ENRICH

EUROPEAN NETWORK OF RESEARCH AND INNOVATION CENTRES AND HUBS, USA

US Research Handbook on Renewable Energy

GAC

SBDC | FOX Small Business Development Center TEMPLE UNIVERSITY

DLR Project Management

spi Sociedade Portuguesa de Inovação

RCISD

NCURA Supporting Research

Disclaimer

Executive Summary

This research handbook is a product of ENRICH in the USA, which is a European Network of Research and Innovation Centers and Hubs. Promoted by the European Commission (EC) through Horizon 2020, ENRICH in the USA acts as a central contact point for European research and innovation actors seeking to grow and reinforce collaboration across the Atlantic. The mission of the Network is to provide standardized as well as various tailor-made, research & innovation internationalization support services to European researchers and innovators, to accelerate access to the United States (US) market and maximize chances of success.

The Research handbook on US R&D Related to Energy – Renewable Energies provide an assessment of the US research community landscape. This aims to support research and innovation cooperation between the European Union (EU) and the US.

The Research handbook identifies the US key university research groups, research centers and industry clusters, as well as some of the main professional associations and conferences/events focused on renewable energy research and development (R&D) activities. Furthermore, the Research handbook identifies potential approaches to develop collaborative projects with the US renewable energy research community and assesses the opportunity for EU researchers to participate in the US funding programs related to renewable energy R&D. Therefore, this research handbook aims to be an effective source to provide insight on the US renewable energy research community and possible first contacts for initial approaches to establishing collaborative activities.

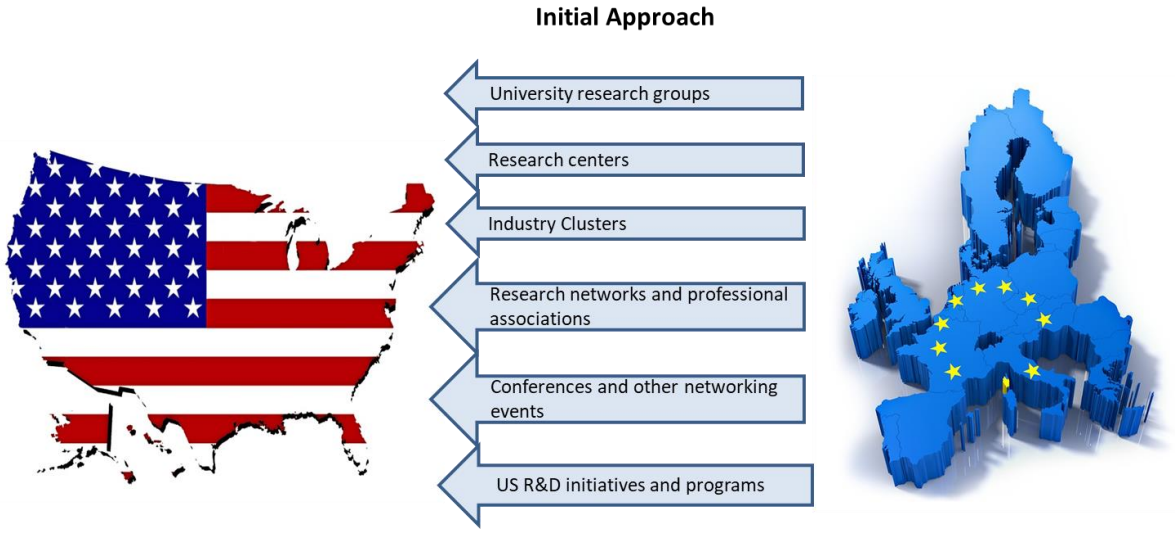


Figure 1 - Initial Approaches to Establishing Collaborative R&D Activities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

The EU and the US are key partners in R&D and innovation[1,2]. The US is the EU's main partner in scientific publications, with nearly one tenth of European scientific publications having participation from US authors[3]. R&D and innovation are key components of the EU and US smart growth strategies. Therefore, in the EU-US Energy Council, both regions emphasized their commitment to cooperate on energy research and innovation (R&I) in key areas, such as energy efficiency, smart and resilient energy grids and storage, critical materials for safe and sustainable energy supply, nuclear energy and interoperability of standards for electric vehicles, and smart grid technologies[4].

The US Government has been highly focused on promoting the development of renewable energy technologies, especially solar and wind energy technologies, through federal policy incentives and R&D grants[5]. In this context, the US research community has concentrated on conducting R&D activities in the field of renewable energy. Several leading universities have established research groups focused on thematic research areas related to renewable energies and developed important cross-collaborative partnerships with key industry players and research centers to advance and refine innovative technologies in this area. By performing cutting-edge research in the renewable energy field, the US is creating an important opportunity to foster knowledge exchange between the EU-US research communities. Therefore, this Research handbook aims to help identify collaborative opportunities in the US in renewable energy research areas.

To identify the US key research players in the renewable energy field, the ENRICH in the USA team conducted extensive desk research based on a literature review and document analysis. This Research handbook is primarily focused on four Thematic Research Areas identified through the overlap between the EU and the US R&D priorities in the renewable energy field: Geothermal Energy, Solar Energy, Water Energy and Wind Energy[6, 7].

This Research handbook reveals that the US research community encompasses a complex set of different actors that work in concert for the development of R&D activities. These key actors in the US research landscape are primarily university research groups, research centers, and industry clusters. Furthermore, there is a high degree of spatial concentration of renewable energy R&D activities in the states of California, Colorado, Illinois and Texas. Another nine states standout due to the presence of leading university research groups, research centers and industry clusters: Idaho, Kentucky, Maine, Massachusetts, Michigan, New Mexico, New York, North Carolina and Tennessee.

[1] https://www.degruyter.com/downloadpdf/j/ergo.2013.8.issue-1/ergo-2013-0002/ergo-2013-0002.pdf
[2] http://ec.europa.eu/research/iscp/index.cfm?amp;pg=usa
[3] https://www.degruyter.com/downloadpdf/j/ergo.2013.8.issue-1/ergo-2013-0002/ergo-2013-0002.pdf
[4] https://ec.europa.eu/research/iscp/pdf/policy/us%20clean_roadmap_2017.pdf
[5] http://sustainableenergy.org/current-state-of-u-s-renewable-energy-policy/
[6] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy
[7] https://energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

University research groups

The US is home to some of the main university research groups in the field of renewable energy. Considering renewable energy is a multidisciplinary topic that consists of knowledge from different research areas, this Research handbook identifies 27 university research groups based on the four Thematic Research Areas related to renewable energy. The 27 university research groups identified are categorized by university, such as University of California Berkeley and Texas A&M University.

Research Centers

In the US, the establishment of research centers have mutually benefited research institutions and industry partners. Research centers are based on multidisciplinary research that creates a powerful node for innovation in the field of renewable energy.

The Research handbook highlights three different types of research centers: (1) Federally funded research and development centers (FFRDC); (2) Research centers that are developed between a university and other entity; and (3) Centers that are established by universities and several companies and other organizations. Based on these three types, nine research centers are highlighted by this Research handbook.

Industry clusters

The assessment of the US research community reveals that industry clusters play a key role in R&D activities that are related to renewable energy. Industry clusters act as a bridge between academic research and the specific needs of the renewable energy sector.

Based on the US Cluster Mapping Project[8], a national economic development initiative led by Harvard Business School with the support of the US Department of Commerce, Economic Development Administration, the Research handbook identifies five industry clusters that stand out for their renewable energy R&D activities: Silicon Valley, Smart Grid Cluster, New York City, Colorado Clean Energy Cluster and Texas Energy Cluster.

Research networks, professional associations and networking events

The Research handbook shows that research networks and professional associations play a crucial role in fostering interaction between academia, industry, and federal/state entities. In the US, research networks focused on science and engineering research and education are highly supported by the government. As a result, research networks, professional associations and networking events are important to accelerate research in this particular field because they provide an opportunity for

[8] http://www.clustermapping.us/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

researchers, community practitioners, and industry members to share knowledge and information for advancing innovative technologies in the field of renewable energy.

The Research handbook identifies six professional associations based on a review of the US conferences and events focused on renewable energy.

US R&D initiatives and programs

The US R&D funding system is highly decentralized and comprises several actors, such as agencies of federal and state governments, universities, the private sector, and non-profit organizations. In the US, the research conducted by universities and research centers are highly supported by federal and state grants that prioritize research areas, which can lead to the country's benefit, such as renewable energy.

The US Federal Government supports renewable energy R&D activities through grants and opportunities for promoting the development and deployment of new technologies. Thus, federal agencies such as the Department of Energy (DoE), the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) have established several programs to support research in the field of renewable energy. In addition, state initiatives are also one of the major ways states can support public projects in key areas, such as renewable energy. The California Energy Commission, New York State Energy Research and Development Authority (NYSERDA) and New Jersey's Clean Energy Program (NJCEP) are examples of agencies that support renewable energy R&D activities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

ENRICH in the USA Summary

ENRICH is the European Network of Research and Innovation Centers and Hubs. Started in April 2017, ENRICH in the USA is a H2020 funded initiative whose mission is to establish a Network of European Research and Innovation Centers and Hubs throughout the United States of America. ENRICH in the USA acts as a central contact point for European research and innovation actors seeking to grow, reinforce collaboration, as well as find commercialization paths across the Atlantic.

To do so, ENRICH in the USA is leveraging a network of vetted European and US Partners (entities - including "Ambassadors") and Experts (persons - including "Mentors") as defined below.

The Ambassadors are stakeholders (entities) already supporting R&I actors, and willing to join forces on outreach, funding, programs, and curriculums; this group includes Angel Networks, Venture Capital Firms, Corporate Investors, Corporate Open Innovation Teams, University Incubators, Equity-based accelerators, Clusters, Region, State and Country Government agencies and more. They can also support ENRICH in the USA via sponsorship (cash or in-kind).

Vetted by approved Ambassadors and ENRICH in the USA team, Experts are individuals who are usually employees of Ambassadors with skills and industry experience. It includes Consultants/Service Providers (i.e., accountants, lawyers, etc.), Angel investors, as well as Mentors. Mentors are volunteering their time to support EU innovators (i.e., review pitch, collaterals, participate in meetings, etc.).

The ENRICH in the USA Network includes the following entities:

- **Three physical ENRICH in the USA Centers:**
  - San Francisco Centre (managed by Temple University SBDC)
  - Boston Centre (managed by Temple University SBDC)
  - Washington, DC Centre (managed by NCURA)

- **Five Landing Hubs across the US and** plans to expand the ENRICH in the USA Network beyond these first Hubs, over four years:
  - In PA: Temple University
  - In VA: George Mason University
  - In CA: California Polytechnic University or Cal Poly
  - In CA: UC Berkeley
  - In IN: Purdue University

- **Planned for 2022:**
  - In MA: University of Massachusetts or U Mass
  - In MI: University of Michigan

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

- In TX: UT Austin
- In MO: University of Missouri or Mizzou
- In ID: Boise State University

The ENRICH in the USA Network is built on local US experience and strong existing ties between the EU and the US, while providing new researcher- and entrepreneur-serving capabilities which address the resource gaps necessary to enable access for all EU Member States and Associated Countries, as well as every state in the US.

A variety of services have been proposed for researchers and entrepreneurs engaged by the Network during the pilot phase, then the Centers' pilot activities have been evaluated to inevitably retain the initiative's most successful components to ensure a sustainable plan for ENRICH in the USA in the future.

Piloted services targeted various, commercially viable technology maturity levels, both research-oriented and market-oriented and included research connection symposia, business matchmaking opportunities, working visits, immersion weeks, innovation tours to US organizations to explore technology/product partnerships and/or business development middle/long term opportunities, pitching to potential investors, entrepreneurial bootcamps, workspace access, mentorship/advisory, hands-on (pre-acceleration) enrichment programs, and more.

ENRICH in the USA Consortium:

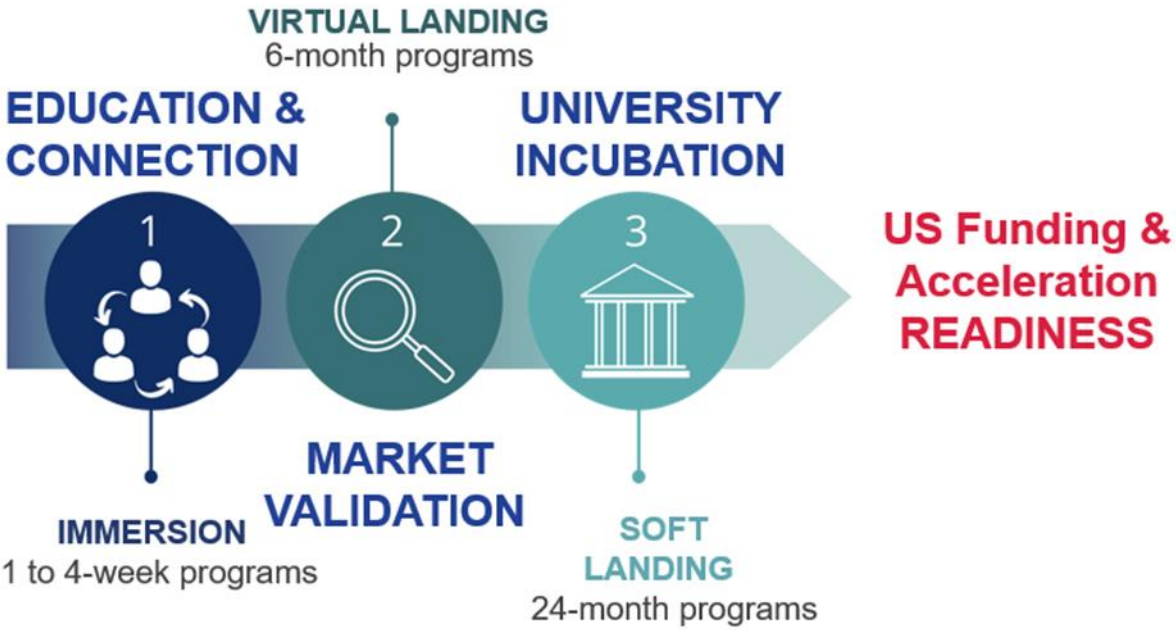
Coordinator: GAC Group (GAC), France

Partners:

