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Data Article

Great Britain's power system with a high penetration of renewable energy: Dataset supporting future scenarios

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ABSTRACT

The share of variable renewable energy (VRE) is forecasted to increase in the energy sector to meet decarbonization targets and/or reduce their dependence on fossil fuels. The modeling of future power system scenarios is crucial to assess the role of different flexibility options, including low-carbon technologies. The data presented here support the research article "The role of energy storage in Great Britain's future power system: focus on hydrogen and biomass". These data include updated parameters, inputs, equations, biomass resource potential and biomass demand to balance bio-power and bio-hydrogen requirements. The Future Renewable Energy Performance into the Power System Model (FEPPS), a rule-based model that includes flexibility and stability constraints, has been used, and the hourly results of future scenarios by 2030 and 2040 are provided. Researchers, policy-

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makers, and investors could use this paper as these data provide insights into the role of different technologies (including hydrogen and biomass) in power generation, system flexibility, decarbonization and costs.

Specifications Table

Subject	Renewable Energy, Sustainability, and the Environment
Specific subject area	Power system modelling
Data format	Raw, Analyzed, Filtered
Type of data	Table, Equation
Data collection	The Future Renewable Energy Performance into the Power System Model (FEPPS) has been used in the study. The data collection was based on the input data and parameters needed to model the future power system of Great Britain according to the flexibility and stability restrictions in FEPPS. The transmission system operator provides historical data of demand, power generation and exchanges of interconnections. It should be noted that all these data were used for projections (demand, renewables, and interconnections) or to obtain and set the flexibility parameters for the other conventional technologies. The transmission operator also provides the installed capacities of future scenarios, which are needed as inputs. The parameters for biomass were obtained based on a literature review. The required inputs and parameters are detailed below. 1. The historical data of demand, the power generation embedded in the distribution network, and the flow from interconnections were obtained from National Grid Electricity System Operator (ESO), and the power generation connected to the transmission system from ELEXON (the company that manages the Balancing and Settlement Code). Historical data have a half-hourly resolution and were averaged to obtain hourly data. 2. The installed capacities used for the model were obtained from National Grid ESO, specifically the Leading the Way scenario “LW”. 3. The model is developed in Visual Basic for Applications. The results for Great Britain were based on the specifications and constraints of FEPPS, and the scenarios provided are 2030 and 2040. 4. The biomass resource availability and bioenergy potential were obtained from outputs of the many scenarios of biomass resource models and academic studies (Table 8). 5. Great Britain’s biomass resource demands estimated to potential bio-power and bio-hydrogen (Tables 9 and 10) were calculated considering feedstock energy content (Table 4) and the conversion/ yield efficiencies of different bio-power conversion and bio-hydrogen production technologies (Tables 5 and 6).
Data source location	Institution: National Grid ESO, ELEXON Country: Great Britain Primary dataset: historical data of demand, interconnections, power generation by fuel type (2019), and future scenarios developed by National Grid ESO. Links: https://www.nationalgrideso.com/data-portal/historic-demand-data https://www.bmreports.com/bmrs/?q=generation/fueltype/current https://www.nationalgrideso.com/future-energy/future-energy-scenarios/documents
Data accessibility	Repository name: HARVARD Dataverse Data identification number: 10.7910/DVN/W97UKZ Direct URL to data: https://doi.org/10.7910/DVN/W97UKZ
Related research article	K. Guerra, A. Welfle, R. Gutiérrez-Alvarez, M. Freer, L. Ma, P. Haro, The role of energy storage in Great Britain’s future power system: focus on hydrogen and biomass, Appl. Energy. 357 (2024) 112447 https://doi.org/10.1016/j.apenergy.2023.122447

1. Value of the Data

- These data include inputs, equations and parameters to update the FEPPS model for Great Britain. These data allow the projection of the region's interconnections to get the import and export balances and provide the curtailment levels used in the study due to flexibility and stability constraints.
- This paper provides data on the region's biomass resource potential (Mt) and bioenergy potential (PJ), identified across different studies. Researchers can use the data to compare the biomass potential with other regions or to analyze their use for other purposes.
- This study provides bio-power conversion efficiencies and bio-hydrogen yields considering different technologies and the potential biomass demands to balance bio-power and bio-hydrogen power system needs in future scenarios.
- These data also include the hourly results of the model for the Great Britain power system by 2030 and 2040. These are future demand, historical and final power output of renewables and interconnections, power generation of conventional and low-carbon generation technologies, biomass and hydrogen requirements, storage needs, total system inertia, emissions and costs.
- Accordingly, these data provide valuable insights for researchers, stakeholders and policymakers, as this and the related research study could serve as a basis for the investment and deployment of new low-carbon generation and storage technologies and to analyse, develop, or compare their performance on flexibility, stability, emissions reduction and costs impact in future scenarios.

