



# HYDROGEN - DE-CENTRALISED HUB STUDY WORKSHOP MEETING

# WORKSHOP AGENDA

1. **Introductions**
2. **Presentation: De-Centralised Green Hydrogen – Site ID**
3. **Topic Area 1: Key Site Requirements – Green Hydrogen**
4. **Topic Area 2: Producing Green Hydrogen**
5. **Topic Area 3: Hydrogen Demand and/or Export**
6. **Round-Up & Review**



# DE-CENTRALISED GREEN HYDROGEN - SITE IDENTIFICATION

## BRIEF & PURPOSE

- “Identify and carry out an assessment of potential locations for decentralised / hub green or low-carbon hydrogen production”.
- Scotland wide scope and spatial analysis of Green Hydrogen production opportunities
- ‘De-Centralised Sites’ – co-located with renewable energy generation and at small-medium scale (c.10-100MW)
- Focus on curtailed / constrained renewable energy as key area of opportunity for green hydrogen production.

## KEY DELIVERABLES

**Mapping & Data** of energy availability and other key criteria

**Site Factsheets** –site assessment and review

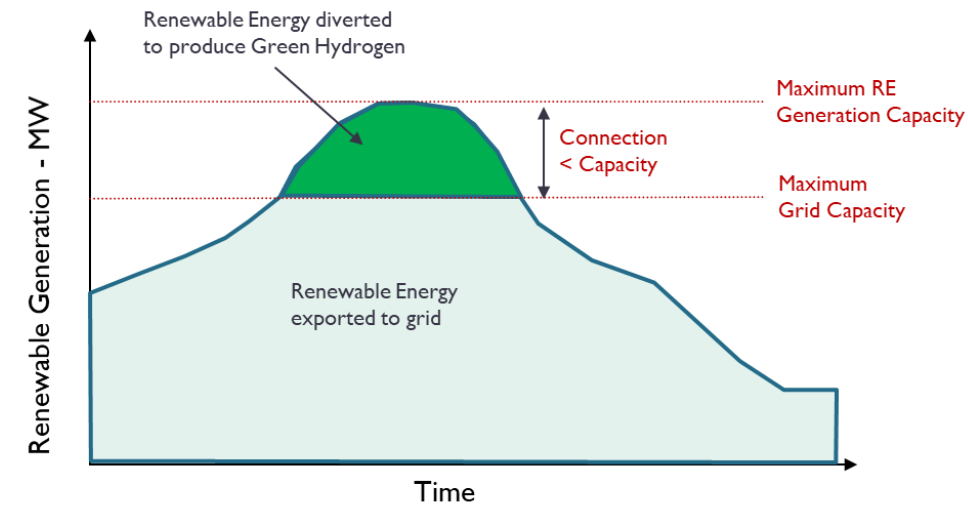
**Written Report** – preferred De-Centralised Hub locations / sites

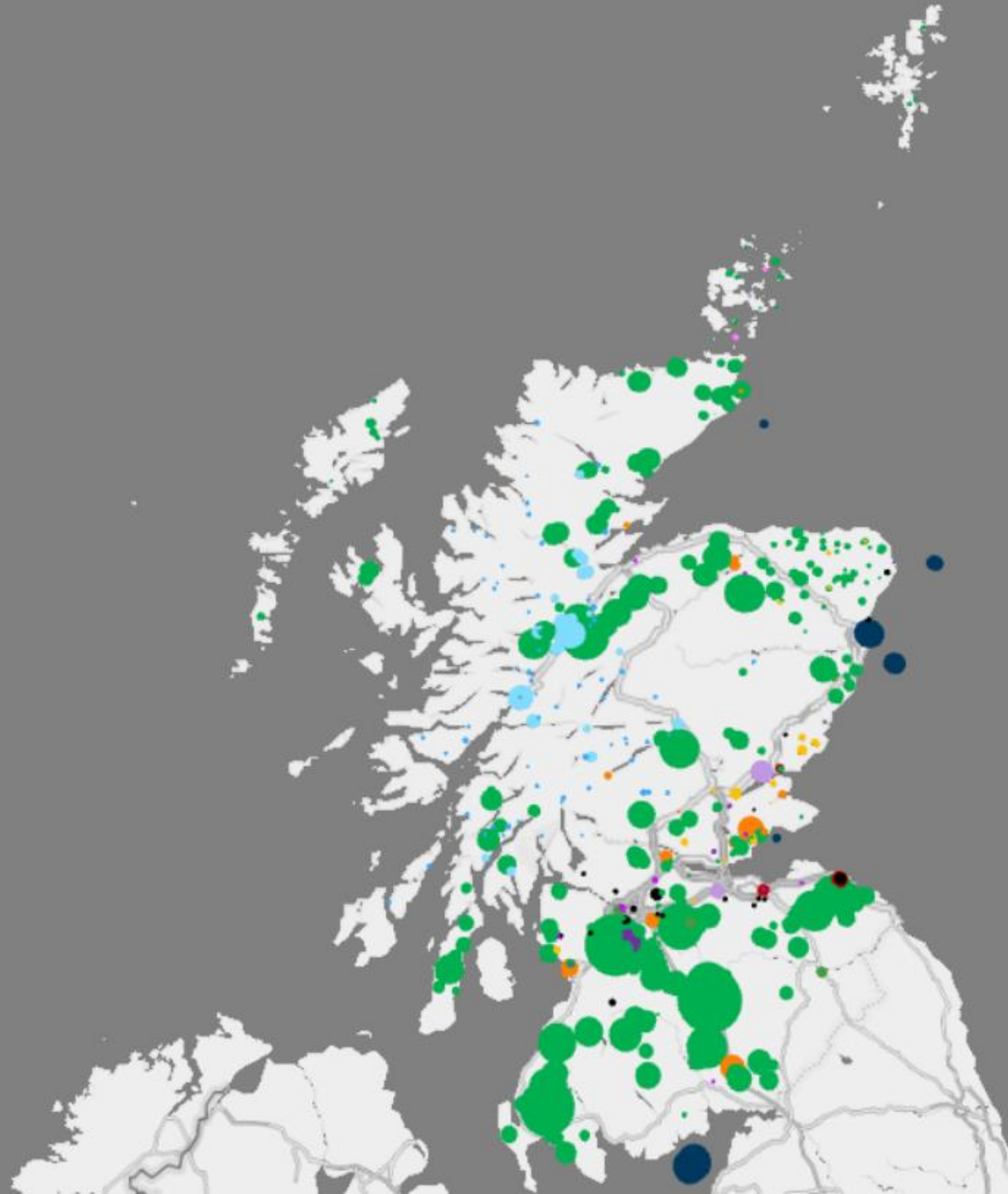
**Summary Report** – suitable for publication (excl. commercial sensitive info)