> German Aerospace Centre (DLR), Germany
> Temple University SBDC (Temple), USA
> European Business and Innovation Centre Network (EBN), Brussels - Partner in Phase 1 (2017-2020)
> International Business Innovation Association (InBIA), USA - Partner in Phase 1 (2017-2020)
> European American Enterprise Council (EAEC), USA - Partner in Phase 1 (2017-2020)
> INTRASOFT International (INTRA), Luxembourg - Partner in Phase 1 (2017-2020)
> Sociedade Portuguesa de Inovação (SPI), Portugal
> Regional Centre for Information and Scientific Development (RCISD), Hungary
> National Council of University Research Administrators (NCURA), USA

Services:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Table of Figures

List of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

List of Abbreviations

Table 1 - List of Abbreviations

Abbreviation	Explanation
ACE	Advanced Clean Energy
ACORE	American Council on Renewable Energy
ARPA-E	Advanced Research Projects Agency-Energy
ASES	American Solar Energy Society
AWEA	American Wind Energy Association
CCEC	Colorado Clean Energy Cluster
CEC	California Energy Commission
CRADA	Cooperative Research and Development Agreement
CSTEC	Centre for Solar and Thermal Energy Conversion
DoE	US Department of Energy
EC	European Commission
EDA	Economic Development Agency
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EPCN	Energy, Power, Control and Networks
ESCA	European Secretariat for Cluster Analysis

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Abbreviation	Explanation
EU	European Union
FFRDC	Federally funded research and development centers
FOA	Funding Opportunity Announcement
FY	Fiscal Year
GDP	Gross Domestic Product
GEA	Geothermal Energy Association
GRDA	Geothermal Resource Development Account
GTO	Geothermal Technologies Office
IEDP	Innovative Energy Demonstration Program
INL	Idaho National Laboratory
ISTC	Illinois Science Technology Coalition
IUCRC	Industry–University Cooperative Research Centers
LLNL	Lawrence Livermore National Laboratory
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NCPV	National Centre for Photovoltaics
NJCEP	New Jersey's Clean Energy Program
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
NYC ACRE	New York City Accelerator for a Clean and Renewable Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Abbreviation	Explanation
NYREC	New York Renewable Energy Cluster
NYSERDA	New York State Energy and Research Development Authority
NYU-Poly	Polytechnic Institute of New York University
OISE	Office of International Science and Engineering
ORNL	Oak Ridge National Laboratory
PON	Program Opportunity Notice
RAEL	Renewable & Appropriate Energy Laboratory
RC	Research Coordinator
RDD&D	Research, Development, Demonstration, and Deployment
REV	Renewable Energy Vermont
RFP	Request for Proposals
RFQ	Requests for Quotation or Qualifications
R&D	Research and Development
R&I	Research and Innovation
SBIR	Small Business Innovation Research
SEIA	Solar Energy Industries Association
SET-Plan	Strategic Energy Technology Plan
SETO	Solar Energy Technologies Office
SME	Small and Medium-sized Enterprise
STTR	Small Business Technology Transfer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Abbreviation	Explanation
SVCE	Silicon Valley Clean Energy
TIA	Technology Investment Agreement
US	United States
USDA	United States Department of Agriculture
USREA	United States Renewable Energy Association
WETO	Wind Energy Technologies Office
WPTO	Water Power Technologies Office

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

1 Introduction

Context

This Research handbook, which has been developed within context of the ENRICH in the USA network [9], aims to provide relevant information on the United States (US) landscape concerning the renewable energy research community. It provides information on the research community, including key research universities, research centers, networks, relevant conferences and events, as well as important industry clusters and initiatives involving the public and private sectors.

The Research handbook can be an effective source and tool to gain knowledge on the US renewable energy research community and:

- To identify potential approaches to developing collaborative projects with US researchers, research groups and research organizations. The researchers, research groups and centers can be contacted directly to develop a rapport, and potential interest in collaborating.
- To identify relevant networks and conferences that can be used as a conduit to meeting potential collaborators.
- To identify and assess the opportunity to participate in US funding programs related to renewable energy research and development (R&D), in order to propose potential project opportunities to US research counterparts.

Therefore, it is the hope of the research handbook authors that the information is useful in assisting European Union (EU) researchers in their efforts to develop stronger ties to the US research community that is focused on renewable energy.

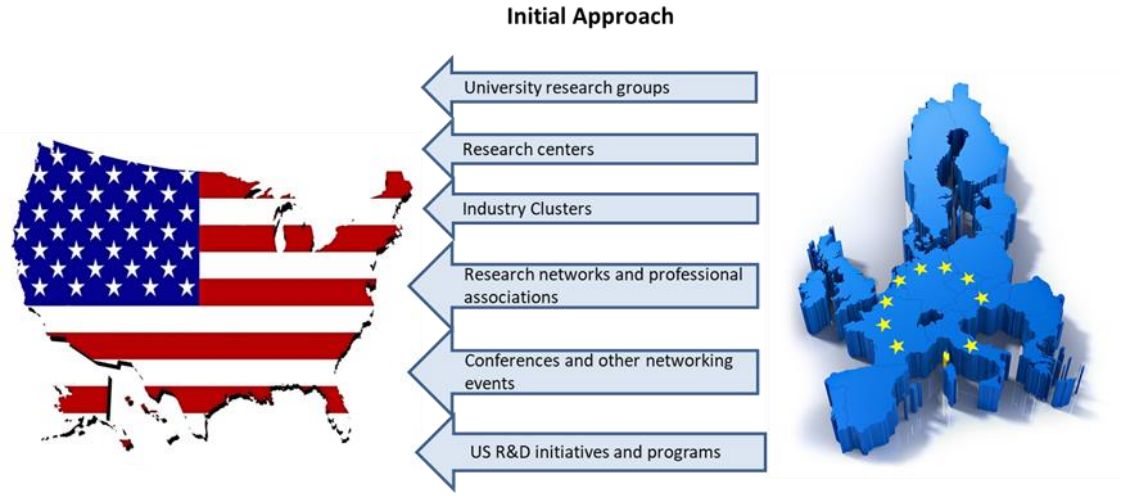


Figure 2 - Initial Approaches to Establishing Collaborative R&D Activities

[9] https://near-us.eu/project-overview

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

Energy sector: Renewable Energy

The European Commission (EC) defines renewable energy as the energy that can be produced from sources, such as wind, solar, hydro, tidal, geothermal, and biomass[10]. This is opposed to traditional methods of energy production which often involved the burning of fossil fuels. The US Renewable Energy Resources Act of 1980[11] defines renewable energy resources as any energy resource which has recently originated in the sun, including direct and indirect solar radiation and intermediate solar energy forms such as wind, ocean thermal gradients, ocean currents and waves, hydropower, photovoltaic energy, products of photosynthetic processes, organic wastes, and others[12,13,14].

Renewable energies such as geothermal energy, solar energy, waterpower and wind power have a crucial role in tackling the twin challenge of promoting energy security and reducing the dangerous effects of global warming emissions[15,16]. Renewable energies have several benefits that can contribute to national and regional development. These benefits include, but are not limited to, improvement of public health, increase of energy supply diversity, decrease of local environmental pollution, and the creation of new jobs[17,18].

Despite that those renewable energies derive from sources that are abundant, they are not highly efficient, and the prices are not affordable[19]. Moreover, reducing greenhouse gas emissions and developing new environmental assets still require innovation and development of new green technologies[20]. Therefore, R&D activities are crucial for the development of next generation, advanced renewable energy technologies[21].

Importance of renewable energy research to the EU

According to the Renewable Energy Directive (2009/28/EC), the EU is highly committed to promoting energy supply security, fostering technological development and innovation, and providing opportunities for employment and regional development[22]. Therefore, the EU has committed itself to achieve at least a 32% share of renewable energy consumption by the year 2030[23]. Moreover, to meet

[10] https://ec.europa.eu/energy/en/topics/renewable-energy
[11] https://definitions.uslegal.com/r/renewable-energy-resources-act/
[12] https://definitions.uslegal.com/r/renewable-energy-resource/
[13] https://www.congress.gov/bill/96th-congress/senate-bill/932
[14] http://uscode.house.gov/statviewer.htm?volume=94&page=716
[15] https://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WnLqP6hl8dU
[16] https://www.euractiv.com/section/energy-environment/linksdossier/eu-renewable-energy-policy/
[17] https://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WnLqP6hl8dU
[18] https://www.iea.org/publications/freepublications/publication/renewenergy.pdf
[19] https://www.conserve-energy-future.com/advantages-and-disadvantages-of-renewable-energy.php
[20] https://www.oecd.org/sti/outlook/e-outlook/stipolicyprofiles/newchallenges/greentechnologyandinnovation.htm
[21] https://www.nap.edu/read/9843/chapter/4
[22] https://ec.europa.eu/jrc/en/research-topic/renewable-energy
[23] https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

the EU's energy and climate targets for 2030, EU countries need to establish a 10-year integrated national energy and climate plan (NECP) for the period from 2021 to 2030. The national plans outline how the EU countries intend to address five areas: energy efficiency, renewables, greenhouse gas emissions reductions, interconnections, and research and innovation[24].

The EU is highly focused on promoting coordinated R&D policies in order to foster the development and implementation of renewable technologies that can lead to a more secure, sustainable, competitive, and affordable energy system[25, 26]. In this context, the EU has implemented the Strategic Energy Technology Plan (SET-Plan), which aims to accelerate the development and deployment of low-carbon technologies, such as Photovoltaics, Concentrated Solar Power, Wind Energy, Ocean Energy, Hydro Power and Geothermal Energy[27]. Moreover, Cluster 5 of Horizon Europe is dedicated supporting research and innovation to achieve climate neutrality in Europe by 2050, entailing the transition to climate neutrality of the energy and mobility sectors by 2050 at the latest, while boosting their competitiveness, resilience and utility for citizens and society and their ecological footprint, ensuring a just transition. Thus, as outlined in Horizon Europe Action Plan 2021-2024, research and innovation actions will support the implementation of the Paris Agreement, the European Green Deal (greater ambition for 2030 requires faster technological development and accelerated economic and societal transformation); the European Economic Recovery Plan and other EU priorities in the areas of climate, energy, and mobility.

Importance of renewable energy research to the US

In 2019, the electricity sector was the second largest source of US greenhouse gas emissions, accounting for 25 percent of the US total. This is mainly caused by fossil fuels like coal, and natural gas.[28] In this context, the US Government has been highly focused on promoting the development of renewable energy technologies, especially solar and wind energy technologies, through federal policy incentives and R&D grants[29].

Federal initiatives focused on developing and deploying renewable technologies fall within the scope of the Energy Policy Act of 2005[30], the Energy Independence and Security Act of 2007[31], the American Recovery and Reinvestment Act of 2009[32] and, more recently, the Clean Air Act under Section 111(d)

[24] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/energy-and-green-deal_en
[25] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy
[26] https://ec.europa.eu/jrc/en/research-topic/renewable-energy
[27] https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan
[28] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[29] http://sustainableenergy.org/current-state-of-u-s-renewable-energy-policy/
[30] https://www.epa.gov/laws-regulations/summary-energy-policy-act
[31] https://www.epa.gov/laws-regulations/summary-energy-independence-and-security-act
[32] https://www.grants.gov/web/grants/learn-grants/grant-policies/recovery-act-2009.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

known as the Clean Power Plan of 2015[33, 34]. Moreover, the 2013 US Climate Action Plan aims to reduce carbon pollution and foster the expansion of renewable energy technologies[35]. In fact, federal policies regarding renewable energies are also enacted and required at the local and state levels due to the importance of reducing global warming emissions[36].

In 2020, consumption of renewable energy in the United States grew for the fifth year in a row, reaching a record high of 12% of total US energy consumption. According to the information from the US Energy Information Administration, renewable energy was the only source of US energy consumption that increased in 2020 from 2019[37]. Further, the share of renewable energy in the country's energy consumption has doubled since 2008, which further outlines the importance of the development of R&D activities in this field[38]. Renewable growth is expected to further accelerate in, and beyond 2021 as the new administration plans to execute on a platform that includes rejoining the Paris Climate Accord, investing USD 2 trillion in clean energy, and fully decarbonizing the power sector by 2035 in order to achieve a larger goal of net-zero carbon emissions by 2050[39, 40].

Renewable energy cooperation between the EU and the US

The EU and the US are key partners in R&D. In 1998, the EU and the US signed the Agreement for Scientific and Technological Cooperation, which governs R&D and innovation cooperation between the EU and the US. This agreement has been renewed four times for a period of five years each time, and is now valid until October 2023[41,42].

The EU and the US are important allies in the field of energy[43]. In 2009, the EU and the US established the EU-US Energy Council, which aims to strengthen coordination on strategic energy issues of mutual interest of R&D cooperation, such as renewable energies[44, 45]. In 2018, during the 8th EU-US Energy Council both parties discussed the possibilities of cooperation with regards to energy security,

[33] https://www.ucsusa.org/our-work/global-warming/reduce-emissions/what-is-the-clean-power-plan#.WnNGg6hl8dV
[34] http://sustainableenergy.org/current-state-of-u-s-renewable-energy-policy/
[35] https://www.iea.org/policiesandmeasures/pams/unitedstates/name-44831-en.php?s=dHlwZT1yZSZzdGF0dXM9T2s,&return=PG5hdiBpZD0iYnJlYWRjcnVtYiI-PGEgaHJlZj0iLyI-SG9tZTwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy8iPlBvbGljaWVzIGFuZCBNZWFzdXJlczwvYT4gJnJhcXVvOyA8YSBocmVmPSIvcG9saWNpZXNhbmRtZWFzdXJlcy9yZW5ld2FibGVlbmVyZ3kvIj5SZW5ld2FibGUgRW5lcmd5PC9hPjwvbmF2Pg,,
[36] https://www.sciencedirect.com/science/article/pii/S0301421511000449

[37] https://www.eia.gov/todayinenergy/detail.php?id=48396
[38] https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

[39] https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/renewable-energy-outlook.html

[40] https://joebiden.com/clean-energy/
[41] http://ec.europa.eu/research/iscp/pdf/policy/roadmaps_usa-2016.pdf
[42] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Ari0009
[43] https://ec.europa.eu/energy/en/topics/international-cooperation/united-states-america
[44] https://ec.europa.eu/energy/en/topics/international-cooperation/united-states-america
[45] https://energy.gov/ia/us-eu-energy-council

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

including diversification of energy sources, suppliers, and routes as well as clean energy innovation and other relevant technological areas[46]. ´

EU-US Agenda for global change (2020), sets out some of the guiding principles of cooperation for a transatlantic partnership between the EU and the US for the future. The document emphasizes that the EU and the US should capitalise on their experience and expertise through a new green tech alliance to create lead markets and cooperate on clean and circular technologies, such as renewables, grid-scale energy storage, batteries, clean hydrogen, and carbon capture, storage and utilisation. This would complement the work done by the EU-US Energy Council and provide strong ground for transatlantic investment and support partner countries in meeting their climate commitments[47].