2. Background

This dataset supports the original research article [1], as it provides updates on the FEPPS model applied to Great Britain regarding curtailment levels, interconnections, and the hourly results of the model (demand, power generation of all technologies, curtailment, emissions and costs). The FEPPS model's detailed methodology and validation are explained in [2,3]. The methods for including low-carbon generation and storage technologies are explained in [4]. The novelty of the related research article was the analysis of different paths of hydrogen production from biomass (besides curtailment) for its use in the power system considering the resource availability and bioenergy potential of an island (Great Britain) using a rule-based and stability-constrained model. Therefore, the data presented in this paper support the figures of the related research article, specifically the biomass resource potential in the region (Fig. 9), the biomass demand (Mt) for bio-power requirements (Fig. 10) and the biomass demand for bio-hydrogen needs (Fig. 11) at grid level. The biopower conversion efficiencies and biohydrogen yields used in the study and a description of the bio-hydrogen production technologies are also provided.

3. Data Description

1. Parameters of the FEPPS model for Great Britain (GB)

The related research article analyzed the role of power generation and storage technologies, including different technologies for hydrogen production from biomass (potential and requirements) in the future power system of Great Britain. The interconnections of Great Britain were included in the model, and the parameters used are detailed in Table 1.

Table 2 shows the limits for the curtailment levels of wind and solar photovoltaic (PV) and the limits for the reduction of hydropower used as inputs of the model. According to the methodology described in [2], once the power output of each technology is obtained after projections/modelling, the surplus load is adjusted to match demand. According to the merit order

Table 1
New parameters and variables included in the model.

Symbol	Unit	Parameter
IC_{fi}	MW	Historical import capacity - Interconnection with France
IC_{fe}	MW	Historical export capacity - Interconnection with France
IC_{nii}	MW	Historical import capacity - Interconnection with Northern Ireland
IC_{nie}	MW	Historical export capacity - Interconnection with Northern Ireland
IC_{nei}	MW	Historical import capacity - Interconnection with the Netherlands
IC_{nee}	MW	Historical export capacity - Interconnection with the Netherlands
IC_{iri}	MW	Historical import capacity - Interconnection with the Republic of Ireland
IC_{ire}	MW	Historical export capacity - Interconnection with the Republic of Ireland
IC_{bi}	MW	Historical import capacity - Interconnection with Belgium
IC_{be}	MW	Historical export capacity - Interconnection with Belgium
IC_{bi}	MW	Historical import capacity - All Interconnections
IC_{he}	MW	Historical export capacity - All Interconnections
PI_f	MWh	Historical imported power - Interconnection with France
PI_n	MWh	Historical imported power - Interconnection with Northern Ireland
PI_{ne}	MWh	Historical imported power - Interconnection with the Netherlands
PI_{ir}	MWh	Historical imported power - Interconnection with the Republic of Ireland
PI_{be}	MWh	Historical imported power - Interconnection with Belgium
H_{pi}	MWh	Historical imported power - All Interconnections
NI_f	MWh	Historical exported power - Interconnection with France
NI_n	MWh	Historical exported power - Interconnection with Northern Ireland
NI_{ne}	MWh	Historical exported power - Interconnection with the Netherlands
NI_{ir}	MWh	Historical exported power - Interconnection with the Republic of Ireland
NI_{be}	MWh	Historical exported power - Interconnection with Belgium
H_{ni}	MWh	Historical exported power - All Interconnections
NIC_{fi}	MW	New import capacity - Interconnection with France
NIC_{fe}	MW	New export capacity - Interconnection with France
NIC_{nii}	MW	New import capacity - Interconnection with Northern Ireland
NIC_{nie}	MW	New export capacity - Interconnection with Northern Ireland
NIC_{nei}	MW	New import capacity - Interconnection with the Netherlands
NIC_{nee}	MW	New export capacity - Interconnection with the Netherlands
NIC_{iri}	MW	New import capacity - Interconnection with the Republic of Ireland
NIC_{ire}	MW	New export capacity - Interconnection with the Republic of Ireland
NIC_{bi}	MW	New import capacity - Interconnection with Belgium
NIC_{be}	MW	New export capacity - Interconnection with Belgium
NIC_{fui}	MW	New import capacity - All Interconnections
NIC_{fue}	MW	New export capacity - All Interconnections
Symbol	**Unit**	**Variable**
NPI_f	MWh	New imported power - Interconnection with France
NP_{ni}	MWh	New imported power - Interconnection with Northern Ireland
NP_{ne}	MWh	New imported power - Interconnection with the Netherlands
NP_{ir}	MWh	New imported power - Interconnection with the Republic of Ireland
NP_{be}	MWh	New imported power - Interconnection with Belgium
NP_{fui}	MWh	New imported power - Other Interconnections
NNI_f	MWh	New exported power - Interconnection with France
NN_{ni}	MWh	New exported power - Interconnection with Northern Ireland
NN_{ne}	MWh	New exported power - Interconnection with the Netherlands
NN_{ir}	MWh	New exported power - Interconnection with the Republic of Ireland
NN_{be}	MWh	New exported power - Interconnection with Belgium
NN_{fue}	MWh	New exported power - Other Interconnections