# DE-CENTRALISED GREEN HYDROGEN - SITE IDENTIFICATION

“FOLLOWING THE ENERGY...”

- Scotland has large-scale renewable energy capacity and set to grow significantly through 2020's and into 2030's. Grid experiences levels of constraint / curtailment where there is insufficient capacity in the transmission system to export renewable energy.
- Focus of early work to date seeking to identify and map constrained / curtailed renewables. Collation, detailed review and cross-referencing between BEIS (REPD), National Grid, SPEN, SSEN data-sets of current and planned renewable energy strands of analysis:
  1. **Curtailed Renewable Energy** – Renewable energy curtailed through the Balancing Mechanism (complexities around incentives and future operation of grid balancing)
  2. **Flexible & Non-Firm Connections** – A constrained grid connection where full power output may not be able to be exported to the grid.
  3. **Planned Projects Without Grid Connection** – Renewable energy projects in the planning system currently without a Grid Connection. Strong candidate sites for hydrogen.
  4. **Room for Growth** – Planned / operational renewable energy with grid connection below the level of MW it has consent for – opportunity to grow / divert expansion to hydrogen.





## Where is the energy?

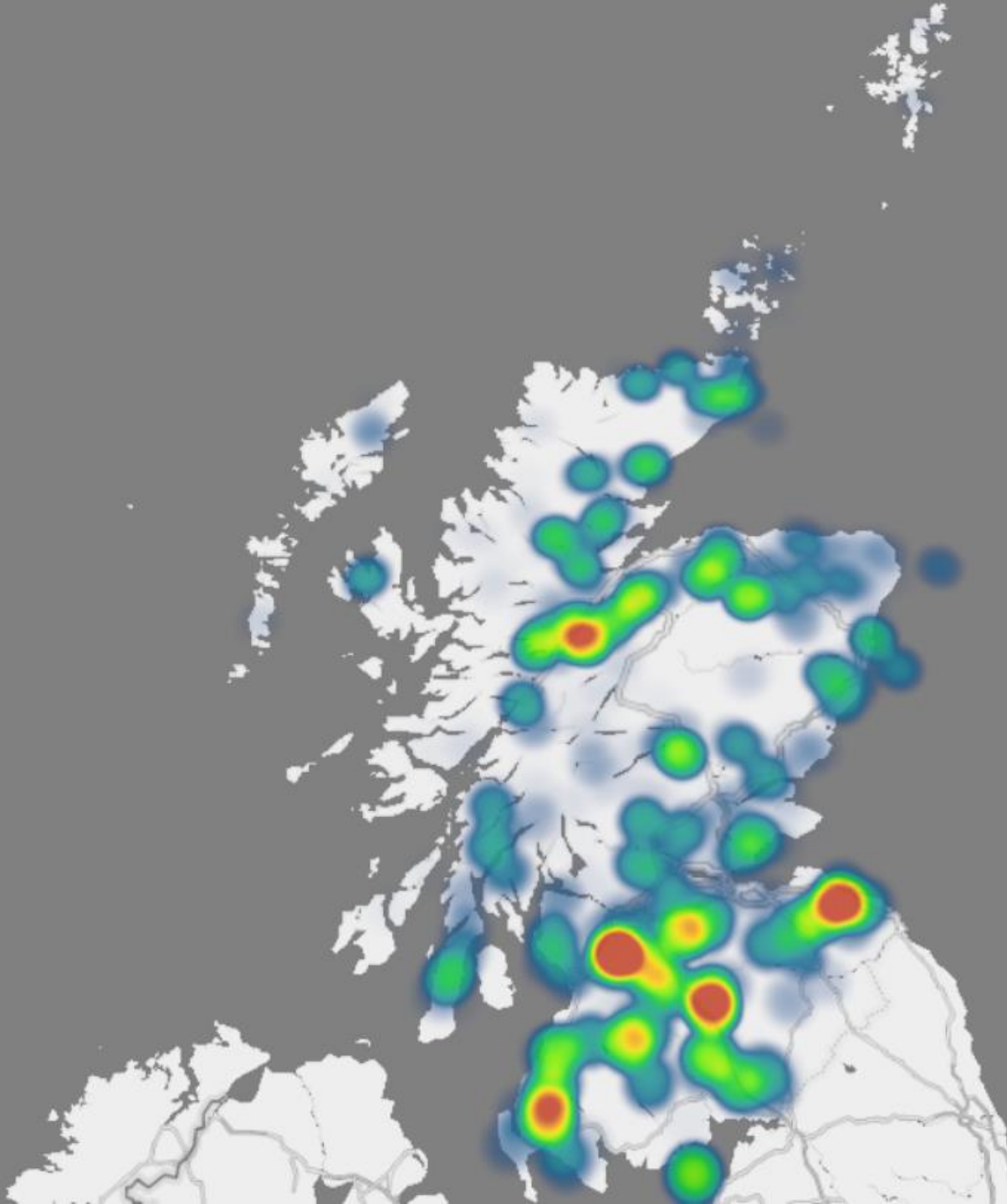
- Currently operational Sites
- All major renewable technologies

