ICLEI Local Governments for Sustainability

100% RENEWABLES CITIES & REGIONS ROADMAP

Supported by:

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IKI INTERNATIONAL CLIMATE INITIATIVE

solutionsgateway Climate, Energy, and Finance Solutions

100% RENEWABLES SOLUTIONS PACKAGE

Sector coupling for renewable energy integration

This solution is part of a package of solutions meant to guide local and regional governments in implementing a local renewable energy transition by providing guidance on mechanisms, applications or technologies that can help accelerate their climate and energy action.

It was produced as part of the 100% Renewables Cities and Regions Roadmap project, which supports nine cities and regions across Argentina, Indonesia and Kenya to develop bankable renewable energy projects and in-depth local strategy and action plans to achieve one hundred percent renewable energy. The 100% Renewables Cities and Regions Roadmap project is implemented by ICLEI – Local Governments for Sustainability and funded through the International Climate Initiative (IKI), which is implemented by the Federal Ministry for Economic Affairs and Climate Action (BMWK) in close cooperation with the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Federal Foreign Office (AA).

DISCLAIMER

All cities are unique. The Solutions Gateway has been developed as an advanced knowledge catalogue to provide an overview of possible Low Emissions Development Solutions. The Solutions and Packages it contains provide guidance on general conditions, which may not correspond to the existing conditions in your city or jurisdiction. The consultation and use of the Solutions Gateway does not waive the need for the Local Government to assess the feasibility of a Solution or Package in the local context in its city or jurisdiction, prior to implementation. Please note that the impacts, benefits and co-benefits indicated are generally valid but may not materialize in particular circumstances.

ABOUT SOLUTIONS GATEWAY

Solutions Gateway is an online resource platform for Local Governments where they will be able to find possible Low Emissions Development (LED) Solutions for their cities.

In the context of the Solutions Gateway, Solutions are processes, or groups of actions, which Local Governments can implement to deliver climate change mitigation results and enhance local sustainable development. Taking an integrated approach, and focusing on Local Governments usual responsibilities and roles, Solutions include core actions as well as enabling and multiplying actions essential to maximize their effectiveness and efficiency. These include policy, regulatory, governance, capacity building, awareness raising, stakeholder engagement, etc.

ABOUT ICLEI – LOCAL GOVERNMENTS FOR SUSTAINABILITY

ICLEI – Local Governments for Sustainability is a global network working with more than 2,500 local and regional governments committed to sustainable urban development. Active in 125+ countries, ICLEI influences sustainability policy and drives local action for low emission, nature-based, equitable, resilient and circular development. ICLEI's Members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

AUTHORS

Mohammad Almalla (ICLEI World Secretariat)

COLLABORATORS

Kanak Gokarn (ICLEI World Secretariat)

DESIGN

Olga Tokareva (ICLEI World Secretariat)

CONTACT

ICLEI – Local Governments for Sustainability e.V.
Kaiser-Friedrich-Str. 7
53113 Bonn | Germany
Tel. +49-228 / 97 62 99-00
www.iclei.org