for limitations, which is the opposite of the dispatch, the first technology to be reduced is Cogeneration and non-renewable waste (CR), then Renewable Thermal and other renewables (TR), hydro and finally VRE (wind and solar PV). CR and TR are reduced based on the surplus load and the flexibility parameters shown in Table 2 of the research article [1]. For renewables, these curtailment levels (Table 2) are assumed so that levels 1 and 2 set the maximum curtailment levels required due to technical and flexibility restrictions of conventional power plants, and level 3 sets the additional curtailment required due to inertia constraints. These levels represent the maximum percentages of curtailment or load reduction in the hours of surplus power, and

Table 2
Curtailment and reduction levels for future scenarios.

Curtailment and reduction	Hydro		Wind			Solar PV		
	All scenarios			2030	2040		2030	2040
Level 1[a]	n_{1h}	-	n_{1w}	40 %	50 %	n_{1p}	60 %	70 %
Level 2[a]	n_{2h}	10 %	n_{2w}	40 %	50 %	n_{2p}	60 %	70 %
Level 3[b]	-	-	n_{3w}	40 %	50 %	n_{3p}	80 %	90 %

[a] Levels that allow the surplus generation of VRE to be adjusted. Curtailment required due to flexibility constraints of conventional power plants.

[b] Levels that allow adjusting the system inertia (curtailment required for system stability).n_{1h}, n_{2h}: reduction levels for hydro; n_{1w}, n_{2w}, n_{3w}: curtailment levels for wind power; n_{1p}, $n_{2p,}$ n_{3p}: curtailment levels for solar PV.

Table 3
International interconnections and future projects of GB included in FEPPS.

Interconnections*	Equations
New imported power with France (MWh)	$NPI_f = \frac{PI_f}{IC_{fi}} \cdot NIC_{fi}$
New export power with France (MWh)	$NNI_f = \frac{NI_f}{IC_{fe}} \cdot NIC_{fe}$
New import power with Northern Ireland (MWh)	$NP_{ni} = \frac{PI_n}{IC_{nii}} \cdot NIC_{nii}$
New export power with Northern Ireland (MWh)	$NN_{ni} = \frac{NI_n}{IC_{nie}} \cdot NIC_{nie}$
New import power with the Netherlands (MWh)	$NP_{ne} = \frac{PI_{ne}}{IC_{nei}} \cdot NIC_{nei}$
New export power with the Netherlands (MWh)	$NN_{ne} = \frac{NI_{ne}}{IC_{nee}} \cdot NIC_{nee}$
New import power with the Republic of Ireland (MWh)	$NP_{ir} = \frac{PI_{ir}}{IC_{iri}} \cdot NIC_{iri}$
New export power with the Republic of Ireland (MWh)	$NN_{ir} = \frac{NI_{ir}}{IC_{ire}} \cdot NIC_{ire}$
New import power with Belgium (MWh)	$NP_{be} = \frac{PI_{be}}{IC_{bi}} \cdot NIC_{bi}$
New export power with Belgium (MWh)	$NN_{be} = \frac{NI_m}{IC_{be}} \cdot NIC_{be}$
New import power Other Interconnections (MWh)	$NP_{fui} = \frac{H_{pi}}{IC_{hi}} \cdot NIC_{fui}$
New export power Other Interconnections (MWh)	$NN_{fue} = \frac{H_{ni}}{IC_{he}} \cdot NIC_{fue}$
Import balance (MWh)	$PIB = NPI_f + NP_{ni} + NP_{ne} + NP_{ir} + NP_{be} + NP_{fui}$
Export balance (MWh)	$NIB = NNI_f + NN_{ni} + NN_{ne} + NN_{ir} + NN_{be} + NN_{fue}$