Range 0-500 MW installed capacity

Bubbles showing size in MWe of renewable energy generation.

Source: Renewable Energy Planning Database

Installed Capacity (MWelec) (Sum)



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- All major renewable technologies

Range 0-500 MW installed capacity

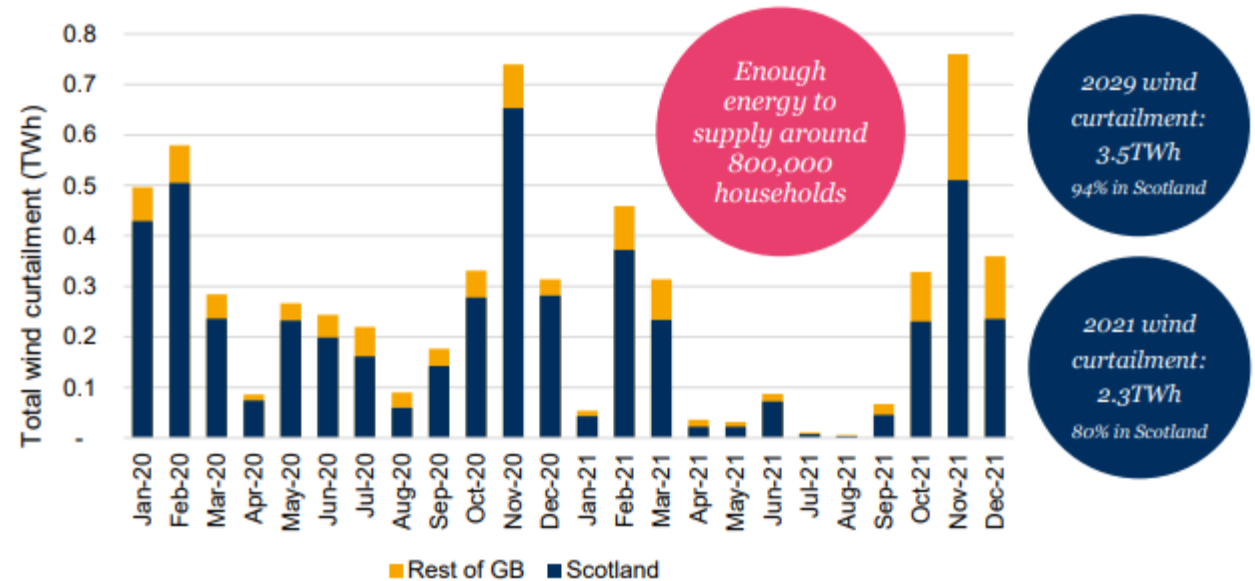
Bubbles showing size in MWe of renewable energy generation.

Source: Renewable Energy Planning Database

# STRAND I – CURTAILMENT

- Curtailment payments made to large wind farms which participate in National Grid 'Balancing Mechanism' – connected to Transmission network.
- Wind farms need to be instructed (and compensated) to reduce output to maintain grid stability.
- Complex auction process and subsidy environment influences levels of curtailment and associated payments.
- Significant quantities of renewable energy 'discarded' as part of the function of the Grid – is there scope / feasibility to utilise for green hydrogen production...

