University Institute (EUI), and it works closely with the European Commission. The Florence School of Regulation, dealing with the main network industries, has developed a strong core of general regulatory topics and concepts as well as inter-sectoral discussion of regulatory practices and policies.
Complete information on our activities can be found online at: fsr.eui.eu

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The Robert Schuman Centre for Advanced Studies (RSCAS), created in 1992 and directed by Professor Brigid Laffan, aims to develop inter-disciplinary and comparative research on the major issues facing the process of European integration, European societies and Europe's place in 21st century global politics. The Centre is home to a large post-doctoral programme and hosts major research programmes, projects and data sets, in addition to a range of working groups and ad hoc initiatives. The research agenda is organised around a set of core themes and is continuously evolving, reflecting the changing agenda of European integration, the expanding membership of the European Union, developments in Europe's neighbourhood and the wider world.

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Co-funded by the
Erasmus+ Programme
of the European Union

doi:10.2870/031591
ISBN:978-92-9466-092-3
ISSN:2467-4540
QM-AX-21-043-EN-N