* The new imported power of each interconnection was divided by 3.5 by 2030 and 1.5 by 2040 to approach the imported power of the “Leading the Way” scenario.

the model ensures that they are sufficient to allow the demand to be matched. For example, the model starts the adjustment in Level 1, curtailing wind, as necessary, up to the limit; if there is still a surplus, solar PV is curtailed. Afterwards, in Level 2, hydro, wind, and solar PV outputs are reduced until there is no surplus. Hydro was not considered in level 1 as this technology provides synchronous inertia. Finally, if there is a lack of inertia, level 3 is applied. As a reference, since no data is yet available on curtailment levels with expected future renewable shares, in the historical year selected for the previous study [2], about half of the installed wind capacity was authorized to provide adjustment services. Therefore, this study starts in Level 1 with 40 % and 50 %, to continue the reduction in Levels 2 and 3. We also assume that solar PV will provide these services due to the high installed capacity, starting at 60 % in 2030.

The equations used to project imports and exports and to obtain the balances of interconnections are provided in Table 3.

2. Biomass resource potential - calculation assumptions

Table 4 shows the energy content assumed for the dry and wet biomass (lower heating value: LHV). Table 5 provides the assumptions of the conversion efficiencies for different bio-power conversion technologies, and Table 6 shows the hydrogen yields of different production pathways.

Table 4
Feedstock energy content (CV) assumptions.

	Range of net calorific (LHV) [5]
'Dry' biomass including Lignocellulosic Biomass*	12.66–27.82 MJ/kg
'Wet' biomass including organic wastes, manures, and sewage sludge.	10-30–31.85 MJ/kg

[*] The term lignocellulosic biomass includes different types of materials and residues of forestry, waste plant fragments and firewood, and residues from the agricultural and paper industry.

Table 5
Bio-power technology conversion technology assumptions.

Bio-power technologies		Conversion efficiency (%)	Feedstock assumption	References
Anaerobic digestion	Dedicated power	*30–35*	Wet	[6,7]
	CHP (electricity fraction)[a]	*25–40*	Wet	[7,8]
Gasification	CHP (electricity fraction)[a]	*25–30*	Dry	[8]
Combustion	Cofiring	*36–50*	Dry	[8,9]
	Large scale dedicated power (10–50 MWe)	*30–40*	Dry	[7,9]
	Small scale ($<$0.1 MWe)	*11–20*	Dry	[8,9]
	CHP (electricity fraction)[a]	*16–50*	Dry	[8,9]
	Large scale BECCS (10–50 MWe)	*17–38*	Dry	[10]

[a] Overall energy efficiency of biomass CHP plants for industry/ district heating ranges from 70 % to 90 % [10].

Table 6
Bio-hydrogen technology production assumptions.

Bio-hydrogen production pathways		H_2 Yield (g/kg feedstock)	Feedstock assumption	References
Thermal pathways	Biomass gasification	*40–190*	Forest residue, industrial waste	[11]
	Biomass pyrolysis	*25–65*	Lignocellulosic	[12]
	Steam reforming	*40–130*	Ethanol	[11]
	Partial oxidation	*16–140*	Wet biomass (moisture $>$ 35 %)	[11]
	Supercritical water gasification (SWG)	*20–40*	Biomass in solution	[13]
	Aqueous phase reforming (APR)	*10–40*	Forest residue, industrial waste	[14]
Biological pathways	Dark fermentation	*4–44*	Organic wastes, algal biomass	[11]
	Photo-fermentation	*9–49*	Organic wastes	[11]
Biomass electrochemical production pathways	Membrane electrolysis cells (MEC)	*15–98*	Ethanol, Glycerol	[15]
	Proton exchange Membrane electrolysis cells (PEMEC)	*15–98*		[15]

3.1. Bio-hydrogen technology descriptions

Table 7 describes the different pathways (thermal, biological and electrochemical) for hydrogen production.