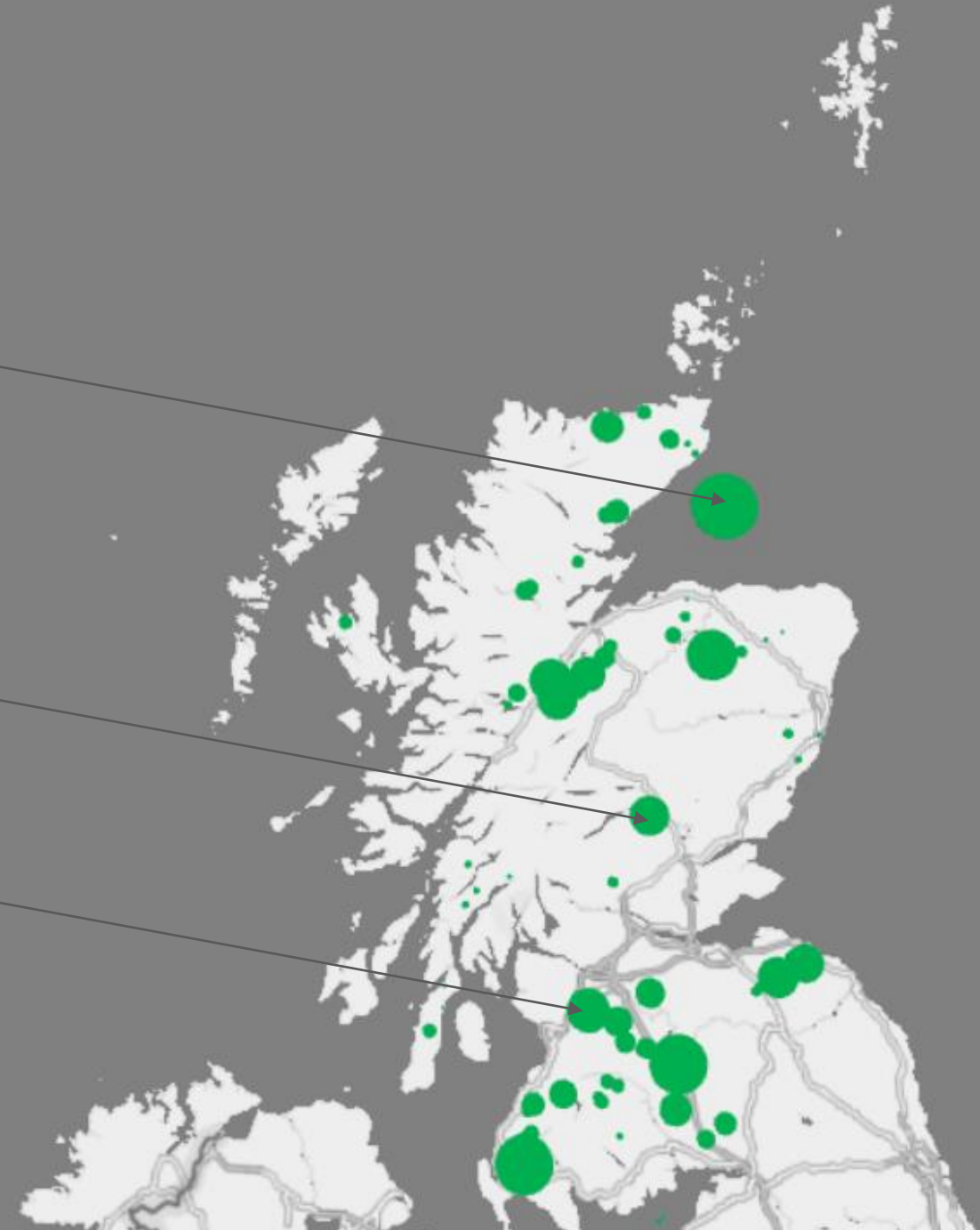
**Figure 2:** Total wind curtailment by month, GB and Scotland



Beatrice

Griffin

Whitelee



### 84 sites participating in 'Balancing Mechanism'

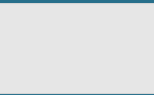
Larger scale sites directly connected to National Grid Transmission Network

- Beatrice
- Fallago Rig
- Whitelee
- Griffin

Bubbles showing average MWh/day 'curtailed' since commencement of operation.

Variability by site - but high levels of renewable energy 'discarded' as part of grid stability and balancing.

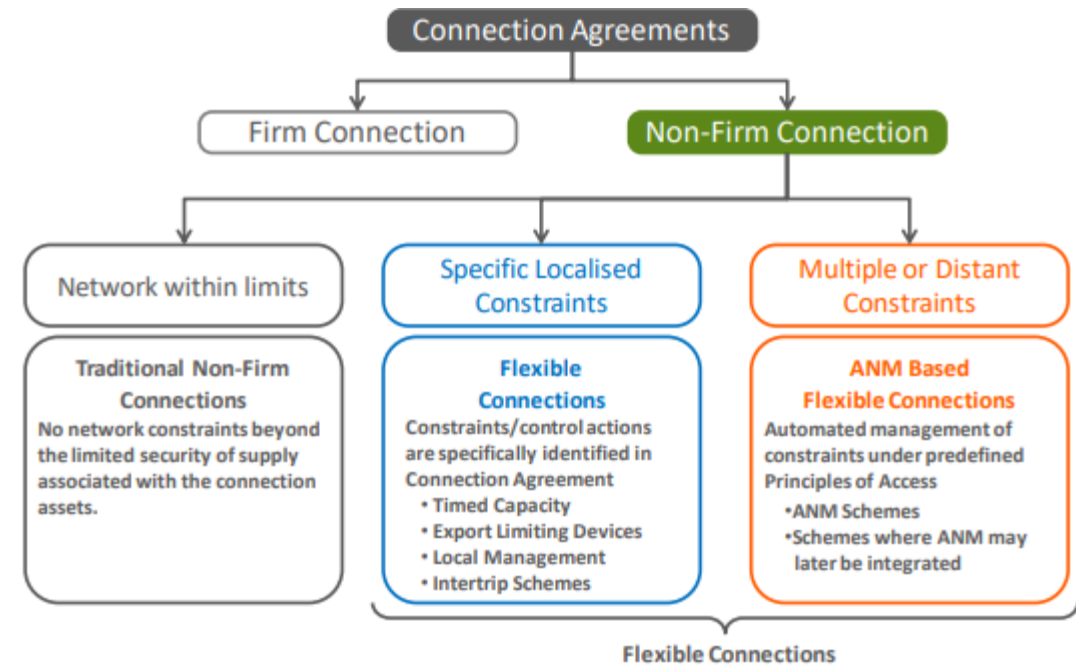
Is there future scope / feasibility to utilise for green hydrogen production...