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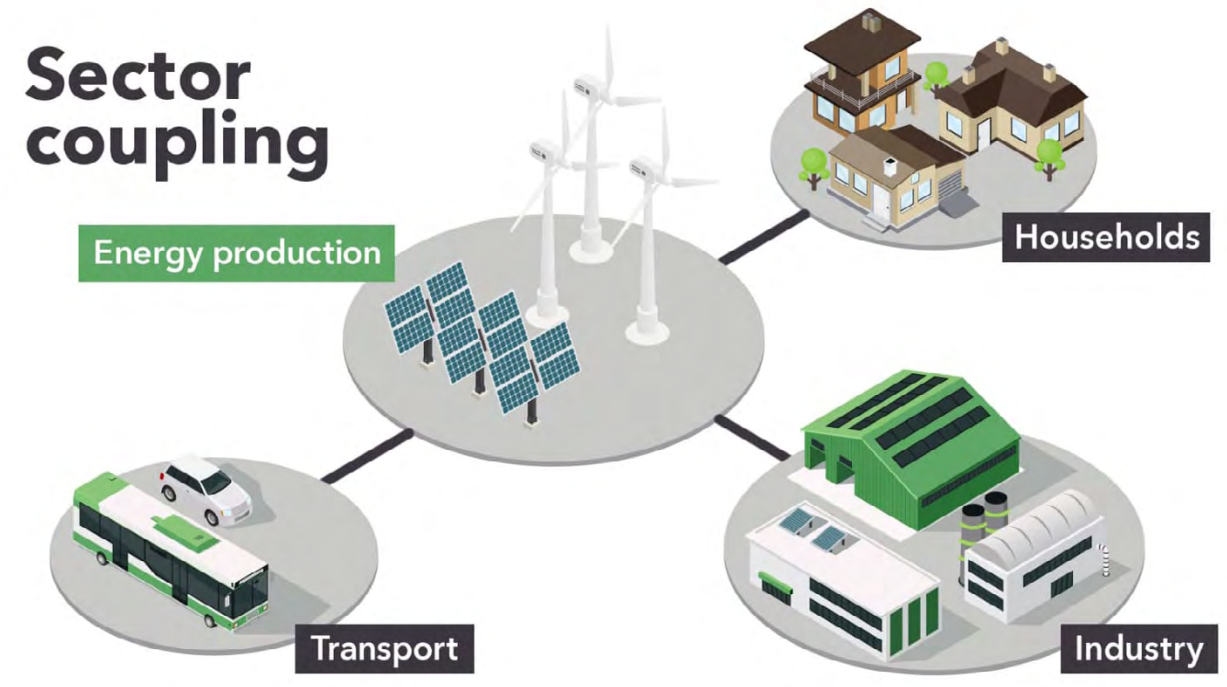
1. INTRODUCTION

Sector coupling is defined as the process of interconnecting power generating resources with energy consuming sectors such as the heating, transport, gas, and other. This is in order to economically optimize operations of the energy system and facilitate the integration of the intermittent renewables through enhanced energy system flexibility [2]. There are two main strategies: first, through electrification by promoting electric mobility and replacing traditional heating systems with electric heat pumps, to use renewable electricity instead of fossil fuels. The second strategy is through "Power-to-X", whereby synthetic fuels are produced from renewable electricity through transformation into heating (P2H) or cooling, gas (P2G), or liquid (P2L) for use in final consumption [3]. The generated fuels and carriers such as hydrogen, methane, gasoline, or kerosene can also reduce CO2 emissions using the existing gas and heat infrastructure [7].

1.1 RELEVANCE

Cities require a continuous supply of energy and consume 75% of the global primary energy, and need to minimize their ecological footprint to become sustainable. However, increasing population growth, urbanization and economic growth are putting more pressure on energy systems [5]. To reach net-zero emissions by 2050, governments will need to increase the deployment of all available clean and efficient renewable energy technologies [6]. For the simple fact that energy is more than just electricity—energy is also used in the form of heat and transport which is counted in the country's final primary energy demand. The transformation of our energy systems must go beyond just the power sector and address other energy-consuming sectors. This can either be achieved by using renewables directly or by using electricity from renewables to bring the energy transition to other sectors [4].



1.2 MAIN IMPACTS

- Energy market scenarios analysis of the EU shows that effective sector coupling can translate into reduction in emissions by 60% from transport, buildings and industry between now and mid century, or 71% on 1990 levels [1]
- Sector coupling is expected to be mostly effective for the buildings sector through electrification [1]
- For industry, it is expected for low-temperature processes such as food and beverages to be among the first to electrify and then followed by steel, cement and other high-temperature, energy-intensive businesses [1]
- The use of renewable energy-powered electric vehicles instead of internal combustion engines can potentially provide a plausible solution to decarbonise the urban transport sector. This can bring about less air and noise pollution in the cities [2]
- Sector coupling can also contribute in supporting the local economy, as electricity can be increasingly generated from distributed power generation systems, and can improve energy security by reducing the dependency on the supply of hydrocarbons [2]
- Sector coupling entails the electrification of several sectors which means raising gross electricity consumption 75% up to 2050, which will need a corresponding increase for solar and wind manufacturing capacity and associated economic benefits [2]
- Sector coupling through decarbonising the energy system through a mix of different low-carbon energy carriers and technologies is found to be the most cost effective approach to decarbonize the economy without reducing its competitiveness [8]