Table 7
Descriptions of bio-hydrogen production pathways as adapted from Lepage et al (2021) [9].

Biomass gasification	• Highly endothermic process conducted in an oxygen-deficient medium at approximately 1000 °C. • Consumes an oxidising agent to produce a synthesised gas composed of hydrogen, methane, carbon monoxide, nitrogen, and carbon dioxide. • Process differs according to the oxidising agent used and can be designated either as air gasification, oxygen gasification, or steam gasification.
Biomass pyrolysis	• Similar to gasification but can be performed at lower temperatures and without an oxidising agent. • Pyrolysis typically occurs at temperatures ranging between 400 and 800 °C, under a pressure of up to 5 bar. • According to the operating temperature, pyrolysis can be divided into three classes: conventional (or slow) pyrolysis, fast pyrolysis, and flash pyrolysis. - Conventional pyrolysis is carried out at temperatures below 450 °C and results in a high charcoal content. - Fast pyrolysis produces a high bio-oil yield of up to 75 wt% at medium temperatures (450–600 °C) with a high heating rate (approximately 300 °C/min) and a short residence time. - Flash pyrolysis is similar to fast pyrolysis but at higher temperatures (above 600 °C) and higher heating rates (>1000 °C/s), while the residence time is shorter (below 1 s), and is used to maximise the gas yield • Fast and flash pyrolysis gas yields are lower compared with gasification.
Steam reforming	• Concomitant purification reaction that improves the syngas composition during steam gasification by reducing the carbon-to-hydrogen mass ratio (C/H). • After the drying step, the pyrolysis reaction occurs, and the biomass is converted into a gas rich in CO, CO_2, CH_4, LHC (C_2H_4), C, and tar (primary). • Steam gasification promotes the steam reforming reaction and increases the yield of H_2 produced compared with air gasification, rather than promoting a combustion reaction. • During the reforming reactions, the primary tar is cracked into secondary tar, and then into tertiary tar. At extremely high temperatures (~1250 °C), it is possible to eliminate all the tar.
Partial oxidation	• Alternative thermochemical route that has been developed at the laboratory scale to be more robust for the biomass type, including wet biomass (moisture > 35 %) such as wood and carbohydrates. • Water requires a temperature above 374 °C and a pressure higher than 221.2 bars to become a supercritical fluid. Under these conditions, the dielectric constant of water decreases as well as the quantity of hydrogen bonds. • Organic compounds and gases are miscible in supercritical water at high temperatures, facilitating their conversion. • Residence times can be very low compared with other gasification processes (2–6 s), and the reaction can be conducted at a lower temperature (600–650 °C).

(*continued on next page*)

Table 7 (*continued*)