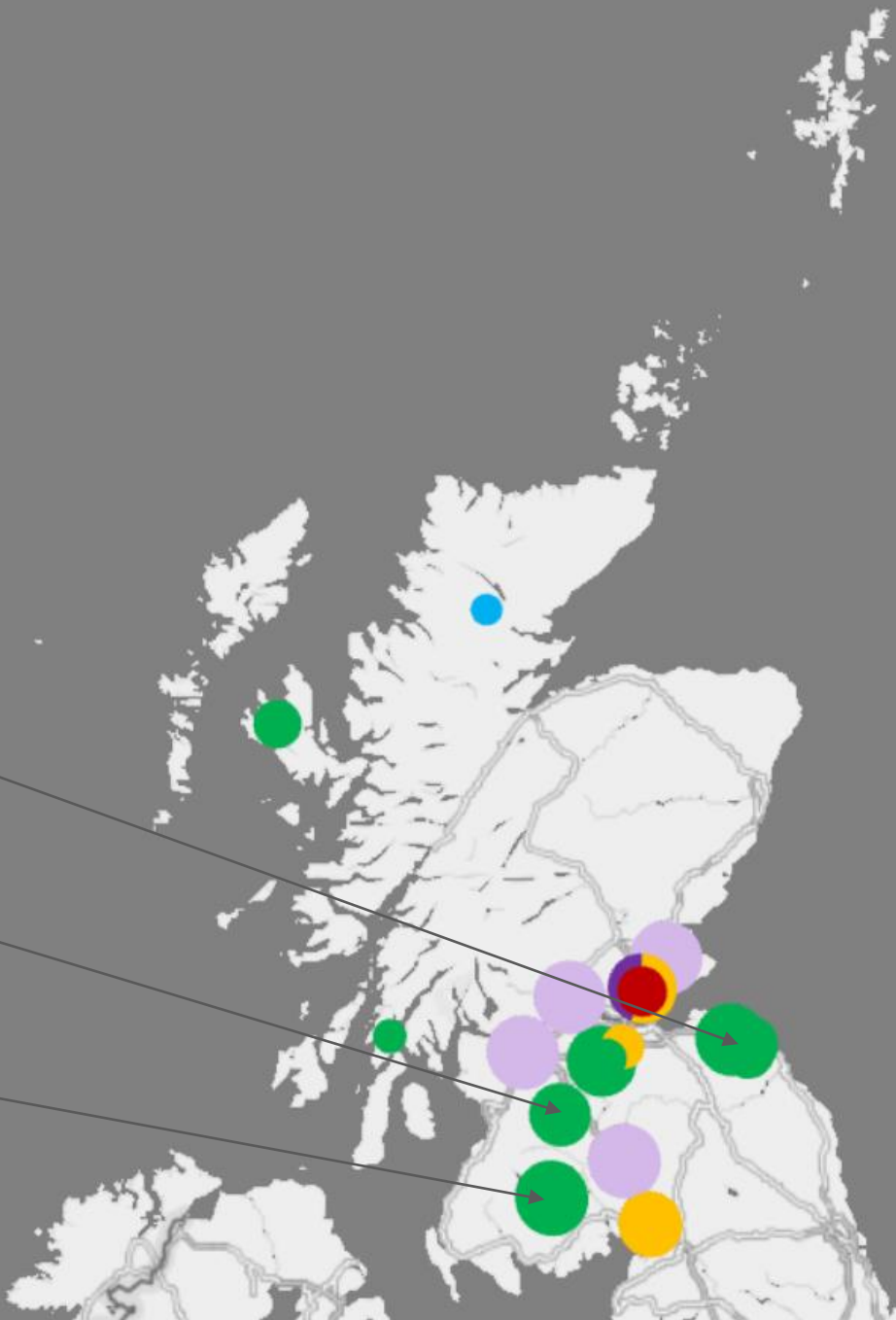


# STRAND 2 – FLEXIBLE CONNECTIONS

- Renewable energy generators with a flexible or ‘non-firm’ grid connection (as listed on SPEN / SSEN Connection Registers)
- Restricted by conditions around maximum export or constraining output under network conditions – typically in constrained areas of electricity distribution network.
- A quicker / cheaper connection for generators while grid reinforcement is planned and delivered. May become ‘firm’ at later date.
- Often associated with forms of Active Network Management by grid operator (SPEN / SSEN) to manage constraint and network load.



- Battery - RE Co-Located
- Battery - Stand-Alone
- EFW Incineration
- Large Hydro
- Solar Photovoltaics
- Wind Onshore



Aikengall, Quixwood Moor, Penmanshiel Wind Farms

Hare Craig Windfarm

Cornharrow Wind Farm & BESS

c. 12 Sites additional sites of 10MW+ Capacity confirmed with Flexible or 'Non-Firm' Grid Connection

- Flexible or 'Non-Firm' Connection potentially complementary to diverting curtailed renewable energy to green hydrogen production.
- Future / additional sites will increase Flexible connections. Greater prevalence of 'Active Network Management' by DNOs.
- Significant number of planned / scoping schemes especially in SSEN area are 'To be Confirmed' and likely to be subject to some form of Flexible Connection.