1.3 BENEFITS

- Sector coupling provides a solution for utilization of the excess electric power generated by renewable energy sources [2]
- Sector coupling enables ancillary services in the organized wholesale electricity markets for a more efficient, electrified and renewable-based electricity system [2]
- Benefits accrue as well from improving energy efficiency by the energy conversion of different energy carriers in the process of implementing sector coupling strategies to improve the overall system efficiency. This includes, for instance, power-to-heat by using heat pumps, and EVs instead of internal combustion engines, enhancing both engine and fuel efficiency [2]
- System modeling and analysis shows significant increase in the market values of renewable energy systems with increased flexibility in the electricity sector through closer interconnections with demand sectors [9]
- Sector coupling makes the use of excess electricity possible for electrolysis to produce hydrogen and synthetic methane. These can be stored on a large scale and over longer periods hence providing a source of seasonal flexibility in energy supply [11]

1.4 SUGGESTED INDICATORS FOR MONITORING RESULTS

- Increased electric power generation from renewable energy systems (kWh/year)
- Number of electric vehicles (number of e-vehicles)
- Increased indirect use of renewable energy for electrolysis and production of Hydrogen (kg H_2/year)
- Increased use of renewable energy to produce, store and valorize methane gas (Nm^3 CH_4/year)
- Thermal energy generated through electric heat pumps (MJ/year)
- Increased energy storage capacity
- Reduction of GHG emissions (t CO_2 eq)

1.5 TYPICAL LOCAL GOVERNMENT ROLES

- Policy maker
- Planner
- Legislator/regulator
- Coordinator
- Consumer and procurement
- Operator of municipal facilities and infra-structures
- Mobilization and stakeholder engagement

2. INTEGRATED SOLUTION OVERVIEW

	Enabler Actions	Required Actions	Multiplier Actions
Policy	• Setting or advocating for policies to foster IT infrastructure, as the development of smart energy management systems that is based on state-of-the-art IT infrastructure is a key enabler for the coordination of decentralized actors with sector-coupling and/or flexible technologies in the energy sector • Develop the standards and energy efficiency labels to enable widespread use of sector coupling technologies such as heat pumps and electric mobility • Adopt an integrated planning and operation approach in energy policy to create synergies between the different energy sectors and mainly the power and gas sectors • Setting energy conservation and climate change mitigation targets and adopting policy to achieve the same	• Have in place all policies and regulations and supporting infrastructure to increase the renewable energy integration in the mix, or advocate for them where needed • Setting up the policies to make smart and bidirectional charging possible. This is important so that energy planners make sure that the charging infrastructure they create possesses this technology • Setting up the targets, policies, and tariffs needed that allow and incentivize the increase of renewable energy resources where possible—a clear stated policy can help attract interest and resources • Set up the regulations that encourage self consumption of power generated by renewable energy resources including through building codes etc.	• Implement adjustments to electricity prices structure in order to strengthen the business case of P2G where possible • Implement adjustments to offering the discounted grid tariffs for reversible electrolysis or provide tax exemptions for electrolyser operators producing green hydrogen where possible • Provide incentives for green hydrogen and other clean fuel producers • Support initiatives that decrease the capital costs via innovation and deployment of technologies at different scales such as P2G • Ban or tax fossil fuel furnaces, boilers and internal combustion engines, or spur efforts to move away from them through transparent policy making • Establish and develop a market for a widespread hydrogen use for the promotion of technological learning • Drive support to electrify public transport and buildings
Stakeholders and Awareness	• Engaging think tanks and academia in research and development of renewable energy resources, energy management digitization, flexibility options, and energy storage	• Engage energy providers in the process of infrastructure planning • Share energy efficiency labels • Launch campaigns on sector coupling and electrification of the energy sector • Create a communication plan with the relevant stakeholders	• Increasing acceptance for renewable energy and e-mobility options through increased public knowledge • Increasing Industry willingness to invest in sustainable energy and energy storage systems through clear policy and incentives