Supercritical water gasification (SWG)	• An alternative thermochemical route that has been developed at the laboratory scale to be more robust for the biomass type, including wet biomass (moisture $>$ 35 %) such as wood and carbohydrates. • Water requires a temperature above 374 °C and a pressure higher than 221.2 bars to become a supercritical fluid. Under these conditions, the dielectric constant of water decreases as well as the quantity of hydrogen bonds. • Organic compounds and gases are miscible in supercritical water at high temperatures, facilitating their conversion. • Reaction is endothermic. • Residence times can be very low compared with other gasification processes (2–6 s), and the reaction can be conducted at a lower temperature (600–650 °C).
Aqueous phase reforming (APR)	• APR converts mainly oxygenated compounds into hydrogen. • Feedstock molecules are dissolved during the aqueous phase and react with water molecules at low temperatures ($<$270 °C) and high pressures (up to 50 bar).
Dark fermentation	• Dark fermentation occurs when anaerobic microorganisms, such as micro-algae or specific bacteria, are sustained in the dark at temperatures between 25 and 80 °C, or even at hyperthermophilic ($>$80 °C) temperatures, depending on the strains. • Under these conditions, the gas produced contains H_2, CO_2, and small amounts of CH_4, CO, and H_2S, depending on the converted substrate. • Hydrogen is primarily produced from the anaerobic metabolism of pyruvates generated during the catabolism of carbohydrates.
Photo-fermentation	• Catalysed by nitrogenases in purple non-sulphur bacteria to convert organic acids or biomass into hydrogen from solar energy in a nitrogen-deficient medium.
Membrane electrolysis cells (MEC) Proton exchange membrane electrolysis cells (PEMEC)	• Electrochemical process widely investigated for hydrogen production by splitting water molecules. • The mechanism occurs in a fuel cell (containing a cathode and an anode) at a low temperature and relies on the flow of an electric current through a conductive electrolyte (alkali or polymer) in water. This results in the splitting of water into O_2 and H_2. • Conversion is fast, straightforward, and produces pure H_2 after separation. • Electrochemical conversion is also possible for biomass. The difference between water and biomass electrolysis lies in the reaction occurring at the anode. The feedstock is oxidised instead of producing gaseous oxygen from the water. Biomass electrolysis can be achieved through two different technologies: - Proton Exchange Membrane Electrolysis Cell (PEMEC) - Microbial Electrolysis Cell (MEC). • Both PEMECs and MECs are commonly used for bio-based molecules such as ethanol and glycerol. Polymeric molecules, such as cellulose or wood sawdust, cannot be converted directly by electrolysis.

Table 8
UK biomass resource potential (Mt) and bioenergy generation potential (PJ) in 2030 and 2040, reflecting the range of outputs from existing studies.

			Values identified across UK studies [16–19]				
			Min	1Q	Median	3Q	Max
2030	Bioenergy potential (PJ)		241	432	714	1028	1508
	Feedstock availability (Mt)	Crops	2.28	5.37	12.36	16.64	27.10
		Forestry	1.68	2.71	3.90	5.96	9.70
		Residues	8.02	10.73	11.71	12.25	15.77
		Waste	1.08	4.61	10.73	20.87	29.16
2040	Bioenergy potential (PJ)	152	375	483	721	1130	
	Feedstock availability (Mt)	Crops	1.79	2.33	3.90	7.86	15.61
		Forestry	2.17	2.87	4.88	7.43	9.70
		Residues	2.38	4.99	6.07	11.54	20.54
		Waste	1.90	10.14	11.33	12.25	15.39

Table 9
Potential biomass resource demand (Mt) forecast to balance future bio-power requirements (Mt) in 2030 *and* 2040, via a range of bioenergy conversion technologies.

				Demand	
				Low	High
Biomass demand for thermal combustion - direct bio-power (Mt)	2030	FEPPS forecast of power generation from biomass (GWh):		3868	
		Anaerobic digestion	Dedicated power	1.25	3.26
			CHP (elec. fraction)	1.09	4.31
		Gasification	CHP (elec. fraction)	1.67	2.73
		Combustion	Cofiring	1.00	2.05
			Large scale dedicated Power	1.25	2.42
			Small scale dedicated Power	2.50	7.50
			CHP (elec. fraction)	1.00	5.87
			Large scale BECCS	1.32	5.15
	2040	FEPPS forecast of power generation from biomass (GWh):	*2037*		
		Anaerobic Digestion	Dedicated power	0.66	1.72
			CHP (elec. fraction)	0.58	2.27
		Gasification	CHP (elec. fraction)	0.88	1.44
		Combustion	Cofiring	0.53	1.08
			Large scale dedicated power	0.66	1.27
			Small scale dedicated power	1.32	3.95
			CHP (elec. fraction)	0.53	3.09
			Large scale BECCS	0.69	2.71

3.2. Biomass resource potential forecast results

Table 8 shows the biomass resource and bioenergy potential in the UK (minimum, 1st and 3rd quartile, median and maximum values) and supports Fig. 9 of the related research paper [1]. Tables 9 and 10 provide the potential biomass to balance future bio-power and biohydrogen requirements, respectively, in 2030 and 2040 in Great Britain, according to FEPPS forecasts and support Figs. 10 and 11 of the related paper [1].