# STRAND 3 – PLANNED PROJECTS W/O GRID CONNECTION

- Where are planned / future renewable projects emerging – and what is their grid connection status?
- Are there renewable energy projects in the planning system (under construction, approved, application submitted) that are currently without a Grid Connection as listed by SPEN / SSEN / NG.
- Potentially strong candidate sites for Green Hydrogen production – utilising curtailed renewable energy
- Collation, review, cross-reference of BEIS, SSEN, SPEN, National Grid data-sets for renewable energy projects.

Renewable Energy Planning Database

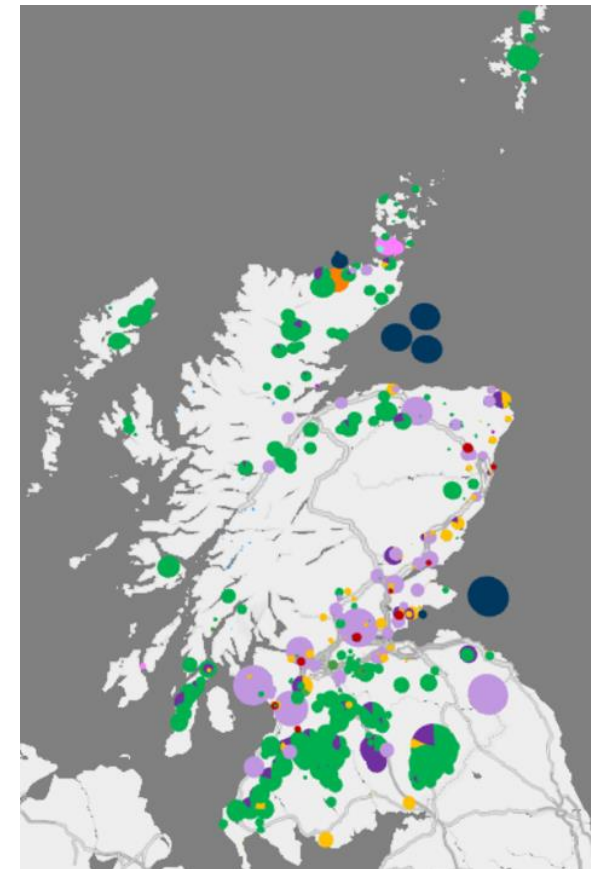
Version: January 2023 (Q4)

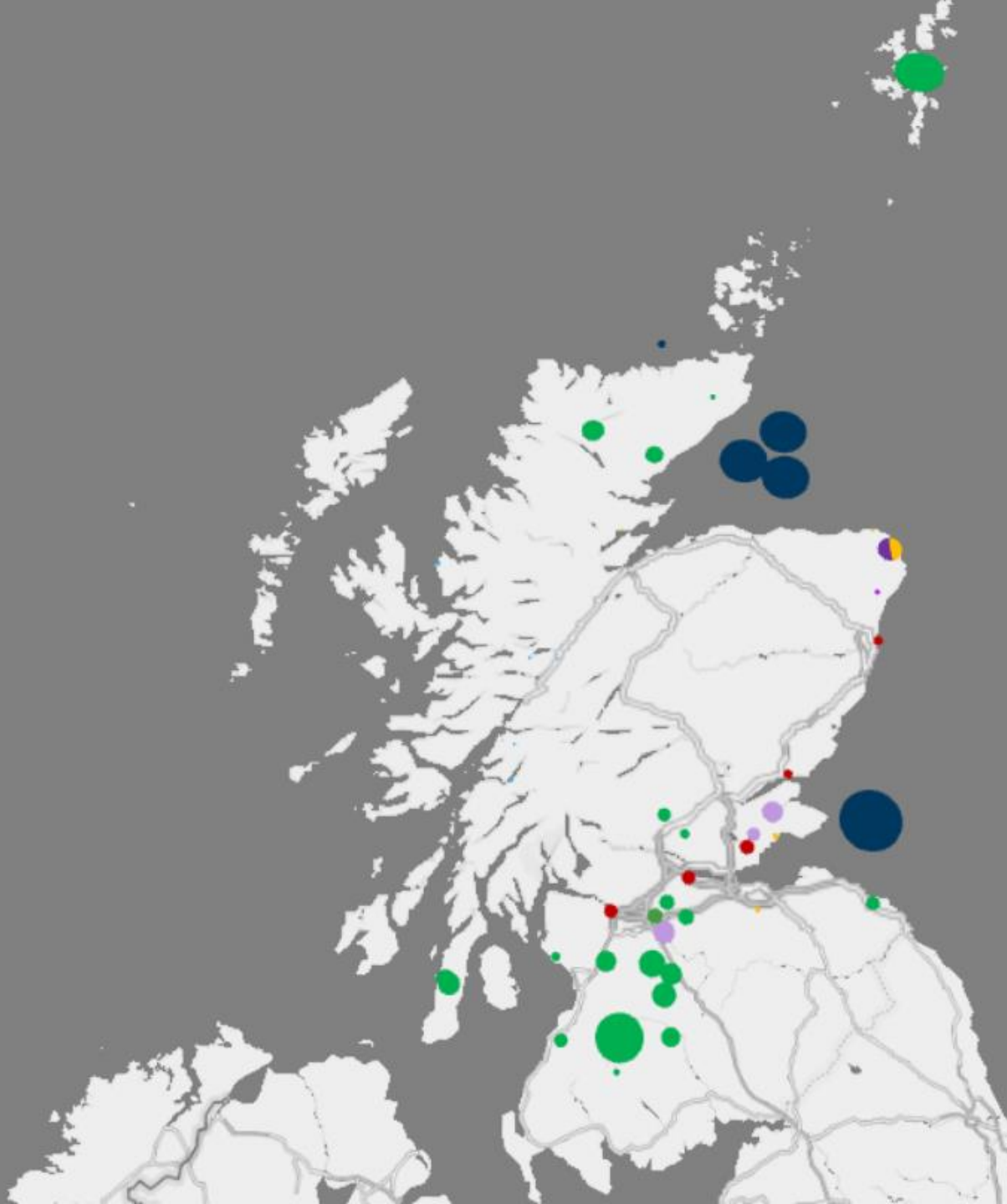
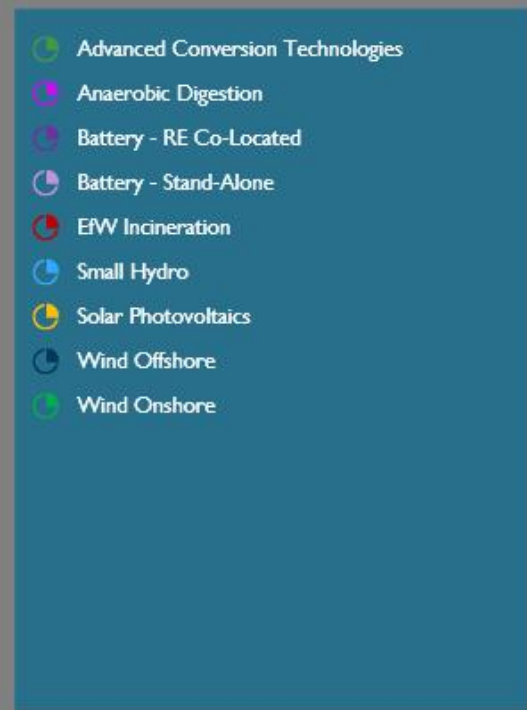
  