Most recently, at the EU-US summit in June 2021, both the EU and the US agreed to accelerate a climate-neutral future, ensure a just transition that leaves no one behind, and to lead by example through becoming net zero greenhouse gases economies no later than 2050[48].

Moreover, the EU and US cooperation on energy technology R&D activities is promoted through the EU's Research and Innovation Framework Programme (previously H2020 and now Horizon Europe), which emphasize the importance of conducting R&D activities in the fields of Photovoltaics, Concentrated Solar Power, Wind energy, Ocean Energy, Hydropower and Geothermal Energy[49, 50]. Since both the EU and the US recognize the development and deployment of renewable energies as strategic research priorities, the cooperation between both parties is expected to be promoted and strengthened in the years to come[51].

Thematic Research Areas related to renewable energy

The EU and the US have defined specific R&D priorities related with renewable energy. Thus, according to the previous H2020 Work Programme "Secure, Clean and Efficient Energy", the EU defined the development of R&D activities in the fields of "Photovoltaics, Concentrated Solar Power, Wind energy, Ocean Energy, Hydro Power, Geothermal Energy, Renewable Heating and Cooling, Energy Storage, Biofuels and Alternative Fuels, Carbon Capture and Storage", as its main priorities in the area of Low Carbon Technologies[52]. It should be highlighted that 14 organisations from the USA participated in 13 H2020 projects funded under this topic[53] (details of the EU-US collaborative projects are contained in Annex 2: Summary of the collaborative EU-USA H2020 projects). Horizon Europe programme continues

[46] https://ec.europa.eu/info/news/8th-eu-us-energy-council-brussels-2018-jul-12_en

[47] https://ec.europa.eu/info/sites/default/files/joint-communication-eu-us-agenda_en.pdf

[48] https://ec.europa.eu/energy/topics/international-cooperation/key-partner-countries-and-regions/united-states-america_en

[49] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy

[50] http://ec.europa.eu/research/iscp/pdf/policy/roadmaps_usa-2016.pdf

[51] http://ec.europa.eu/research/iscp/pdf/policy/roadmaps_usa-2016.pdf

[52] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy

[53] https://webgate.ec.europa.eu/dashboard/sense/app/f7222aef-4afa-4e6b-9e59-4948dc2e58e1/sheet/dDqktX/state/analysis

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

this trend with the new Cluster 5 Climate, Energy and Mobility. The WP 2021-2022 sets out the objective of supporting the implementation of the Paris Agreement and the United Nations Sustainable Development Goals. The overarching driver for this cluster is to accelerate the twin green and digital transitions and associated transformation of our economy, industry and society with a view to achieving climate neutrality in Europe by 2050[54].

The US Office of Energy Efficiency and Renewable Energy (EERE) 2016–2020 Strategic Plan and Implementing Framework identifies the development and deployment of solar, wind, water, and geothermal power generation technologies as the US R&D priorities in this field[55].

The main thematic research areas related to renewable energy R&D activities identified in this Research handbook represent the commonalities between the EU and the US R&D priorities in the renewable energy field[56, 57]:

- **Geothermal Energy:** Geothermal Energy is a virtually untapped energy resource derived from the earth's heat[58]. The geothermal energy is accessible through the transfer of heat from rocks to the surface via ground water, either through boreholes or naturally occurring cracks and faults[59].
- **Solar Energy:** Solar Energy is sourced from thermal radiation from the sun. This involves the use of a fluid passing through a heat sink exposed to sunlight. The current state of technology development allows the use of two different approaches: solar thermal collectors and photovoltaic cells[60].
- **Water Energy:** Water Energy is the power derived from the energy of falling water or fast running water[61]. Water energy is divided in three main categories, Hydroelectricity, Ocean Energy and Tidal Energy[62].
- **Wind Energy:** Wind Energy is the process by which the wind is used to generate mechanical power or electricity. The wind turbines convert the kinetic energy from the wind into mechanical power. This, in turn, is converted into electricity[63].

Although there are other areas that may also be of high interest to the European research and industry communities, the scope of this Research handbook is based on its objective which is to demonstrate

[54] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-8-climate-energy-and-mobility_horizon-2021-2022_en.pdf
[55] https://energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf
[56] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/secure-clean-and-efficient-energy
[57] https://energy.gov/sites/prod/files/2015/12/f27/EERE_Strategic_Plan_12.16.15.pdf
[58] https://energy.gov/eere/geothermal/about
[59] http://s3platform.jrc.ec.europa.eu/geothermal-energy
[60] http://instituteforenergyresearch.org/topics/encyclopedia/solar/
[61] http://www.alternative-energy-tutorials.com/hydro-energy/hydro-energy.html
[62] http://www.renewablegreenenergypower.com/water-hydro-energy-is-a-very-important-renewable-energy-source/
[63] http://windeis.anl.gov/guide/basics/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

the various avenues EU researchers can take to approach the US research community related to the above-mentioned areas. A similar approach could be taken for many related areas of interest.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

2 US research community landscape

The US is the world leading country in terms of R&D investment, and this is still a fact when the public and private sectors are analysed separately[64,65]. In 2018, the country's total spending on R&D was $580 billion (nearly €494 billion), which represents about 2.9% of its Gross Domestic Product (GDP), and more importantly, will account for over a quarter of the global R&D investment[66]. The R&D programs are mainly supported by industry ($404 billion, nearly €344 billion), the Federal Government ($127 billion, nearly €108 billion), Academia ($21 billion, nearly €18 billion), and non-profits organizations ($22 billion, nearly €19 billion)[67].

In addition, the EERE mainly carries out the federal R&D investment in renewable energies. The Fiscal Year 2020 Budget Request provides $2.4 billion (nearly €2 billion) to fund innovations that will make US energy sources more affordable, reliable, and efficient; focused on energy storage and harsh environment materials, investments in federal R&D infrastructure and testbeds, as well as other activities that build on US energy dominance. The Request continues to focus the Department's energy ($2.4 billion, nearly €2 billion) and science ($5.5 billion, nearly €4.6 billion) programs on early-stage R&D at the national laboratories to advance American primacy in scientific and energy research in an efficient and cost-effective manner[68].

The US research landscape is comprised of world leading universities, research centers, research networks and industry clusters that are primarily funded by an extensive network of federal and state funding initiatives and industry endowments[69]. The US research community encompasses a complex set of different actors that receive support through a large number of agencies, such as the DoE and the National Science Foundation (NSF).

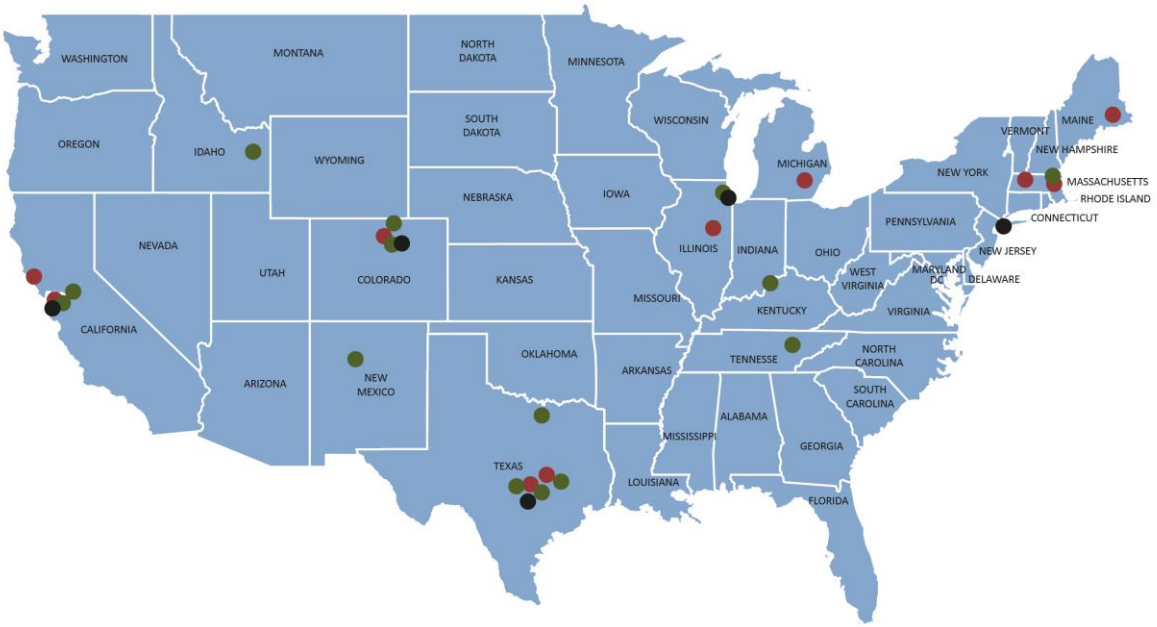
Considering the geographic distribution of the key players within the US renewable energy research community, there are several aspects that should be highlighted. First, as it can be seen from the map below, the states of California, Colorado, and Texas have a high concentration of renewable energy R&D activity. Secondly, it is important to emphasize that the northeast region of the US also has a high concentration of important renewable energy R&D activities, particularly in the states of Maine, Massachusetts, Michigan, and New York.

[64] https://www.aip.org/fyi/2016/us-rd-spending-all-time-high-federal-share-reaches-record-low
[65] https://www.iriweb.org/sites/default/files/2016GlobalR%26DFundingForecast_2.pdf
[66] http://digital.rdmag.com/researchanddevelopment/2018_global_r_d_funding_forecast?pg=4#pg4

[67] https://fas.org/sgp/crs/misc/R44307.pdf

[68] https://www.energy.gov/cfo/articles/fy-2020-budget-justification
[69] http://www.rcuk.ac.uk/international/offices/us/research-landscape-in-the-usa/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.



University research groups

Massachusetts Institute of Technology
Cambridge, Massachusetts

Stanford University
Stanford, California

Texas A&M University
College Station, Texas

University of California, Berkeley
Berkeley, California

University of Colorado Boulder
Boulder, Colorado

University of Illinois Urbana-Champaign
Champaign, Illinois

University of Maine
Orono, Maine

University of Massachusetts Amherst
Amherst, Massachusetts

University of Michigan
Ann Arbor, Michigan

University of Texas at Austin
Austin, Texas

Research Centers

Argonne National Laboratory
Lemont, Illinois

Center for Next Generation Photovoltaics
Fort Collins, Colorado
- Austin, Texas
- College Station, Texas
- Killeen, Texas

Conn Center for Renewable Energy Research
Louisville, Kentucky

Idaho National Laboratory
Idaho Falls, Idaho

Lawrence Livermore National Laboratory
Livermore, California

National Renewable Energy Laboratory
Golden, Colorado

Oak Ridge National Laboratory
Oak Ridge, Tennessee

Sandia National Laboratories
- Livermore, California
- Albuquerque, New Mexico

WindSTAR
Richardson, Texas
- Lowell, Massachusetts

Industry clusters

Silicon Valley, California
San Francisco Bay Area, California

Smart Grid Cluster, Illinois
Chicago, Illinois

New York City, New York
New York City, New York

Colorado Clean Energy Cluster
Boulder, Colorado

Texas Energy Cluster, Texas
Austin, Texas

Figure 3 - US Geographic Distribution of University Research Groups, Research Centers and Industry Clusters Focused on Renewable Energies R&D Activities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

2.1. University research groups

University research groups are comprised of researchers who share common, and complementary research interests in leading areas. Moreover, these research groups often share similar needs regarding research infrastructure[70,71]. With respect to this research handbook, a university research group is either a research centre or an institute housed at a university campus, a division, department, or laboratory of a university.

The research groups identified in this section have been selected based on extensive literature review of their citations. The identified research groups are focused on at least one of the four main thematic research areas: Geothermal Energy, Solar Energy, Water Energy, and Wind Energy.

The research of renewable energies requires knowledge from several different disciplines, such as engineering, environmental sciences, materials science or physics. Hence, universities can have more than one research group focused on renewable energy research.

In this Research handbook, there have been identified three types of research groups: groups, such as the Texas A&M Institute for Quantum Science and Engineering and the Institute for Sustainability, Energy and Environment at the University of Illinois Urbana-Champaign, which are not exclusively dedicated to renewable energies research; groups totally dedicated to renewable energy related research activities, such as the MIT Centre for Clean Water and Clean Energy and the Renewable & Appropriate Energy Laboratory at the University of California, Berkeley; and groups focused only on one specific type of renewable energy, such as the Wind Energy Centre at the University of Massachusetts Amherst and the Marine, Ocean and Offshore Research Group at the University of Maine.

Most of the identified research groups are focused on developing R&D activities in the field of solar energy, which reveals the current importance that is given by the US research community to this thematic research area. In fact, the advancement of technologies such as Solar Photovoltaic Technology[72], Concentrating Solar Power Systems[73], Solar Process Heat Processes[74] and Passive Solar Technology[75] is considered highly important to overcome some of the solar energy drawbacks[76, 77].