Table 10
Potential biomass resource demand (Mt) forecast to balance future bio-hydrogen requirements (Mt) in 2030 and 2040, via a range of bio-hydrogen production technologies.

				Demand	
				Low	High
Biomass demand for bio-hydrogen production pathways (Mt)	2030	FEPPS forecast hydrogen demand from biomass (kt):		2375	
		Thermal Pathways	Biomass gasification	12.50	46.88
			Biomass pyrolysis	36.54	58.46
			Steam reforming	18.27	41.11
			Partial oxidation	16.96	131.47
			SWG	59.38	59.38
			APR	59.38	178.13
		Biological Pathways	Dark fermentation	53.98	539.77
			Photo-fermentation	48.47	215.42
		Electrochemical pathways	MEC	24.23	134.10
			PEMEC	24.23	134.10
	2040	FEPPS forecast hydrogen demand from biomass (kt):		1249	
		Thermal pathways	Biomass gasification	6.57	24.65
			Biomass pyrolysis	19.22	30.74
			Steam reforming	9.61	21.62
			Partial oxidation	8.92	69.14
			SWG	31.23	31.23
			APR	31.23	93.68
		Biological pathways	Dark fermentation	28.39	283.86
			Photo-fermentation	25.49	113.29
		Electrochemical pathways	MEC	12.74	70.52
			PEMEC	12.74	70.52

3.3. Repository data

Repository data include the hourly results of the modeling for the Great Britain power system by 2030 and 2040, published and accessible in [20]. The Excel file includes the future demand, historical and final power output of wind, solar PV, and hydropower and interconnections (with France, Northern Ireland, the Netherlands, The Republic of Ireland, and Belgium), power output of cogeneration and non-renewable waste, renewable thermal and other renewables, combined cycle, average rotational inertia contribution of each technology, total system inertia, emissions and costs. New low-carbon generation technologies are also included in FEPPS. The resulting data from including these technologies are combined cycle that can be replaced without affecting inertia, curtailment of VRE, hydrogen produced from electrolysis and biomass, hydrogen flow in storage (salt caverns), and power output of batteries, fuel cells, adiabatic compressed air energy storage and hydrogen combined cycle turbines. These technologies' average rotational inertia contribution, the new total system inertia, the new emission factor and levelized cost of electricity are also provided. The first sheet presents the index, and the second and third present the data for 2030 and 2040, respectively. Each scenario has hourly data (8760) for 88 parameters (excluding columns A and B), providing 770 880 data.

4. Experimental Design, Materials and Methods

The Future Renewable Energy Performance into the Power System Model (FEPPS) has been used in the related research paper to obtain future scenarios for Great Britain's Power System. FEPPS is a rule-based model that follows a merit-order approach. The detailed methodology that