	Enabler Actions	Required Actions	Multiplier Actions
Stakeholders and Awareness	• Spreading awareness to energy system operators and service providers of the need to phase out fossil fuels and the need for energy technology transition • Developing a comprehensive action plan to engage and communicate all stakeholders in the power, heat, mobility, and energy providers • Communicate steps and plans on sector coupling with stakeholders	• Support the research and development related to energy storage and flexibility technologies • Spreading awareness directly or indirectly through power providers on energy conservation and clean energy technologies and energy labeling systems	• Increasing private sector interest in investing in sustainable infrastructure
Governance	• Creating clear procedures for setting up e-mobility related infrastructure • Setting up environmental regulations for all sectors: industry, households, and mobility	• Put in place the regulations and standards related to green-hydrogen (or other) storage and transmission or where possible, advocate for their development • Put in place regulations related to smart energy systems and energy management data transfer	• Collaborate with other peer governments and other levels of government to create demand clusters etc. and take advantage of economies of scale
Capacity Building	• Developing capacities in designing, commissioning, monitoring, integrating, maintaining, and financing renewable energy resources • Increasing knowledge of energy and power management systems and the possibilities of sector coupling • Increasing the capabilities in integrating digitalization in the energy sector	• Raised awareness and knowledge of the integration of renewable energy systems and energy efficiency and the various possibilities • Enhance capacities in developing smart energy systems regulations and guidelines • Increased skills in engaging the different sectors of power and gas in sector coupling action plans	• Incorporate the academic sector for continuous improvement (e.g. conducting research on data efficiency and opportunities for improvement), as well as industry experts

	Enabler Actions	Required Actions	Multiplier Actions
Technical	• Expand capacities of power networks to handle increased intermittent renewable power, through investment, regulation or advocating for the above • Digitalization of the energy sector and enhanced exchange of data should be pursued at all levels, with adequate protections in place • Encouraging various actors to install bidirectional smart power meters	• Setting up power systems and power markets so that that encourages and favors the use of renewable electricity during times of oversupply, or advocate for these changes at the relevant level • Review safety elements of P2G and their injection into existing infrastructure, and train personnel accordingly	• Expansion of power network and/or development of decentralized systems can be integrated with other local plans in consultation with the utility e.g. identifying demand centers • Encouraging innovation and research to lower costs of renewables-based gasses and their integration into existing sectors
Finance	• Engage utilities and energy companies in investing in hydrogen and power to gas solutions • Facilitate the access to funding to overcome the high investment costs, at national or international levels, or advocate for the same • Explore alternate financing models e.g. public-private partnerships	• Set tax systems that favor renewable energy over fossil based fuels • Provide the access or ease the process to reach out local and international funding for renewable and environmental energy technologies and pilot projects • Reduce taxes or provide incentives to e-mobility as well as heat pumps and electric appliances that can replace fossil fuels through electrification • Subsidize or reduce tax on heat pumps and electric stoves	• Setting up financing mechanisms for long term contracts of renewable energy power and energy storage systems • Advocating for mass investment in P2G and P2L fuels to build infrastructure for industries and mobility types that are identified as hard-to-abate

3. WORKFLOW /PROCESS PHASES

3.1 PREPARATION

- Make a clear commitment that reflects market, economic and political developments with clear statement on the energy transition and the phasing out of fossil fuels
- Assess the existing policy environment for the promotion of renewable energy, identifying gaps
- Run technical and financial feasibility studies, including possible business models and ways to attract investment, and potential uses/demand centers for P2X
- Identify local stakeholders and start an early engagement process to increase investments and interest in renewable energy, flexibility options and technologies
- Once key industries are identified, assess the their willingness to adopt clean energy solutions for their processes
- Promote electrification of the buildings sector and transportation through clear policies and communication
- Assess the financial resources that the government has available to implement these policies, including pilot programs, and identify other external funding sources

3.2 APPROVAL

- Set market rules and guideline as well as standards or advocate for them at a national level, including accurate tariffs and a fair financial incentives
- Ensure the process for approval is streamlined, especially with new technologies at play