[70] http://www.sussex.ac.uk/research/about/groups/
[71] https://www.wits.ac.za/health/research/research-entities/definition-of-an-entity/
[72] https://www.nrel.gov/workingwithus/re-photovoltaics.html
[73] https://www.nrel.gov/workingwithus/re-csp.html
[74] https://www.nrel.gov/workingwithus/re-solar-process.html
[75] https://www.nrel.gov/workingwithus/re-solar.html
[76] https://www.nrel.gov/workingwithus/re-solar.html
[77] https://www.our-energy.com/solar_energy_research_in_united_states.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Table 2 - Sample of University Research Groups

Massachusetts Institute of Technology (MIT)

Research Group	Research coordinator (RC) Name	RC email address	Relevant research areas	Internet link
MIT Rohsenow Kendall Heat Transfer Laboratory	Professor John Lienhard	lienhard@mit.edu [78]	Water Energy	https://meche.mit.edu/people/faculty/LIENHARD@MIT.EDU
MIT Centre for Ocean Engineering	Professor Nicholas Makris	makris@mit.edu [79]	Water Energy	http://meche.mit.edu/people/faculty/MAKRIS%40MIT.EDU
MIT Energy Initiative	Professor Robert Armstrong	rca@mit.edu	Solar Energy	https://cheme.mit.edu/profile/robert-c-armstrong/
MIT Photovoltaic Research Laboratory	Professor Tonio Buonassisi	Buonassisi@mit.edu [80]	Solar Energy	http://meche.mit.edu/people/faculty/buonassi%40mit.edu

[78] Alternative contact: gervaisc@mit.edu
[79] Alternative contact: gfox@mit.edu
[80] Alternative contact: kellymj@mit.edu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

Stanford University

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link
Stanford Precourt Institute for Energy	Professor Jim Chen	jimchen@stanford.edu	Geothermal Energy, Solar Energy and Wind Energy	https://energy.stanford.edu/people/jimmy-chen

Texas A&M University

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link
Texas A&M Centre for Electrochemical System and Hydrogen Research	Professor Hong-Cai Joe Zhou	zhou@chem.tamu.edu	Solar Energy	https://www.chem.tamu.edu/rgroup/zhou/index.html
Texas A&M Energy Institute	Professor Stratos Pistikopoulos	stratos@tamu.edu	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	https://engineering.tamu.edu/chemical/profiles/pistikopoulos-stratos.html
Texas A&M Institute for Quantum Science and Engineering	Professor Marlan Scully	scully@tamu.edu	Solar Energy	https://physics.tamu.edu/directory/marlan-scully/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

University of California, Berkeley

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link
Energy & Resources Group	Professor Daniel M. Kammen	kammen@berkeley.edu	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	http://guide.berkeley.edu/departments/energy-resources-group/#contacts
Javey Research Group	Professor Ali Javey	ajavey@berkeley.edu	Solar Energy	http://nano.eecs.berkeley.edu/
Renewable & Appropriate Energy Laboratory (RAEL)	Professor Daniel M. Kammen	kammen@berkeley.edu	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	https://rael.berkeley.edu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

University of Colorado Boulder

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link
Dukovic Group	Professor Gordana Dukovic	gordana.dukovic@colorado.edu	Solar Energy	https://www.colorado.edu/lab/dukovicgroup/
Electrical Grid and Energy Storage Research Group	Professor Frank Barnes	Frank.Barnes@colorado.edu	Water Energy	https://www.colorado.edu/faculty/barnes/research
Energy and Power Systems	Professor Annie Bennett	annie.bennett@ucdenver.edu	Solar Energy and Wind Energy	http://www.ucdenver.edu/academics/colleges/Engineering/Programs/Electrical-Engineering/Research/Pages/EnergyandPowerSystems.aspx

University of Illinois Urbana-Champaign

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Electrical and Computer Engineering Department	Professor Philip T Krein	krein@illinois.edu	Solar Energy and Wind Energy	https://ece.illinois.edu/research/
Institute for Sustainability, Energy and Environment	Professor Benjamin J. McCall	bjmccall@illinois.edu	Solar Energy and Wind Energy	http://bjm.scs.illinois.edu/
Shim Research Group	Professor Moonsub Shim	mshim@illinois.edu	Solar Energy	https://shimlab.matse.illinois.edu/
Pilawa Research Group	Professor Robert Pilawa-Podgurski	pilawa@illinois.edu	Solar Energy	https://pilawa.ece.illinois.edu/

University of Maine

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Marine, Ocean and Offshore Research Group	Professor Susan J. Hunter	mhunter@maine.edu	Water Energy and Wind Energy	https://umaine.edu/moorgroup/

University of Massachusetts Amherst

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link
Centre for Energy Efficiency and Renewable Energy (CEERE)	Professor Beka Kosanovic	kosanovi@ecs.umass.edu	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	http://www.ceere.org/
Wind Energy Center	Professor James F. Manwell	manwell@ecs.umass.edu	Wind Energy	www.umass.edu/windenergy/

University of Michigan

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Centre for Solar and Thermal Energy Conversion (CSTEC)	Professor Peter F. Green	pfgreen@umich.edu	Solar Energy	https://www.greengroup.engin.umich.edu/
Dasgupta Group	Professor Neil Dasgupta	ndasgupt@umich.edu	Solar Energy	https://dasgupta.engin.umich.edu/
Electrical and Computer Engineering Faculty, Power and Energy Department	Professor Ian A. Hiskens	hiskens@umich.edu	Solar Energy and Wind Energy	https://ece.umich.edu/eecs/research/area.html?areaname=power-energy

University of Texas at Austin

Research group	Research coordinator (RC) name	RC email address	Relevant research areas	Internet link

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

IGERT Sustainable Grids	Professor Risa Hartman	rhartman@che.utexas.edu	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	http://research.engr.utexas.edu/igertsustainablegrids/
Energy Institute	Professor Brian Korgel	korgel@che.utexas.edu	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	https://energy.utexas.edu/brian-korgel
Webber Energy Group	Professor Michael E. Webber	webber@mail.utexas.edu	Solar Energy and Wind Energy	http://www.webberenergygroup.com/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

2.2. Research Centers

Renewable energy research centers are crucial to translate scientific knowledge into new discoveries that can lead to technology innovation, development, and deployment. Therefore, renewable energy research requires an interdisciplinary approach that includes the contribution of researchers and industry members from different disciplines, such as engineering, environmental sciences, materials science or physics. In this context, there are three main types of renewable energy research centers considered by this Research handbook:

- Federally funded research and development centers (FFRDC): DoE national laboratories that work closely with universities, industry, and other national laboratories (e.g., Argonne National Laboratory).
- Research centers that have a strong direct collaboration with universities. Among these centers there are two different types: centers that are developed between a university and other entity (e.g., Conn Centre for Renewable Energy Research); and centers that are established by universities and several companies and other organizations (e.g., NSF sponsored Industry–University Cooperative Research Centers (IUCRC)).

The research centers highlighted in this section were identified based on the abovementioned criteria and consist only of examples of centers that are globally recognized by their renewable energy R&D activities. The selection of the centers was done by desk research, which included an extensive literature review and a review of known federal entities that support the establishment of these types of research centers.

Argonne National Laboratory

Research Areas: Geothermal Energy, Solar Energy and Wind Energy

Coordinator: Dr. Paul K. Kearns, www.anl.gov/about-argonne/leadership

The Argonne National Laboratory is a multidisciplinary research centre that aims to promote sustainable energies, a healthy environment and national security. The centre is a DoE national laboratory which works in agreement with universities, industry, and other national laboratories on subjects that are considered to be too large for one single institution. Thus, the centre often collaborates with national and international leading organizations in order to discover new ways to develop energy innovations[81]. Furthermore, the centre has a broad list of renewable energy research programs that include biofuels, hydropower, solar energy, wind power, geothermal power and their integration into electric power grids[82].

www.anl.gov/

[81] https://www.anl.gov/about-argonne
[82] https://www.anl.gov/energy/renewable-energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

Centre for Next Generation Photovoltaics, IUCRC

Research Areas: Solar Energy

Coordinator: Brian Korgel, www.iucrc.org/node/5201

The Centre for Next Generation Photovoltaics is a NSF IUCRC focused on improving the photovoltaics industry, including developing both new and established thin film PVs, taking into account performance, cost, availability, environmental impact and manufacturability. The Centre was established by the Colorado State University, Texas A&M University, Texas A&M University-Central Texas and the University of Texas at Austin[83]. Currently, the Centre brings together members consisting of large enterprises, small businesses and federal research organizations, such as the US Army Research Laboratory[84], Next Generation Technologies Inc.[85] and Ideal Power[86]. The Centre research portfolio includes a wide range of topics related with Photovoltaics and Solar space[87].

Conn Centre for Renewable Energy Research

Research Areas: Geothermal Energy, Solar Energy, Water Energy and Wind Energy

Coordinator: Dr. Henry "Hank" Conn, https://www.conncenter.org/technical-advisory-board

www.conncenter.org/

The Conn Centre for Renewable Energy Research was established by the University of Louisville in collaboration with the state of Kentucky in order to advance the deployment of renewable energy. Thus, the Centre performs R&D activities on potentially commercial renewable energy and energy efficiency technologies[88]. The Conn Centre Technical Advisory Board has identified seven core research areas: Solar Manufacturing R&D, Solar Fuels, Biofuels, Energy Storage, Advanced Energy Materials, Materials Characterization and Energy Efficiency Conservation. Moreover, the Conn Centre encourages the establishment of research partnerships with universities and industries in order to promote the acceleration of renewable energies[89].

http://www.conncenter.org/

Idaho National Laboratory (INL)

Research Areas: Wind Energy

[83] http://www.iucrc.org/center/next-generation-photovoltaics
[84] https://www.arl.army.mil/www/default.cfm
[85] https://nextenergy.tech/
[86] http://www.idealpower.com/
[87] http://www.nextgenpv.org/center-research
[88] http://www.conncenter.org/
[89] http://www.conncenter.org/research-development

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Coordinator: Dr. Mark Peters, www.inl.gov/mark-peters-bio/

The INL is a DoE national laboratory, which is focused on energy, national security, science and environment. The INL is the US largest laboratory for nuclear energy R&D and aims to promote safe, competitive and sustainable energy systems[90]. The Centre has a research program on renewable energies, which is mainly focused on Wind Energy and Power Systems[91]. Moreover, the INL has established important partnerships with researchers, academic institutions, industry, students, teachers, government agencies and businesses in order to promote innovation and technology deployment[92].

www.inl.gov/

Lawrence Livermore National Laboratory (LLNL)

Research Areas: Water Energy and Wind Energy

Coordinator: Wiliam H. Golstein, www.llnl.gov/about/organization

The LLNL is a DoE national laboratory mainly focused on responding to scientific issues of national importance and enhancing the country's defence. In this context, the LLNL aims to promote national energy security and reduce environmental impact through the deployment of renewable and sustainable energies, mainly Water and Wind Energy[93]. Thus, the LLNL is focused on developing innovative technologies to enable the expanded use of renewable energies, improve efficiency, leverage new resources and reduce costs[94]. Furthermore, the LLNL practices Open Innovation by promoting R&D collaborations with federal agencies, state and local governments[95], universities[96], industry members[97] and non-profit organizations[98].

https://st.llnl.gov/

National Renewable Energy Laboratory (NREL)

Research Areas: Geothermal Energy, Solar Energy, Water Energy and Wind Energy

Coordinator: Martin Keller, https://www.nrel.gov/about/director.html

The NREL is a well-known US renewable energy research center, operated by the DoE. The NREL is the only federal laboratory focused on research, development, commercialization, and deployment of

[90] https://www.inl.gov/about-inl/
[91] https://renewableenergy.inl.gov/SitePages/Home.aspx
[92] https://www.inl.gov/inl-initiatives/
[93] https://www.llnl.gov/missions/energy
[94] https://www.llnl.gov/missions/energy
[95] https://science.energy.gov/lp/strategic-partnership-projects
[96] https://ste-dev.llnl.gov/about-us/university-relations
[97] https://ipo.llnl.gov/
[98] https://st.llnl.gov/partnerships/collaborate

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

renewable energy and energy efficiency technologies[99]. The NREL R&D Programs include the Geothermal Technologies Program[100], the Solar Research Program[101], the Waterpower Program[102], the Wind Energy Program[103], among others. Moreover, the NREL contains the National Centre for Photovoltaics (NCPV)[104] and the National Wind Technology Center[105], which are mainly focused on developing scientific advances that can benefit industry stakeholders. The NREL R&D Programs also encompass the International Program that promotes NREL's collaboration with technical institutions and governments around the world to strengthen clean energy markets[106]. The Laboratory main international collaborations include bilateral partnerships[107], multilateral partnerships[108], and energy assessments[109].

www.nrel.gov/

Oak Ridge National Laboratory (ORNL)

Research Areas: Geothermal Energy, Solar Energy, Water Energy and Wind Energy

Coordinator: Dr. Thomas Zacharia, www.ornl.gov/content/thomas-zacharia

The ORNL is the largest DoE science and energy laboratory that conducts basic and applied research in order to deliver innovative solutions to energy and security problems[110]. The ORNL aims to deliver cutting-edge solutions on clean energy with the goal to accelerate the applied use of clean energy innovations[111]. In this context, the ORNL is highly focused on conducting R&D activities on Geothermal, Solar, Water and Wind energies[112]. The ORNL Science and Technology Partnerships Directorate aims to encourage partnerships focused on advancing technology commercialization, entrepreneurship, business development and economic development. Thus, the ORNL often partners with universities, hubs, center, institutes and small businesses[113].

www.ornl.gov/

[99] https://www.nrel.gov/about/mission-programs.html
[100] https://www.nrel.gov/geothermal/
[101] https://www.nrel.gov/solar/
[102] https://www.nrel.gov/water/
[103] https://www.nrel.gov/wind/
[104] https://www.nrel.gov/pv/index.html
[105] https://www.nrel.gov/wind/
[106] https://www.nrel.gov/about/mission-programs.html
[107] https://www.nrel.gov/international/bilateral_partnerships.html
[108] https://www.nrel.gov/international/multilateral_partnerships.html
[109] https://www.nrel.gov/international/global_energy.html
[110] https://www.ornl.gov/content/solving-big-problems
[111] https://www.ornl.gov/cleanenergy
[112] https://www.ornl.gov/research-area/renewable-energy
[113] https://www.ornl.gov/connect-with-ornl/for-industry/partnerships

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Sandia National Laboratories

Research Areas: Water Energy

Coordinator: Dr. James S. Peery, https://www.sandia.gov/about/leadership/peery.html

The Sandia National Laboratories is a FFRDC, which performs R&D activities for industry, responding to certain types of federal government solicitations. The Center's main goal is to promote national security and technology innovation by leveraging the knowledge of experts from many different scientific areas[114]. In this context, the Centre comprises different research programs, which include the Energy Research program[115]. This program includes the Energy/Water Nexus initiative that is focused on Water Energy[116]. Sandia fosters research, technology deployment and technology transfer interactions with federal, state, and local agencies, the private sector, academic institutions, and the local community[117].

www.sandia.gov/

WindSTAR IUCRC

Research Areas: Wind Energy

Coordinator: Dr. Christopher Niezrecki, www.iucrc.org/node/5816

The WindSTAR is an NSF IUCRC that aims to conduct basic and applied research on topics related to the advancement of wind turbines and the wind industry. The Centre was established through a collaboration between the University of Massachusetts Lowell and the University of Texas at Dallas, which have partnered with the Iowa State University and the Maine Wind Industry Alliance in order to develop cutting-edge R&D activities[118]. The Centre brings together university and industry researchers, such as EDP Renewables[119], GE Renewable Energy[120] and Hexion[121]. Currently, the Centre conducts research in six main areas: Composites and Blade Manufacturing; Foundations and Towers; Structural Health Monitoring, Non-Destructive Inspection & Testing; Wind Farm Modelling and Measurement Campaign; Control Systems for Turbines and Farms; and Energy Storage and Grid Integration[122].

www.uml.edu/Research/Windstar/default.aspx

[114] http://www.sandia.gov/about/index.html
[115] http://energy.sandia.gov/office-of-science/
[116] http://energy.sandia.gov/climate-earth-systems/energy-water-nexus/
[117] http://www.sandia.gov/working_with_sandia/index.html
[118] https://www.uml.edu/Research/WindSTAR/about/
[119] https://www.edprnorthamerica.com/
[120] https://www.gerenewableenergy.com/
[121] http://www.hexion.com/
[122] https://www.uml.edu/Research/WindSTAR/research/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

2.3. Industry clusters

For the purpose of this Research handbook, industry clusters are defined as geographic concentrations of businesses of closely related industries. In the US, the industry clusters have been a catalyst for economic growth for over a century, mostly due to the ability of some leading universities in the country to work cooperatively with industry. The US is embracing the system of a label or guarantee of quality from national programs such as the European Secretariat for Cluster Analysis (ESCA) certification based on a bronze, silver, or gold label[123].