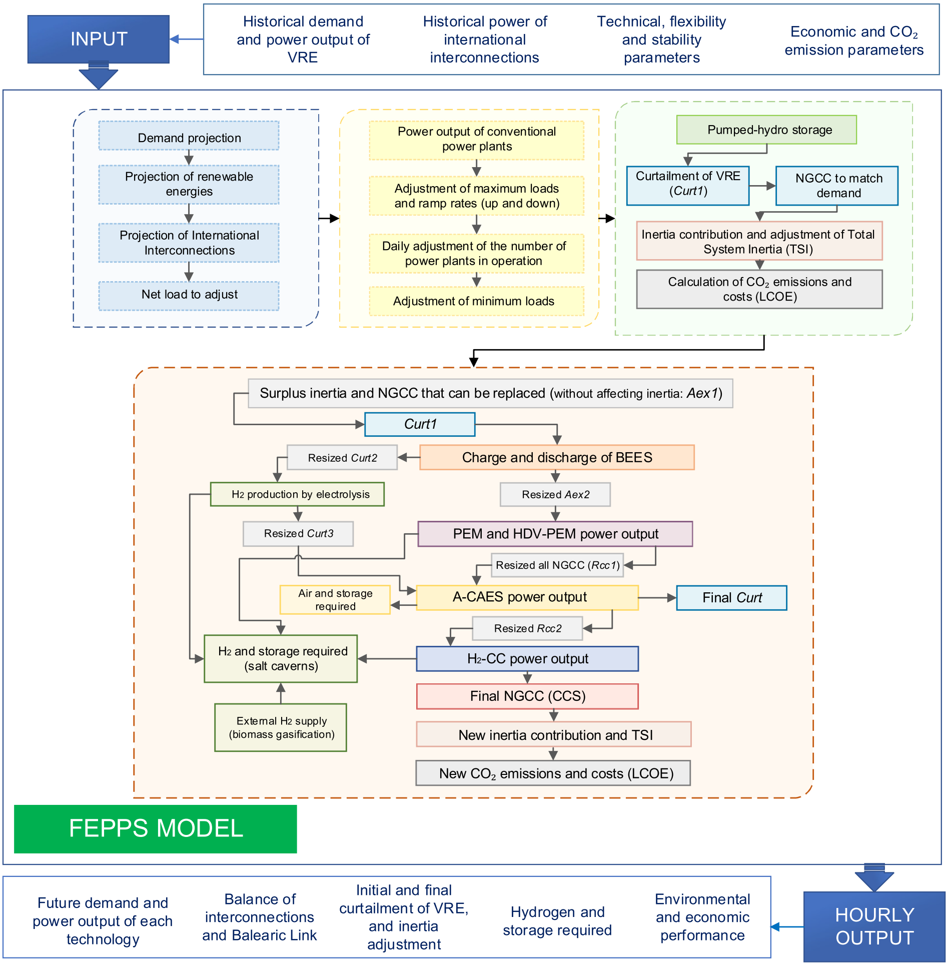

Fig. 1. Flowchart of the FEPPS model [4].

includes the projections of variable renewable energies, interconnections and the modeling of conventional technologies (based on flexibility parameters), inertia calculations, emissions and costs is presented in [2,3]. The flexibility parameters of conventional technologies are maximum and minimum loads, adjustment of the number of power plants operating each hour and ramp-up and ramp-down rates. The inclusion of new low-carbon generation and storage technologies is provided in [4], where the natural gas combined cycle (NGCC) is replaced by new technologies: battery energy storage systems, polymer electrolyte membrane (PEM) and heavy-duty vehicle polymer electrolyte membrane (HDV-PEM) fuel cells, adiabatic compressed air energy storage (A-CAES), hydrogen combined cycle turbines (H_2-CC) and NGCC with CCS. The methodology for power exchanges with interconnections for Great Britain has been updated here, and the updated parameters according to the historical data of the region are provided in the related research paper [1] since the parameters are based on theoretical and historical data. The flowchart of the model, which can be applied to other regions, is presented in Fig. 1.

Several references based on biomass resource models were analysed to obtain the biomass resource availability of the region (Table 8). These include UK TIMES, UK MARKAL, TIAM-UCL, ESME, Biomass Value Chain Model, Biomass Resource Model, Bioenergy with CCS Supply Chain

Model, and other government, industry, and academic studies [1]. The resources are categorized as energy crops, forest resources, residues (from agriculture and industry) and wastes (from multiple sectors that would otherwise be sent to landfills). Different bio-power conversion technologies have been considered, including anaerobic digestion, gasification and combustion pathways and bio-hydrogen production technologies, including thermochemical, biological and electrochemical processes. The biomass resource demands are calculated based on the energy contents and the bioenergy conversion efficiencies, and for hydrogen, they are based on the yields. The FEPPS forecast of power generation from biomass is obtained as a result of the modeled renewable thermal and other renewables technology (TR) (share corresponding to biomass) [2]. The hydrogen requirement in FEPPS from biomass is obtained from the hydrogen produced by electrolysis and the total hydrogen needed to be used by power generation technologies (fuel cells and H2 turbines) [4].

Limitations

'None'.

Ethics Statement

This study meets all the ethical requirements in Data in Brief and did not involve humans, animals experiments or any data collected from social media platforms.

Data Availability

Hourly results of the FEPPS model for Great Britain (future power system by 2030 and 2040) . (Original data) (Harvard Dataverse)

CRediT Author Statement

K. Guerra: Conceptualization, Methodology, Data curation, Software, Writing – original draft, Writing – review & editing; **A. Welfle:** Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing; **R. Gutiérrez-Alvarez:** Data curation, Visualization, Writing – review & editing; **S. Moreno:** Visualization, Writing – review & editing; **P. Haro:** Funding acquisition, Supervision, Visualization, Writing – review & editing.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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