3.3 IMPLEMENTATION

- Set up the budget and procurement procedure (e.g auctions or PPP agreements) in the city/region, exploring other options for newer technologies
- Incentivize investments in P2X and electrification through clear policy signals and incentives where possible, and collaboration with other levels of government
- Promote the construction of hydrogen gas infrastructure as well as e-mobility charging systems through integrated planning
- Collaborate with neighboring governments and the national government to identify synergies

3.4 MONITORING

- Track grid performance to analyze flexibility options and storage systems capacities to ensure smooth overall functioning
- Identify key indicators, track and verify their performance and make transparent the progress made
- Publicize successes and engage in peer exchange with other cities/regions to share lessons learnt and benefit from knowledge exchange

4. REALITY-CHECK

This solution is applicable:

- For fully electrified areas although leapfrogging might be applicable
- In a situation where renewable energy penetration in the power sector is already high while fossil energy remained high
- For cities/regions with a high capacity of power and gas infrastructure and networks, or the possibility of developing these

4.1 REQUIRED PRE-CONDITIONS

- Adequate monitoring and enforcement of building codes etc.
- Adequate availability of renewable energy resources or sufficient interconnections with neighboring regions
- Bringing on board of the power and gas network as well as the private sector towards sector coupling
- Technological expertise or ability to access it

4.2 SUCCESS FACTORS

- High penetration of renewable sources in electricity
- Willingness of gas operators to modify infrastructure towards hydrogen and other gasses
- Overall awareness of sectors and willingness to cooperate
- Access to finance and investment
- Enabling national policy framework to allow for collaboration, clustering and economies of scale
- Sufficient demand for the products of sector coupling

4.3 FOLLOW-UP NEEDED AND/OR RECOMMENDED

- Monitoring of adoption of sector coupling technologies
- Review of safety and operations procedures as needed
- Costs reductions of hydrolysis and power to gas technologies and ways to encourage it
- Continued investments in batteries and flexibility options

4.4 BARRIERS

- Competing with fossil fuel driven lobbies and service providers and an entrenched resistance to change, which can be addressed with the appropriate policy tools
- Lack of expertise and knowledge which can be addressed by collaborating with research institutes and regional or international efforts to share knowledge
- Weak infrastructure and monitoring of quality and standards, which can be addressed through more robust inspection
- Lack of financing leverage which can be addressed through collective advocacy at the national and international levels

4.5 RISKS

If the missing financing problem of renewables does not get resolved through long-term contracts. Then with the rising demand from sector coupling, this will stimulate the build of fossil-fired capacity instead to keep up with the electrified economy. This as well might keep large volumes of capacity of dirtier or less efficient power plants online.

5. CLIMATE CHANGE MITIGATION POTENTIAL

Sector coupling was developing as a solution to increase emissions abatement from the sectors that have minimum to no penetration of renewable energy. While the share of renewable energies in the power sector has received the most attention, some sectors such as buildings, heating, industry and mobility remain highly reliant on fossil fuels. The solution aims to mitigate carbon emissions from these sectors by coupling the renewable energy-powered system with those sectors through electrification and P2X solutions. This is critical to achieve fully decarbonized energy systems—going beyond electricity—and addressing the associated concerns about system flexibility and integration.

6. NATIONAL – SUBNATIONAL INTEGRATION IN THE CONTEXT OF THIS SOLUTION

6.1 BENEFITS TO LOCAL GOVERNMENT

- Piloting such efforts can help gain visibility, take leadership and attract resources for further improvements, and contribute to national-level goals
- Such efforts can attract industrial and technology actors, increasing economic activity and benefits for the city/region

6.2 BENEFITS TO OTHER LEVELS OF GOVERNMENT

- Higher renewable energy use across a diverse mix of technologies can help improve energy security
- Local action can help trial new solutions, and scaling this up can help in achieving national level goals
- Greater technological innovation can boost the green economy and lead to economic development

7. RESOURCES/SUPPORT

See impact of sector coupling on demand profiles as reported by EATON, Bloomberg, Statkraft (2020) - see reference 12.

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World Secretariat
Kaiser-Friedrich-Str. 7
53113 Bonn, Germany

+49-(0)228 / 976 299-00
iclei@iclei.org
www.iclei.org

Connect with us

@iclei
/iclei
/iclei