Despite their importance, the cluster organizations in the US are not as institutionalized as in the EU. Nevertheless, there are numerous clusters that are represented by a formal cluster organization and tend to be supported by local Economic Development Agencies (EDA's); whereas others are part of public and/or private organizations (e.g., federal agencies, industry associations, etc.) that aim to promote competitiveness and innovation in a particular sector.

The US Cluster Mapping Project, a national economic development initiative led by Harvard Business School with the support of the US Department of Commerce, Economic Development Administration, aggregates all the country clusters providing valuable insights on business environment, demographics and performance of the clusters[124]. The platform can be considered as a formal US cluster connector and has been used to identify the most relevant industry clusters for the renewable energy sector.

California Cluster

California is currently at the forefront of renewable energy. The State of California funds and promotes its industry clusters through the California Energy Commission (CEC)[125]. In 2019, California's in-state electricity net generation from all renewable resources combined, including generation from hydroelectric power and from small-scale, customer-sited solar generation, was greater than that of any other state. As reported by the US EIA, California is the US top producer of electricity from solar, geothermal, and biomass energy. In 2019, California was also the nation's second-largest producer of electricity from conventional hydroelectric power (after Washington) and the fifth-largest from wind energy[126].

In 2015, the State committed to ensure that by 2030, 50% of its electricity will come from renewable sources, such as the sun and wind[127]. However, in 2018, this commitment has been further expanded,

[123]ESCA, Jan 2017. http://cluster-analysis.org/benchmarked-clusters/?country=6a7389f0dba345fab09a30cd321b3d23
[124]http://www.clustermapping.us/
[125] https://www.renewableenergyworld.com/articles/2016/07/innovation-clusters-drivers-of-cutting-edge-technologies-for-our-energy-future.html

[126] https://www.eia.gov/state/analysis.php?sid=CA
[127] https://futurism.com/california-reach-renewable-energy-goal-10-years-early/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

with the state passing Senate Bill 100, stablished a landmark policy requiring renewable energy and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045[128].

Furthermore, the Silicon Valley SV-REP, which was launched in 2008, is one of the largest multi-agency programs in the US focused on collaborative procurement of renewable energy. The Project was established by a Joint Venture that comprises the Silicon Valley Network's Public Sector Climate Task Force in partnership with the County of Santa Clara, which also partnered with eight additional public agencies and consulting firms in order to address the challenges related with the implementation of renewable energies[129, 130]. Moreover, the Silicon Valley Clean Energy (SVCE) also aims to provide to the region businesses with new clean energy choices at competitive rates[131].

Currently, Silicon Valley is home to some of the top tech investors in renewable energy, such as Amazon, Alphabet, Apple, Facebook, Google and Salesforce[132, 133]. Furthermore, this cluster is also home to some of the world's leading solar energy companies, such as American Array Solar, Inc.[134], Green Leaf Solar & Electric, Inc.,[135] NRG Clean Power, Inc.[136], SolarCity[137] and SolarUnion[138]. Thus, the combination of a highly skilled labour force and a high concentration of leading universities and research centers, such as Stanford University, UC Berkeley, Lawrence Livermore National Laboratory and the Sandia National Laboratories, together with significant access to venture capital make this a leading cluster in renewable energies R&D activities.

ENRICH in the USA Soft Landing Hubs: Initial Contact point for California

Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation Centers of Universities dedicated to R&I in the Clean Tech domain.

Location of the **ENRICH in the USA Soft Landing Programs** in California is the Citris Berkeley University. CalPoly University, located in the South of the Bay Area is also a vetted ENRICH Soft Landing location focusing on AgTech and CleanTech industries

The University of California (UC), Berkeley is one of the world's preeminent public universities, boasting a distinguished faculty (with 22 Nobel laureates to date), stellar research libraries, and more than 350 academic programs. At the heart of Berkeley's excellence are its 1,582 full-time faculty members, dispersed among 130

[128] https://www.energy.ca.gov/sb100
[129] http://www.solarroadmap.com/regional-initiatives/sv-rep/
[130] https://jointventure.org/index.php?option=com_content&view=article&id=189&Itemid=287
[131] https://www.svcleanenergy.org/about-us/
[132] https://www.fool.com/investing/2017/05/02/silicon-valley-is-driving-american-renewable-energ.aspx
[133]https://www.theguardian.com/sustainable-business/2016/dec/06/google-renewable-energy-target-solar-wind-power
[134] http://www.americanarraysolar.com/
[135] https://greenleafsolarelectric.com/
[136] http://nrgcleanpower.com/
[137] http://www.solarcity.com/
[138] http://www.solarunion.com/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

academic units and 80 interdisciplinary research units, including work in the domain of renewable energy research. Aside from offering several programs and booth camps focused on the research and innovation in the field of renewable energy research, UC Berkley is soft landing site for the **ENRICH in the USA.**

Located at **UC Berkley's Center for Information Technology Research in the Interest of Society (CITRIS) and the Banatao Institute is also the ENRICH in the USA Soft Landing Hub.** The institute has an objective to leverage the research strengths of the University of California campuses at Berkeley, Davis, Merced, and Santa Cruz and operate within the greater ecosystem of the University and the innovative and entrepreneurial spirit of Silicon Valley. In particular, strengthen bridges between world-class laboratory research, state and national policymakers, and companies and startups creating new applications and reshaping entire industries. Thus, the CITRIS and the Banatao Institute facilitate interdisciplinary work, including the work in the area of renewable energy, among hundreds of University of California faculty members, students, corporate partners, and international institutions.

Illinois Cluster

According to the Illinois Power Agency (IPA), the state of Illinois defined a plan to supply 25% of the electricity from renewable energy resources by 2025, a requirement under the 2016 Future Energy Jobs Act[139, 140]. In order to achieve this goal, the plan calls for the procurement of 666 megawatts of community and distributed solar[141]. Outlined in the IPA's revised plan which was approved in 2021, the Illinois Solar for All program is accepting applications for low-income residential distributed generation projects. Project application windows for non-profits/public facilities and low-income community solar projects was open in summer 2021.[142]

The Smart Grid Cluster supports economic growth for companies focused on promoting the future of energy and the grid. The cluster offers a set of business, technical and financing support services that leverage the Illinois region's corporate and research assets and help promote the energy innovation ecosystem[143]. Active cluster participants include corporations, utilities, research institutions, federal labs, and start-ups. In this context, the cluster service providers include key players, such as the Coalition: Energy[144], Energy Foundry[145], Enterprise Works[146], Illinois Science Technology Coalition (ISTC)[147], Illinois Institute of Technology[148] and IMEC[149]. The cluster's partners also include important

[139] https://www.ucsusa.org/our-work/clean-energy/midwest-states/realizing-illinois-clean-energy-potential#.WtRgoYjwbIU
[140] https://www.greentechmedia.com/articles/read/illinois-approves-path-to-a-quarter-renewable-resources-by-2025#gs.UPwmek0
[141] https://www.greentechmedia.com/articles/read/illinois-approves-path-to-a-quarter-renewable-resources-by-2025#gs.UPwmek0

[142] https://www2.illinois.gov/sites/ipa/Pages/default.aspx
[143] http://smartgridcluster.com/
[144] http://coalitionspace.com/
[145] https://www.energyfoundry.com/
[146] http://researchpark.illinois.edu/enterpriseworks
[147] https://www.istcoalition.org/
[148] https://web.iit.edu/
[149] https://www.imec.org/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

players, such as ABB[150], Argonne National Laboratory[151], ComEd[152], Elevate Energy[153] Honeywell[154], Village of Oak Park[155], among others[156].

ENRICH in the USA Soft Landing Hubs: **Initial Contact point for Illinois**

Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation Centers dedicated to R&I in the Clean Tech domain.

Locations for the **ENRICH in the USA Soft Landing Programs** in the closest proximity of the Maryland area is the **ENRICH in the USA Federal Center, Washington D.C** and **George Mason University, VA**.

ENRICH in the USA Federal Centre in D.C. is located **at the National Council of University Research Administrators** premises**.** The Centre is home to **ENRICH in the USA Government Landing Hub,** which connects companies and researchers with the US Government agencies and contractors. With its own centre, the Hub provides a great location for B2G and Research Development activities related Clean Technology. The Hub brings together more than 20 partners, which include government agencies, accelerators, incubators, universities, schools, and co-working spaces in the D.C. area. The US Government agencies that are partners and can be of interest for SMEs and researchers from the Clean Technology domain include DoE, DoD, NIH, USDA, NSF and DoC.

George Mason University is a public, coeducational institution of higher learning in Fairfax, Virginia, US It consists of 12 colleges and schools offering a variety of undergraduate and graduate degrees. Several of its graduate programs have been recognized nationally for excellence and distinction, including the George Mason Office of Sustainability. Mason has worked with Siemens Building Technologies to complete two Energy Savings Performance Contracts to upgrade its buildings to be more energy and water efficient[157]. Highlights of these projects include upgrading their heating and air conditioning equipment, replacing existing lighting with more energy efficient lighting and occupancy sensors, installing low-flow water fixtures, and improving their building automation system to match weather and occupancy schedules. The University is also the location of the **ENRICH in the USA Smart City / Infrastructure Landing Hub**, which includes Virginia Tech University and Smart City Works as partners.

Illinois' RPS requires specified electric utilities and suppliers to get a certain percentage of electricity from renewable sources. According to this law, renewable sources must make up 25% of overall electric sales by 2025, with wind energy accounting for 75% and solar accounting for 6%.[158]

[150] http://new.abb.com/
[151] http://www.anl.gov/
[152] https://www.comed.com/Pages/default.aspx
[153] https://www.elevateenergy.org/
[154] https://www.honeywell.com/
[155] https://www.oak-park.us/
[156] http://smartgridcluster.com/

[157] https://green.gmu.edu/campus-sustainability/energy/

[158] https://www2.illinois.gov/sites/ipa/Pages/default.aspx

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

New York Cluster

Renewable energy resources play a very important role in New York's economy. In, 29% of New York's electric power comes from renewable sources, such as biomass, solar and wind[159]. In this context, New York is home to key renewable energy players, such as corporations, start-ups and research institutions.

The New York City Accelerator for a Clean and Renewable Economy (NYC ACRE) aims to support clean technology and renewable energy companies in New York City, so the city becomes an example for a low-carbon future. Seeded by a grant from the New York State Energy and Research Development Authority (NYSERDA) to the Polytechnic Institute of New York University (NYU-Poly), NYC ACRE aims at developing an ecosystem of entrepreneurs, international companies, and innovative local businesses that provide solutions to climate change and energy issues in the city. Currently, the NYC ACRE comprises industry and research members, such as Brenmiller Energy[160], NECEC[161], Resonant Energy[162], and Voltaiq[163], among others[164].

Furthermore, the New York Renewable Energy Cluster (NYREC) aims to promote the creation of jobs in Hudson Valley in the renewable energy and energy efficiency sectors through the recruitment of new companies and the facilitation of existing company growth[165, 166].

ENRICH in the USA Soft Landing Hubs: Initial Contact point for New York

Through the ENRICH J-1 Soft Landing Programs, interested participants can access Incubators/Innovation centers and partners dedicated to R&I in the Clean Tech domain.

New York is the location of the **ENRICH in the USA Advanced Manufacturing Landing Hub**. Hosted by the Council of the Great Lakes Region, which has offices in Cleveland, Ohio and Toronto, Ontario, Canada and a binational presence at the TReC Incubator in Niagara Falls, New York, the Advanced Manufacturing Hub provides European stakeholders unprecedented connectivity to two national economies, and more importantly, easy access to a number of world-class manufacturing clusters and institutes from various sectors including Clean technology.

159 https://www.eia.gov/state/?sid=NY#:~:text=In%202019%2C%2029%25%20of%20New,100%25%20carbon%20free%20electricity%20goal.
160 http://www.bren-energy.com/
161 https://www.necec.org/
162 http://www.resonant.energy/
163 https://www.voltaiq.com/
164 http://ufl.nyc/members/
165 http://www.tci-network.org/initiatives/initiative/4373
166 http://clustermapping.us/content/new-york-renewable-energy-cluster

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Visiting European stakeholders can enjoy connecting with these centers of excellence and networking with manufacturing giants, including, but not limited to, IBM, Ford Motor Company, General Motors, FiatChrysler, Owens Corning, Lear, Stryker, Cummins, Whirlpool, Dana, Parker Hannifin, Magna International, Boeing, Caterpillar, Rockwell Automation, General Mills, 3M, Dow Chemical, and Procter and Gamble. These companies are deploying the latest state-of-the art technologies in additive, subtractive, robotics-based, and other advanced manufacturing methods to produce a wide variety of products for consumer, government, and commercial use.

Through its partnership with ENRICH in the USA and the TReC incubator in the binational region of Niagara Falls, New York, the Council can also offer soft landing services to those companies wishing to establish longer engagements with advanced manufacturing entities in New York state and the surrounding Great Lakes on both sides of the US – Canada border.

Colorado Cluster

Colorado is a leader in renewable energy. The state has been increasingly investing in wind, solar, geothermal, small hydroelectric, as well as in other renewable energy resources. As a result, since 2010, Colorado's renewable electricity net generation has more than tripled, led by increased wind and solar, and accounted for 30% of the state's total generation in 2020. Moreover, Colorado was the seventh-largest natural gas-producing state in 2020 and seventh among the US states in installed wind power capacity in 2020[167].

The Colorado Clean Energy Cluster (CCEC) was launched in 2006 with the aim of promoting jobs in the area of clean energy in Colorado. Thus, CCEC is focused on innovative and entrepreneurial ways to expand the clean energy sector through actionable projects and initiatives that benefit Colorado's clean energy companies. The CCEC has a member base of over 32 companies, employing over 3,000 people[168]. In addition, the CCEC partners include Colorado State University[169], Exponential Engineering Company[170], Fort Collins Area Chamber of Commerce[171], Rocky Mountain Institute[172], Sustainable Power Systems LLC[173], The City of Boulder, Colorado[174], among others[175].

[167] https://www.eia.gov/state/?sid=CO#tabs-1
[168] http://www.coloradocleanenergy.com/about
[169] https://www.colostate.edu/
[170] http://www.exponentialengineering.com/
[171] https://fortcollinschamber.com/about-us/
[172] https://www.rmi.org/
[173] http://www.sustainablepowersystems.com/
[174] https://bouldercolorado.gov/
[175] http://www.coloradocleanenergy.com/about

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Texas Energy Cluster

Renewable energy is a key element in Texas' strategy to achieve energy independence. In this context, the SECO's Innovative Energy Demonstration Program (IEDP) aims to promote the use of renewable energies and sustainable building design in Texas. Thus, this program funds solar, wind and biomass demonstration projects and supports educational efforts focused on inspiring Texans to use renewable energy systems in their communities[176].

The Texas Energy Cluster comprises three sub-clusters: oil and gas exploration and production, electric/coal/nuclear power generation, and renewable and sustainable energy generation. Texas' combination of natural resources, good transportation systems, skilled labour force and leadership in environmental research give the state an energy benefit[177]. Regarding renewable energies, Texas is home to leading renewable energies companies, such as ALSTOM[178], Avangrid Renewables[179], BP[180], Green Mountain Energy[181], Siemens Gamesa[182] and SUNPOWER[183].

ENRICH in the USA Soft Landing Hubs: Initial Contact point for Texas and Colorado

Through the ENRICH J-1 Soft-Landing Programs, interested participants can access Incubators/Innovation Centers dedicated to R&I in the Clean Tech domain.

ENRICH in the USA affiliated partner site in Texas is hosted by the **Dallas Innovation Alliance.** It is also the affiliated partner site **in the closest proximity of Colorado.**

Located in Dallas, Texas and hosted by the **Dallas Innovation Alliance** (DIA) and their **Innov8te Incubator**, the **ENRICH in the USA Smart City Landing Hub** welcomes EU research, innovation, and business stakeholders who work within smart city applications. The city of Dallas, with DIA at the helm, has had over ten years of government officials and industrial giants collaboratively transforming parts of the city into a "living lab", enabling state of the art solutions in smart city solutions, including renewable energy and clean technologies, to find a real-world, real-time urban demonstration site.

Based in the state capital of Texas, Austin, are also the **Tech Ranch**, an **ENRICH Texas Hub Partner** and a venture accelerator, and the **University of Texas at Austin (UT Austin)** one of the **ENRICH in the USA** partnering institutions and the flagship institution of the University of Texas System.

In particular, **Tech Ranch** is an accelerator comprised of a global ecosystem of entrepreneurs, businesses, investors and community leaders. The accelerator aims to equip entrepreneurs and ecosystems with insights, proven techniques, tools, and processes that develop the business, community, and global impact.

[176] https://comptroller.texas.gov/programs/seco/programs/iedp.php
[177] https://businessintexas.com/industries/energy
[178] http://www.alstom.com/404/?404;http://www.alstom.com:80/power/renewables/wind/
[179] http://www.avangridrenewables.us/
[180] https://www.bp.com/
[181] http://www.greenmountain.com
[182] http://www.siemensgamesa.com/en/
[183] https://www.sunpower.fr/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

3 Recognized research networks/ professional associations and events

Research networks and professional associations play a crucial role in fostering interaction between academia, industry and federal/state entities. Research networks are collaborative forums that foster interaction between researchers and stimulate information exchange[184,185]; whereas a professional association is a body of practitioners of a given profession, formed usually to control entry into the profession, maintain standards, and represent the profession in discussions with other relevant bodies[186, 187].

In the US, research networks are highly focused on science and engineering research and education. The US government supports a large variety of research networks focused on the country's priorities, such as electronics research. In the case of the renewable energy field, most of the US'S networks/ associations would be considered more as professional associations with a connection to the research community.

Professional associations are a crucial segment of the non-profit sector in the US. In 2013, membership organizations alone employed over 1.3 million people in the US[188]. It is important to note that professional and trade associations are simply one segment of the membership organization community. Thus, many new associations are created each year in the US, especially associations focused on key fast-growing industries, such as renewable energies.

The organization of conferences and events is one of the main activities of research networks and professional associations; therefore, a review of the US conferences and events that are focused on renewable energies was conducted to identify the most relevant professional associations in the field of renewable energy.

Through gaining knowledge of the relevant research networks, professional associations and organized conferences, one can determine the most effective approach to establishing relevant contacts in the US research community in order to pursue research collaborative opportunities.

3.1. Research networks and professional associations

American Council on Renewable Energy (ACORE)

ACORE is a non-profit organization that comprises finance, policy and technology expertise to accelerate the transition to a renewable energy economy. ACORE brings together developers,

[184] https://www.ecb.europa.eu/pub/economic-research/research-networks/html/index.en.html
[185] https://councilforeuropeanstudies.org/research/research-networks
[186] https://www.vocabulary.com/dictionary/professional%20association
[187] http://www.dictionary.com/browse/professional-association
[188] http://www.thepowerofa.org/wp-content/uploads/2012/03/PowerofAssociations-2015.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

manufacturers, financial institutions, corporate renewable energy buyers, grid technology providers, utilities, professional service firms, colleges, universities and allied non-profit groups with the aim to promote the development of renewable energy technologies. Furthermore, ACORE is highly focused on facilitating partnerships and undertaking strategic outreach on the policies and financial structures essential to renewable energy growth[189]. ACORE also sponsors events focused on renewable energy, such as the Renewable Energy Grid Forum[190] and the Renewable Energy Policy Forum[191].

https://acore.org/

American Solar Energy Society (ASES)

ASES is a non-profit association that supports the sustainable living and 100% renewable energy. ASES comprises perspectives of science, industry, policy members and citizens in order to accelerate the transition to a renewable energy society[192]. The Society aims to promote renewable energies by organizing annual events like the National Solar Tour and National Solar Conference, which present technical data and academic research to the greater community. ASES has 68 business members that include contractors, developers, dealers, installers, researchers, among others[193].

www.ases.org/

American Wind Energy Association (AWEA)

AWEA is the trade association for the US wind industry, which aims to represent the interests of America's wind energy industry[194]. AWEA regularly conducts research, does advocacy work around issues and policies in the wind industry, and offers a membership program that helps to connect professionals within the field[195]. AWEA's members include project developers, parts manufacturers and researchers. Furthermore, AWEA also promotes several events and training opportunities within the field of wind energy, such as the WINDPOWER Conference & Exhibition, the Regional Wind Energy Conference – Northeast or the Wind Energy Fall Symposium[196].

www.awea.org/

[189] https://acore.org/what-we-do/
[190] https://www.eventbrite.com/e/renewable-energy-grid-forum-registration-43024443268
[191] http://www.acorepolicyforum.org/
[192] https://www.ases.org/about/about-us/
[193] https://www.ases.org/our-community/business-members/
[194] https://www.awea.org/about-awea
[195] https://www.ecotechinstitute.com/ecotech-news/8-renewable-energy-organizations-you-should-know-about
[196] https://www.awea.org/UpcomingAweaEvents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Geothermal Energy Association (GEA)

GEA is a trade association comprised of US companies that promote the extended use of geothermal energy. GEA membership includes small and medium-sized enterprises (SMEs), universities, agencies, suppliers, researchers, contractors, among others[197]. In order to accomplish its mission, GEA: advocates for public policies that will promote the development and utilization of geothermal resources; provides a forum for the industry to discuss issues and problems; promotes R&D activities to improve geothermal technologies; presents industry views to governmental organizations; provides assistance for the export of geothermal goods and services; compiles statistical data about the geothermal industry; and develops education and outreach projects[198].

http://geo-energy.org/Default.aspx

Solar Energy Industries Association (SEIA)

SEIA is the national trade association for the US solar energy industry, which aims to represent the organizations that promote, manufacture, installs and supports the development of solar energy. SEIA's main goal is to create jobs, remove market barriers, promote cost-competitiveness and educate the public on the benefits of solar energy[199]. Furthermore, SEIA aims to promote solar energy at the federal and states level, raising concerns about important issues for the sector[200]. SEIA brings together manufacturers, project developers, installers and financiers from the solar energy industry[201]. The SEIA has roughly 1,000 member companies that include SMEs and multi-national companies[202].

www.seia.org/

Solar Energy Innovation Network

The Solar Energy Innovation Network is a collaborative research effort managed by the NREL and supported by the DoE Solar Energy Technologies Office. The Solar Energy Innovation Network aims to develop and validate new ways for solar energy to improve the affordability, reliability, and resiliency of the US electric grid. In order to accomplish this goal, the Network cooperates with US utilities, state and local governments, non-profit organizations, innovative companies, and system operators that are implementing pilot projects. Thus, the Solar Energy Innovation Network creates teams of stakeholders

[197] http://geo-energy.org/gea_members.aspx
[198] http://geo-energy.org/aboutGEA.aspx
[199] https://www.seia.org/about
[200] https://www.seia.org/initiatives-advocacy
[201] https://www.seia.org/directory
[202] https://www.seia.org/about

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

that work together to develop novel applications of solar energy and other distributed energy technologies in order to develop a more reliable and resilient grid[203].

www.nrel.gov/solar/solar-energy-innovation-network.html

United States Renewable Energy Association (USREA)

The USREA is a renewable energy advocacy group that aims to promote advanced technologies in the renewable energy industry. The USREA membership includes product manufacturers, suppliers, installers and academics in the renewable energy industry, as well as customers[204]. Moreover, the USREA provides services in different areas related with the renewable energy industry, such as product recommendations, web development services, business marketing services and renewable energy system designs[205].

www.usrea.org/

3.2. Conferences and other networking events

Conferences and other networking events provide an important platform where renewable energy researchers and professionals can present and discuss high-quality research and technology advances. Renewable energy conferences are also an excellent opportunity to foster R&D collaboration between researchers, professionals and industry members, share knowledge and discuss the development and deployment of technologies.

Due to the importance of renewable energy, there are several conferences and other networking events focused on this field in the US. Some of the leading renewable energy conferences and other networking events were identified by desk research, which included an extensive literature review and a review of the conferences sponsored by recognized renewable energy professional associations.

The conferences and other networking events identified in this Research handbook show an emphasis on the areas of Solar Energy and Wind Energy In addition, it is interesting to highlight that the conferences and events focused on renewable energies are distributed throughout the year.

[203] https://www.nrel.gov/solar/solar-energy-innovation-network.html
[204] https://www.usrea.org/about-usrea/
[205] https://www.usrea.org/services/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Table 3 - Conferences and Other Networking Events Focused on Renewable Energy

Date	Conference/Event title	Interval	Location	Research Areas	Internet link
3-6 August, 2021	47th Annual National Solar Conference and Summit	Annual	Boulder, Colorado	Solar Energy	www.ases.org/conference/
August 16-19, 2021	Offshore Technology Conference	Annual	Houston, TX	Wind Energy	https://www.otcnet.org/
August 25 – 26, 2021	The Energy Expo	Annual	Miami, FL	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	https://www.theenergyexpo.com/
September 20-23, 2021	North America Smart Energy Week	Annual	New Orleans, LA	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	https://www.solarpowerinternational.com/
21-23 September, 2021	Hydro Vision International	Annual	Spokane, Washington	Water Energy	www.hydroevent.com/index.html
4-5 October, 2021	Renewable Energy Vermont Conference & Expo (REV)	Annual	Burlington, Vermont	Geothermal Energy, Solar Energy, Water Energy and Wind Energy	www.revconference.org/
13-15 October, 2021	Offshore WINDPOWER Conference & Exhibition	Annual	Boston, Massachusetts	Wind Energy	https://www.cleanpowerexpo.org/
18-19 October, 2021	Midwest Gateway To Solar Conference	Annual	Bloomington, Minnesota	Solar Energy	https://www.mnseia.org/gateway-conference

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

Date	Conference/Event title	Interval	Location	Research Areas	Internet link
2-4 November, 2021	Oregon Solar Energy Conference	Annual	Portland, Oregon	Solar Energy	https://www.oseia.org/osec
January 13 – 15, 2022	Intersolar North America	Annual	Long Beach, CA	Solar Energy	https://www.intersolar.us/
16-19 May, 2022	AWEA Wind Energy Fall Symposium	Annual	San Antonio, Texas	Wind Energy	https://engage.awea.org/Events/Calendar-of-Events

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

4 US R&D initiatives and programs

The US R&D funding system is highly decentralized and comprises several actors, such as agencies of federal and state governments, universities, the private sector and non-profit organizations[206]. R&D is a driver of innovation and economic growth and, therefore, has particular importance for the aforementioned actors. In the US, the research developed by universities and research centers are highly supported by funds that prioritize research areas, which can lead to technological breakthroughs[207].

The US Administration is highly committed to tackling climate change and to mitigating its effects; therefore, the FY 2020 Budget provided $7.8 billion (nearly €6.9 billion) in discretionary funding for clean energy R&D across 12 agencies[208, 209]. With that in mind, the Biden administration aims to transform the United States into a 100% clean energy economy by 2050. Within this context, as a plan for the shorter term, the Biden administration announced the new target at 50-52% reduction in US Greenhouse Gas Pollution from 2005 Levels in 2030 that aims to create good-paying union jobs and securing US leadership on clean energy technologies[210].

A review of both US public and state funding initiatives was conducted to identify the most relevant R&D initiatives and programs focused on renewable energies. The following subsection provides descriptions of the initiatives and programs, while Annex 1 provides a summary table of the initiatives and programs.

4.1. Federal initiatives/programs

The US Federal Government supports renewable energy R&D activities through grants and opportunities for promoting the development and deployment of new technologies. At the federal level, the DoE, NSF, National Aeronautics and Space Administration (NASA) and the US Department of Agriculture (USDA) are the federal bodies with the largest budgets for renewable energy R&D activities[211]. Furthermore, the federal agencies have subprograms to support renewable energy R&D activities from early to advanced stages in development and implementation.

---

[206] http://www.euussciencetechnology.eu/assets/content/documents/InnovationSystemInnovationPolicyUS.pdf
[207] http://www.itif.org/files/2011-university-research-funding.pdf
[208] Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, and Transportation, Environmental Protection Agency, Nuclear Regulatory Commission, Tennessee Valley Authority, National Aeronautics and Space Administration, National Science Foundation, and the US Agency for International Development.
[209] https://obamawhitehouse.archives.gov/blog/2016/10/12/factsheet-advancing-clean-energy-research-and-development-presidents-fy-2017-budget

[210] https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/
[211] https://obamawhitehouse.archives.gov/blog/2016/10/12/factsheet-advancing-clean-energy-research-and-development-presidents-fy-2017-budget

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

Therefore, a review of the US Federal Government R&D initiatives and programs was conducted to identify the most relevant ones in the research fields related to renewable energies.

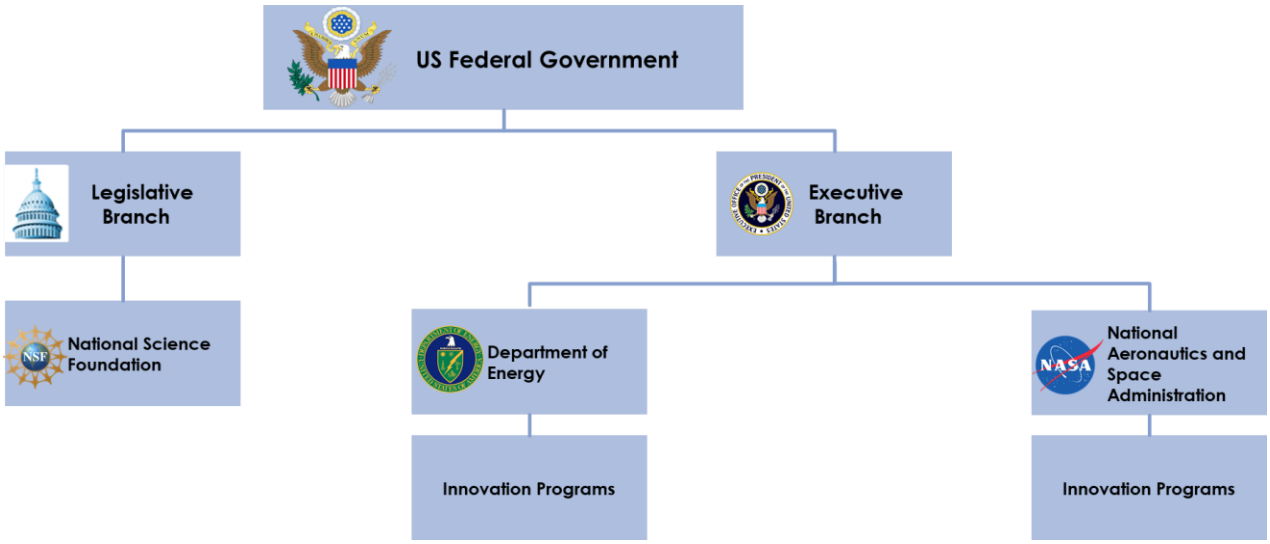


Figure 4 - US Government Organizational Chart

4.1.1. Department of Energy (DoE)

The DoE aims to guarantee the country's security and prosperity by addressing its energy, environmental and nuclear challenges through highly innovative science and technology solutions[212]. Among the DoE Offices there are two that stand out in the field of renewable energy: Advanced Research Projects Agency-Energy (ARPA-E) and the EERE[213].

Advanced Research Projects Agency-Energy (ARPA-E)

The ARPA-E aims to promote the advancement of high-potential/ impact energy technologies, which are in stage that is too early for private investment. Therefore, ARPA-E's awards encourage the development of new ways to generate, store, and use energy. The ARPA-E is focused on supporting projects that promote prosperity, national security, and environmental well-being[214]. In this context, the ARPA-E funds technology-focused and applied R&D projects that can generate real and concrete solutions to important problems in energy creation, distribution, and use. Thus, the ARPA-E promotes periodic FOAs dedicated to solving specific technical barriers of a specific energy area. The ARPA-E also

[212] https://www.energy.gov/about-us
[213] https://www.energy.gov/science-innovation/clean-energy
[214] https://www.arpa-e.energy.gov/?q=arpa-e-site-page/about

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

issues periodic OPEN FOAs to identify high-potential projects that address a wide range of energy-related technologies[215].

First Approach	
Information about Funding Opportunities	European researchers interested in ARPA-E's funding opportunities could contact the representative identified in the FOAs.
International Collaboration	The eligibility criteria for ARPA-E's funding opportunities can be found in the FOAs listed on https://arpa-e-foa.energy.gov/. Each FOA details all eligibility requirements and definitions.
Internet link	https://arpa-e-foa.energy.gov/

Office of Energy Efficiency and Renewable Energy (EERE)

The EERE aims to promote and sustain the US leadership in the transition to a clean energy economy. The EERE has seven main Strategic Goals, which include increasing the generation of electric power from renewable sources[216]. In this context, the EERE promotes funding opportunities with the aim to support research, development, and deployment in the fields of energy efficiency and renewable energy. Most of EERE's funding is provided by grants or cooperative agreements. However, the EERE's funding portfolio also includes other forms of funding such as Cooperative Research and Development Agreements (CRADAs), Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) Awards, Technology Investment Agreement (TIAs) and Unsolicited Proposals[217].

First Approach	
Information about Funding Opportunities	European researchers interested in the EERE funding opportunities could contact the representative identified in the Funding Opportunities Announcements (FOAs).
International Collaboration	The eligibility criteria for EERE's funding opportunities can be found in the FOAs listed on Grants.gov and EERE Exchange. Each FOA details all eligibility requirements and definitions.
Internet link	https://www.energy.gov/eere/funding/eere-funding-opportunities

[215] https://www.arpa-e.energy.gov/?q=programs/apply-for-funding
[216] https://www.energy.gov/eere/about-office-energy-efficiency-and-renewable-energy
[217] https://www.energy.gov/eere/funding/find-funding-office-eere

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Solar Energy Technologies Office (SETO): The SETO aims to support early-stage R&D activities in order to foster the affordability, trustworthiness, and performance of solar technologies on the grid. Thus, the SETO promotes R&D activities that integrate more solar energy into the grid, increase the use and storage of solar energy, and diminish the solar electricity costs[218]. Through a competitive solicitation process, the SETO provides funding opportunities on photovoltaics, concentrating solar power, systems integration, technology to market, and soft costs projects. Moreover, the funding opportunities supported by SETO promote collaborative partnerships among industry, universities, national laboratories, federal, state, local governments, non-government agencies and advocacy groups[219].

First Approach	
Information about Funding Opportunities	European researchers interested in the SETO funding opportunities could contact the representative identified in the FOAs.
International Collaboration	The eligibility criteria for SETO's funding opportunities can be found in the FOAs listed on www.energy.gov/eere/solar/funding-opportunities. Each FOA details all eligibility requirements and definitions.
Internet link	https://www.energy.gov/eere/solar/funding-opportunities

Geothermal Technologies Office (GTO): The GTO researches, develops, and certifies innovative and cost-competitive technologies and tools to utilize geothermal resources in the US. Thus, the GTO aims to support R&D activities on enhanced geothermal systems[220], hydrothermal resources[221], low temperature & coproduced[222], and systems analysis[223, 224]. In this context, the GTO provides funding opportunities mainly through competitive solicitations used to contract for cost-shared research, development, and demonstration projects. Furthermore, the GTO collaborates with industry, academia, and research facilities to advance the development of geothermal energy technologies[225].

First Approach	
Information about Funding Opportunities	European researchers interested in receiving funding from the GTO could contact the representative identified in the FOAs.

[218] https://www.energy.gov/eere/solar/about-solar-energy-technologies-office
[219] https://www.energy.gov/eere/solar/funding-opportunities
[220] https://www.energy.gov/eere/geothermal/enhanced-geothermal-systems-0
[221] https://www.energy.gov/eere/geothermal/hydrothermal-resources
[222] https://www.energy.gov/eere/geothermal/low-temperature-coproduced-resources
[223] https://www.energy.gov/eere/geothermal/systems-analysis
[224] https://www.energy.gov/eere/geothermal/about
[225] https://www.energy.gov/eere/geothermal/geothermal-technologies-office-funding-opportunities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

International Collaboration	The eligibility criteria for GTO's funding opportunities can be found in the FOAs listed on www.energy.gov/eere/geothermal/geothermal-technologies-office-funding-opportunities. Each FOA details all eligibility requirements and definitions.
Internet link	www.energy.gov/eere/geothermal/geothermal-technologies-office-funding-opportunities

Water Power Technologies Office (WPTO): The WPTO aims to promote the development and deployment of a portfolio of innovative technologies for clean and domestic power generation from resources such as hydropower, waves, and tides. Therefore, the WPTO partners with national laboratories, industry, universities, and other federal agencies to develop R&D activities focused on the development of marine and hydrokinetic and hydropower technologies to improve performance, lower cost and support meeting the US growing energy demand through sustainable solutions[226]. In this context, the WPTO funds R&D activities capable of generating electricity from water, through competitive solicitations. The official source for WPTO funding opportunities is FedConnect[227].

First Approach	
Information about Funding Opportunities	European researchers interested in WPTO's funding opportunities could contact the representative identified in the FOAs.
International Collaboration	The eligibility criteria for WPTO's funding opportunities can be found in the FOAs listed on www.energy.gov/eere/water/water-power-funding-opportunities. Each FOA details all eligibility requirements and definitions.
Internet link	www.energy.gov/eere/water/water-power-funding-opportunities

Wind Energy Technologies Office (WETO): The WETO aims to support R&D activities that enable the innovations needed to improve the US wind systems, while continuing to address market and deployment barriers. The WETO is highly focused on lowering the cost of wind energy through the promotion of more efficient, reliable, and more predictable wind energy systems. The WETO collaborates with national laboratories, industry, universities, and other agencies to conduct R&D activities focused on improving performance, lowering costs, and reducing market barriers for wind energy in the US[228]. Moreover, through competitive solicitations, the WETO funds R&D activities that

[226] https://www.energy.gov/eere/water/about-water-power-program
[227] https://www.energy.gov/eere/water/water-power-funding-opportunities
[228] https://www.energy.gov/eere/wind/about-doe-wind-energy-technologies-office

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

promote technological developments to improve the reliability and affordability of wind energy and address barriers to wind energy deployment. The official source for WETO funding opportunities is FedConnect[229].

First Approach	
Information about Funding Opportunities	European researchers interested in WETO´s funding opportunities could contact the representative identified in the FOAs.
International Collaboration	The eligibility criteria for WETO's funding opportunities can be found in the FOAs listed on www.energy.gov/eere/wind/wind-energy-funding-opportunities. Each FOA details all eligibility requirements and definitions.
Internet link	www.energy.gov/eere/wind/wind-energy-funding-opportunities

4.1.2. National Aeronautics and Space Administration (NASA)

NASA supports research in science and technology, including renewable energies, through various research announcements. NASA uses a peer review process to evaluate and select the research proposals submitted to the agency. In this context, NASA's research announcements aim to help NASA achieve national research objectives. Moreover, to submit a research proposal to NASA, the researchers and the affiliated organizations must be registered in NSPIRES[230].

First Approach	
Contact Person	European researchers interested in NASA grants could contact the Grants Team Leader, Dr. Theresa Stanley[231].
Email	Theresa.m.stanley@nasa.gov
International Collaboration	The eligibility criteria for NASA's funding opportunities can be found at NASA's Grants and Cooperative Agreements Manual[232]
Internet link	https://www.grants.gov/web/grants/search-grants.html?keywords=NASA

[229] https://www.energy.gov/eere/wind/wind-energy-funding-opportunities
[230] https://nspires.nasaprs.com/external/
[231] https://answers.nssc.nasa.gov/app/answers/detail/a_id/6344
[232] https://prod.nais.nasa.gov/pub/pub_library/srba/index.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

4.1.3. National Science Foundation (NSF)

The NSF provides support through grants and cooperative agreements to universities, businesses, informal science organizations and other research organizations focused on areas that are most likely to result in spectacular technological progress[233]. The NSF supports cooperative research between universities and industry, as well as the US researchers' participation in international scientific and engineering research activities. Collaboration between US researchers and European researchers can be funded in almost all new proposals to NSF or in supplements to existing NSF awards. Thus, European researchers interested in collaborating with US researchers could ask their US counterparts to contact the NSF disciplinary program officer or use the Office of International Science and Engineering (OISE) Regional and Country Contacts to inquire about funding possibilities[234].

First Approach	
European Union OISE Regional Contact	eeinfo@nsf.gov
International Collaboration	OISE fosters institutional partnerships throughout the global science and engineering research and education community, and it supports international collaborations in NSF's priority research areas. OISE encourages funding applicants to include an international component in proposals submitted to the appropriate research directorate[235].
Internet links	www.nsf.gov/od/oise/country-list.jsp; www.nsf.gov/od/oise/europe/

Energy, Power, Control, and Networks (EPCN): The NSF EPCN program supports innovative research in modeling, optimization, learning, adaptation, and control of networked multi-agent systems, higher-level decision making, and dynamic resource allocation, as well as risk management in the presence of uncertainty, sub-system failures, and stochastic disturbances. In the area of interest of Energy and Power Systems, the program promotes the development of R&D activities related with "Solar, Wind, and Storage Devices Integration with the Grid"[236]. The program provides grants to qualified scientists, engineers, and educators that conduct R&D activities in the fields of the program[237].

[233] https://www.nsf.gov/about/how.jsp
[234] https://www.nsf.gov/od/oise/europe/
[235] https://www.nsf.gov/od/oise/about.jsp
[236] https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505249
[237] https://www.nsf.gov/pubs/policydocs/grantsgovguide0118.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

First Approach	
Contact Person	European researchers interested in EPCN program could contact the Program Director, Dr. Anthony Kuh[238].
Email	akuh@nsf.gov
International Collaboration	The application form needs to include whether the project involves activities outside the US or partnership with international collaborators[239].
Internet link	https://www.nsf.gov/staff/staff_list.jsp?orgId=5915&subDiv=y&org=ECCS&from_org=ECCS

[238] https://www.nsf.gov/staff/staff_bio.jsp?lan=akuh&org=ECCS&from_org=ECCS
[239] https://www.nsf.gov/pubs/policydocs/grantsgovguide0118.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

4.2. State initiatives/programs

State initiatives are one of the major ways states can support public projects in key research areas, such as renewable energy. Thus, state clean energy funds have been highly focused on renewable energy deployment and commercialization efforts. However, a considerable number of funds have been allocated to support earlier stage technology R&D activities[240].

4.2.1. California Energy Commission (CEC)

CEC is the State's primary energy policy and planning agency, which aims to reduce the energy costs and environmental impacts of energy use through the promotion of safer, more resilient, and more reliable supplies of energy[241]. CEC aims to develop and implement Research, Development, Demonstration, and Deployment (RDD&D) policies and programs that foster strategic energy investments to promote innovations that can lead to new energy solutions, and bring clean energy ideas to the marketplace[242].

CEC funds R&D activities through requests for Proposals, Funding Programs, Contracts and Solicitations. Furthermore, the CEC has specific programs focused on renewable energies, such as the Geothermal Resource Development Account (GRDA)[243] and the Renewable Energy program[244].

First Approach	
Information about Funding Opportunities	European researchers interested in the California Energy Commission funding opportunities could contact the email contained within each solicitation[245].
International Collaboration	The eligibility criteria for the California Energy Commission can be found at the Application Manual, Section 1, subtitle “Eligible Bidders[246].
Internet link	https://www.energy.ca.gov/funding-opportunities/solicitations

[240] https://emp.lbl.gov/sites/default/files/case-study-lbnl-918.pdf
[241] http://www.energy.ca.gov/commission/
[242] http://www.energy.ca.gov/commission/documents/201406_California_Energy_Commission_Strategic_Plan.pdf
[243] http://www.energy.ca.gov/contracts/geothermal.html
[244] http://www.energy.ca.gov/contracts/renewables.html
[245] http://www.energy.ca.gov/contracts/efficiency.html#IFB-17-403
[246] http://www.energy.ca.gov/contracts/

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 733286.

4.2.2. New York State Energy Research and Development Authority (NYSERDA)

NYSERDA provides objective information and analysis, innovative programs, technical expertise, and support to help the citizens increase energy efficiency, promote the use of renewable energy, and reduce reliance on fossil fuels. In this context, NYSERDA has been actively advancing energy solutions and working to reduce climate change effects[247].

NYSERDA provides funding opportunities through various programs, such as residential, commercial, transportation and environmental[248]. In addition, NYSERDA uses four types of competitive solicitations: Program Opportunity Notice (PON), Request for Proposals (RFP), Open Enrollment PON and Requests for Quotation or Qualifications (RFQ)[249]. The NYSERDA funding programs include programs focused on clean energy research, such as the Advanced Clean Energy (ACE) Exploratory Research Funding[250].

First Approach	
Information about Funding Opportunities	European researchers interested in NYSERDA funding opportunities could contact the representative identified in each program[251]. European researchers interested in the ACE Exploratory Research Funding could contact Mr. Richard Drake (richard.drake@nyserda.ny.gov)[252].
International Collaboration	The NYSERDA funding opportunities are targeted towards businesses and researchers. Technical questions should be directed to the project managers identified in each solicitation[253].
Internet link	www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities

4.2.3. New Jersey's Clean Energy Program (NJCEP)

NJCEP aims to promote increased energy efficiency and the use of renewable sources of energy including solar, wind and geothermal energies. The main goal of the NJCEP is to foster less pollution,

[247] https://www.nyserda.ny.gov/
[248] https://www.nyserda.ny.gov/Funding-Opportunities
[249] https://www.nyserda.ny.gov/Funding-Opportunities
[250] https://portal.nyserda.ny.gov/CORE_Solicitation_Detail_Page?SolicitationId=a0rt0000000QnqdAAC
[251] https://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities
[252] https://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities
[253] https://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

lower costs and reduce demand for electricity[254]. In this context, the NJCEP issues grants and solicitations focused on promoting the use of alternative sources of energy[255].

First Approach	
Contact Person	European researchers interested in NJCEP funding opportunities could contact the representative identified in each solicitation.
International Collaboration	The eligibility criteria for the NJCEP funding opportunities can be found in the Promotion Requirements and Guidelines of each solicitation.
Internet link	www.njcleanenergy.com/main/grants-solicitations/grants-and-solicitations-0

[254] http://www.njcleanenergy.com/main/about-njcep/about-njcep
[255] http://www.njcleanenergy.com/main/grants-solicitations/grants-and-solicitations-0

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

5 Observations

From the assessment of the US renewable energy research community, it can be concluded that the US is one of the global leaders concerning this research field. The analysis of the US research landscape reveals that its research community includes a wide range of different actors that conduct multidisciplinary R&D activities. Therefore, the renewable energy research community encompasses a joint effort of academia, industry and federal/state entities, which have been working together to develop innovative technologies that can accelerate the use of renewable energies in the country.

The key players of the US renewable energy research community are highly concentrated in the states of California, Colorado, Illinois and Texas, which play a key role in this field. Moreover, it is important to emphasize the northeast region of the US also has a high concentration of important renewable energy R&D activities, particularly in the states of Maine, Massachusetts, Michigan, and New York.

In the field of renewable energies, partnerships between industry and universities are highly important since they promote the development and deployment of new innovative technologies. In this context, the need to refine the existing technologies and decrease the costs of renewable energies emphasizes the need for research-industry partnerships. Therefore, in the US the development of industry-university research partnerships has been crucial to exchange knowledge and develop advanced technologies.

As detailed within this Research handbook, clusters are also one of the main drivers of R&D activities. The US energy industry recognizes the mutual benefits of establishing partnerships with members from academia in order to exchange knowledge and develop new advanced technologies. As previously mentioned, in the renewable energy field it is highly important that academia and industry can work together in order to develop cleaner and more affordable solutions. Thus, in the US, the industry clusters represent key platforms to foster the connection between industry and academia.

Moreover, it is important to highlight that the development of R&D activities in the field of renewable energies requires an interdisciplinary team. Thus, professional associations and networking events provide an opportunity for the different renewable energy-related professionals and researchers to share knowledge and information that can lead to the development of new technologies.

In the US, the research is highly supported by programs and initiatives from federal and state government entities, such as the DoE, NASA, NSF, and the CEC. Currently, the US Federal Government supports renewable energy R&D activities through grants and opportunities for promoting the development and deployment of new technologies. In this context, it is important to emphasize that President Trump's Administration has a different strategy regarding clean energy and the FY 2019 foresees cuts in renewable energy R&D funds.

Nevertheless, the US government is highly committed in supporting EU-US R&D cooperation. It is important to highlight the information related to federal and state funds and grants for European researchers is difficult to find. European researchers interested in US initiatives and programs focused

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

on renewable energies often need to contact the program officers to know specific details about international eligibility. In fact, only a few programs and initiatives have specific information available online about eligibility, which delays access to information and the establishment of partnerships.

As a general statement, the analysis carried out in this Research handbook reveals there are important EU-US R&D cooperation opportunities in the field of renewable energy. Both regions consider renewable energy as a research priority and are highly committed to support research in this field in order to mitigate the effects of climate change.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Annex 1: Summary of the US Federal and Private Funding Initiatives and Programs

Table A1 - Summary of the US Federal and State Funding Initiatives and Programs

Agencies	Programs/ Initiatives	Relevant Research Areas	Contact Info	Internet link
Federal Initiatives and Programs				
DOE	EERE funding opportunities	Renewable Energies (no specific thematic area)	Contact the point of contact identified in the FOAs	https://www.energy.gov/eere/funding/eere-funding-opportunities
	SETO funding opportunities	Solar Energy	Contact the point of contact identified in the FOAs.	www.energy.gov/eere/solar/funding-opportunities
	GTO funding opportunities	Geothermal Energy	Contact the point of contact identified in the FOAs.	www.energy.gov/eere/geothermal/geothermal-technologies-office-funding-opportunities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

Agencies	Programs/ Initiatives	Relevant Research Areas	Contact Info	Internet link
	WPTO funding opportunities	Water Energy	Contact the point of contact identified in the FOAs.	www.energy.gov/eere/water/water-power-funding-opportunities
	WETO funding opportunities	Wind Energy	Contact the point of contact identified in the FOAs.	www.energy.gov/eere/wind/wind-energy-funding-opportunities
	ARPA-E funding opportunities	Renewable Energies (no specific thematic area)	Contact the point of contact identified in the FOAs.	https://arpa-e-foa.energy.gov/
NASA	NASA grants	Renewable Energies (no specific thematic area)	Dr. Theresa Stanley Theresa.m.stanley@nasa.gov	www.grants.gov/web/grants/search-grants.html?keywords=NASA
NSF	NSF grants	Renewable Energies (no specific thematic area)	eeinfo@nsf.gov	www.nsf.gov/od/oise/country-list.jsp; www.nsf.gov/od/oise/europe/
	EPCN program	Solar and Wind Energy	Dr. Anthony Kuh	https://www.nsf.gov/staff/staff_list.jsp?orgId=5915

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Agencies	Programs/ Initiatives	Relevant Research Areas	Contact Info	Internet link
			akuh@nsf.gov	&subDiv=y&org=ECCS&from_org=ECCS
State Initiatives and Programs				
CEC	CEC funding opportunities	Renewable Energies (no specific thematic area)	Contact the email contained within each solicitation.	https://www.energy.ca.gov/funding-opportunities/solicitations
NYSERDA	NYSERDA funding opportunities	Renewable Energies (no specific thematic area)	Contact the contact identified in each program.	www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities
NJCEP	NJCEP funding opportunities	Geothermal, Solar and Wind Energy	Contact the contact identified in each solicitation	www.njcleanenergy.com/main/grants-solicitations/grants-and-solicitations-0

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Annex 2: Summary of the collaborative EU-USA H2020 projects* within the topic of Secure, Clean and Efficient Energy

Project Title	Project Acronym	Thema	CORDIS link	Topic Code
Advanced Design Tools for Ocean Energy Systems Innovation, Development and Deployment	DTOceanPlus	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/785921	LCE-16-2017
Closed Loop Wind Farm Control	CL-Windcon	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/727477	LCE-07-2016-2017
CO2 capture from cement production	CEMCAP	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/641185	LCE-15-2014
COmbined suN-Driven Oxidation and CO2 Reduction for renewable energy storage	CONDOR	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/101006839	LC-SC3-RES-1-2019-2020
Delivering digital Energy Labelling solutions to enable consumer action on purchasing energy efficient appliances	Digi-Label	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/696081	EE-10-2015
Development of all thin-film PERovskite on CIS TANDem photovoltaics	PERCISTAND	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/850937	LC-SC3-RES-1-2019-2020
Fuel via Low Carbon Integrated Technology from Ethanol	FLITE	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/857839	LC-SC3-RES-24-2019
HIghly advanced Probabilistic design and Enhanced Reliability methods for high-value, cost-efficient offshore WIND	HIPERWIND	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/101006689	LC-SC3-RES-31-2020
Innovative photocatalysts integrated in flow photoreactor systems for direct CO2 and H2O conversion into solar fuels	NEFERTITI	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/101022202	LC-SC3-RES-3-2020
International cooperation for selective conversion of CO2 into METHAnol under SOLar light	METHASOL	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/101022649	LC-SC3-RES-3-2020
Selective Electrochemical Reduction of CO2 to High Value Chemicals	SELECTCO2	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/851441	LC-SC3-RES-1-2019-2020
SHale gas Exploration and Exploitation induced Risks	SHEER	Secure, clean and efficient energy	http://cordis.europa.eu/project/id/640896	LCE-16-2014

*Collaborative EU-USA H2020 projects are defined as those H2020 funded projects that featured at least one US organization as a partner in the project consortium.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Annex 3: Bibliography

About -Chinese. (2020, December 2). SVCE. https://www.svcleanenergy.org/zh/about-us/

Apply For Funding | arpa-e.energy.gov. (2021). Arpa-e.Energy.Gov. https://www.arpa-e.energy.gov/about/apply-for-funding?q=programs/apply-for-funding

Biofuels and Renewable Energy - Home. (2021). Biofuels and Renewable Energy. https://renewableenergy.inl.gov/SitePages/Home.aspx

California May Reach Its Renewable Energy Goal 10 Years Early. (2017, November 17). Futurism. https://futurism.com/california-reach-renewable-energy-goal-10-years-early

Centre News. (2021). Ngpv. https://www.nextgenpv.org/center-research

Collaborate | Science and Technology. (2021). Collaborate | Science and Technology. https://st.llnl.gov/partnerships/collaborate

Current state of US renewable energy policy. (2016, June 2). Sustainable Energy Coalition. http://sustainableenergy.org/current-state-of-u-s-renewable-energy-policy/

Engadget is now a part of Verizon Media. (2018, January 31). Engadget. https://www.engadget.com/2018-01-31-trump-seeks-budget-cuts-clean-energy-research.html

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 733286.

FACT SHEET: Advancing Clean Energy Research and Development in the. (2016, October 13). Whitehouse.Gov. https://obamawhitehouse.archives.gov/blog/2016/10/12/factsheet-advancing-clean-energy-research-and-development-presidents-fy-2017-budget

Mission and Programs. (2021). NREL. https://www.nrel.gov/about/mission-programs.html

Moodie, A. (2018, February 14). *Google, Apple, Facebook race towards 100% renewable energy target*. The Guardian. https://www.theguardian.com/sustainable-business/2016/dec/06/google-renewable-energy-target-solar-wind-power

R&D. (2021). Conncenter. https://www.conncenter.org/research-development

Renewable energy | Energy. (2021). Https://Ec.Europa.Eu/Energy/En/Topics/Renewable-Energy https://ec.europa.eu/energy/topics/renewable-energy_en

Renewable Energy | ORNL. (2021). Renewable Energy | ORNL. https://www.ornl.gov/science-area/clean-energy/research-area/renewable-energy

RenewableEnergyWorld, RenewableEnergyWorld, & RenewableEnergyWorld. (2021, July 15). *The Latest in Clean Energy News*. Renewable Energy World. https://www.renewableenergyworld.com/

Research | WindSTAR I/UCRC. (2021). UMass Lowell. https://www.uml.edu/Research/WindSTAR/research/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.

Sandia National Laboratories: About Sandia. (2021). Sandia National Laboratories. https://www.sandia.gov/about/index.html

Silicon Valley Renewable Energy Project – Solar Roadmap. (2021). Silicon Valley Renewable Energy Project. https://www.solarroadmap.com/regional-initiatives/sv-rep/

Solar Energy Innovation Network. (2021). Solar Research | NREL. https://www.nrel.gov/solar/solar-energy-innovation-network.html

T. (2015, October 12). *Solar energy research in United States – Our energy*. Solar Energy Research In United States. https://www.our-energy.com/solar_energy_research_in_united_states.html

US state policies for renewable energy: Context and effectiveness. (2011, May 1). ScienceDirect. https://www.sciencedirect.com/science/article/pii/S0301421511000449

Wind, Hydro, Solar and Hybrid Power | GE Renewable Energy. (2021). GE Renewable Energy. https://www.ge.com/renewableenergy/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004518.