Department for  
Business, Energy  
& Industrial Strategy

 Scottish & Southern  
Electricity Networks  
TRANSMISSION

 SP ENERGY  
NETWORKS

nationalgridESO



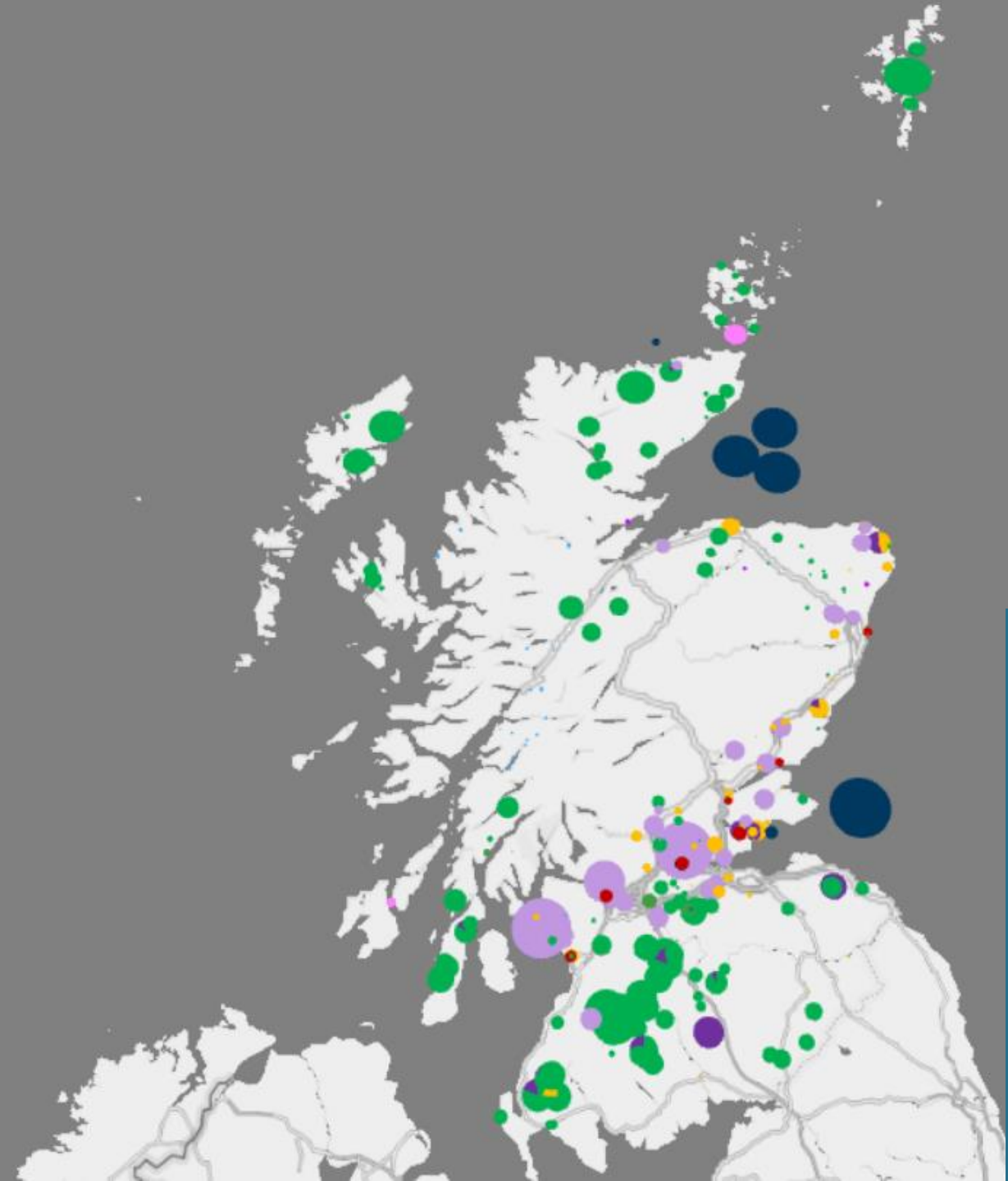


### Where are the next phases of renewable energy?

- Sites Under Construction
- All major renewable technologies

Source: Renewable Energy Planning Database

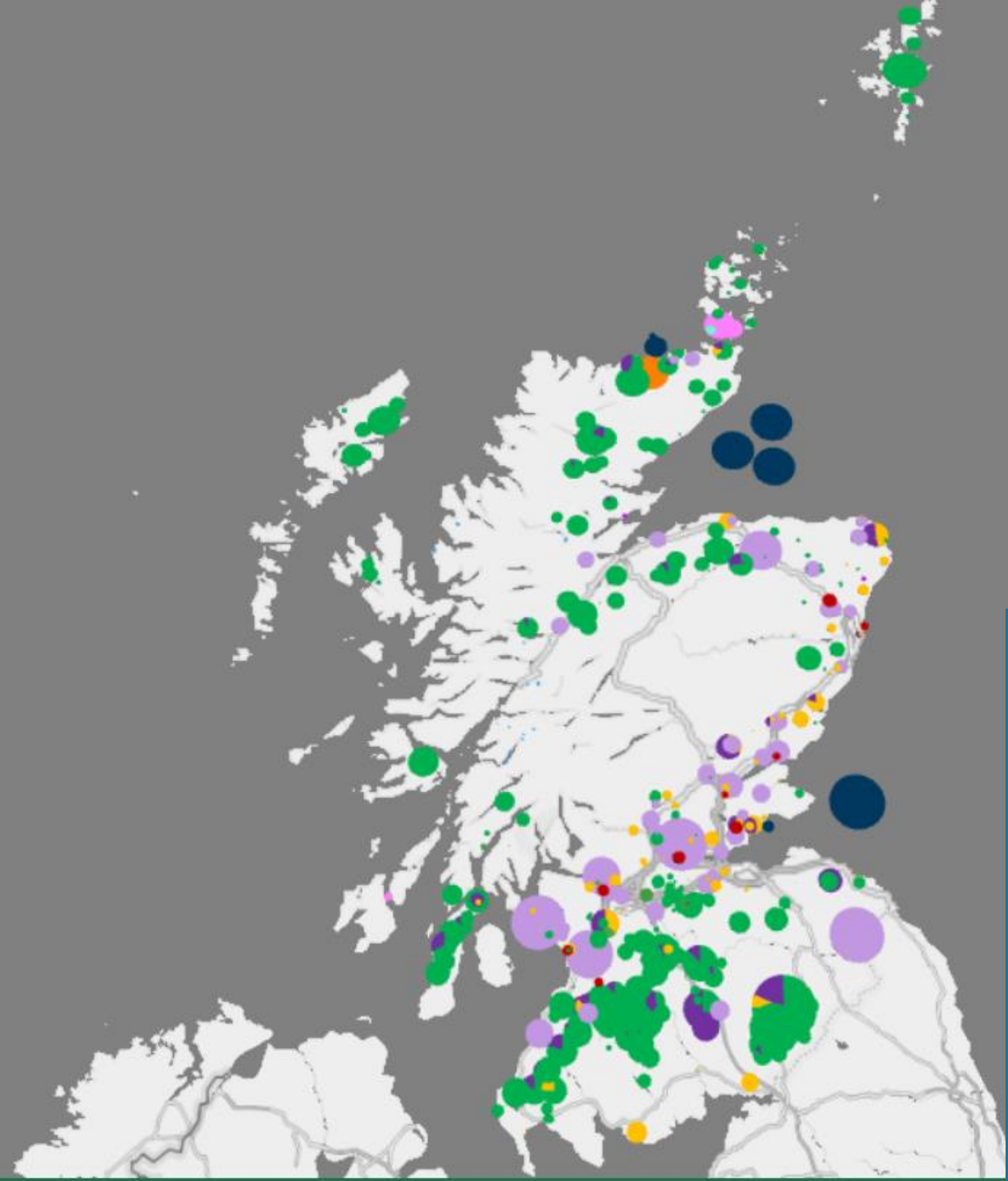
- Advanced Conversion Technologies
- Anaerobic Digestion
- Battery - RE Co-Located
- Battery - Stand-Alone
- Biomass (dedicated)
- EFW Incineration
- Hydrogen
- Landfill Gas
- Small Hydro
- Solar Photovoltaics
- Tidal Barrage and Tidal Stream
- Wind Offshore
- Wind Onshore



## Where are the next phases of renewable energy?

- Sites Under Construction
- Sites with Planning Permission
  
- All major renewable technologies

Source: Renewable Energy Planning Database

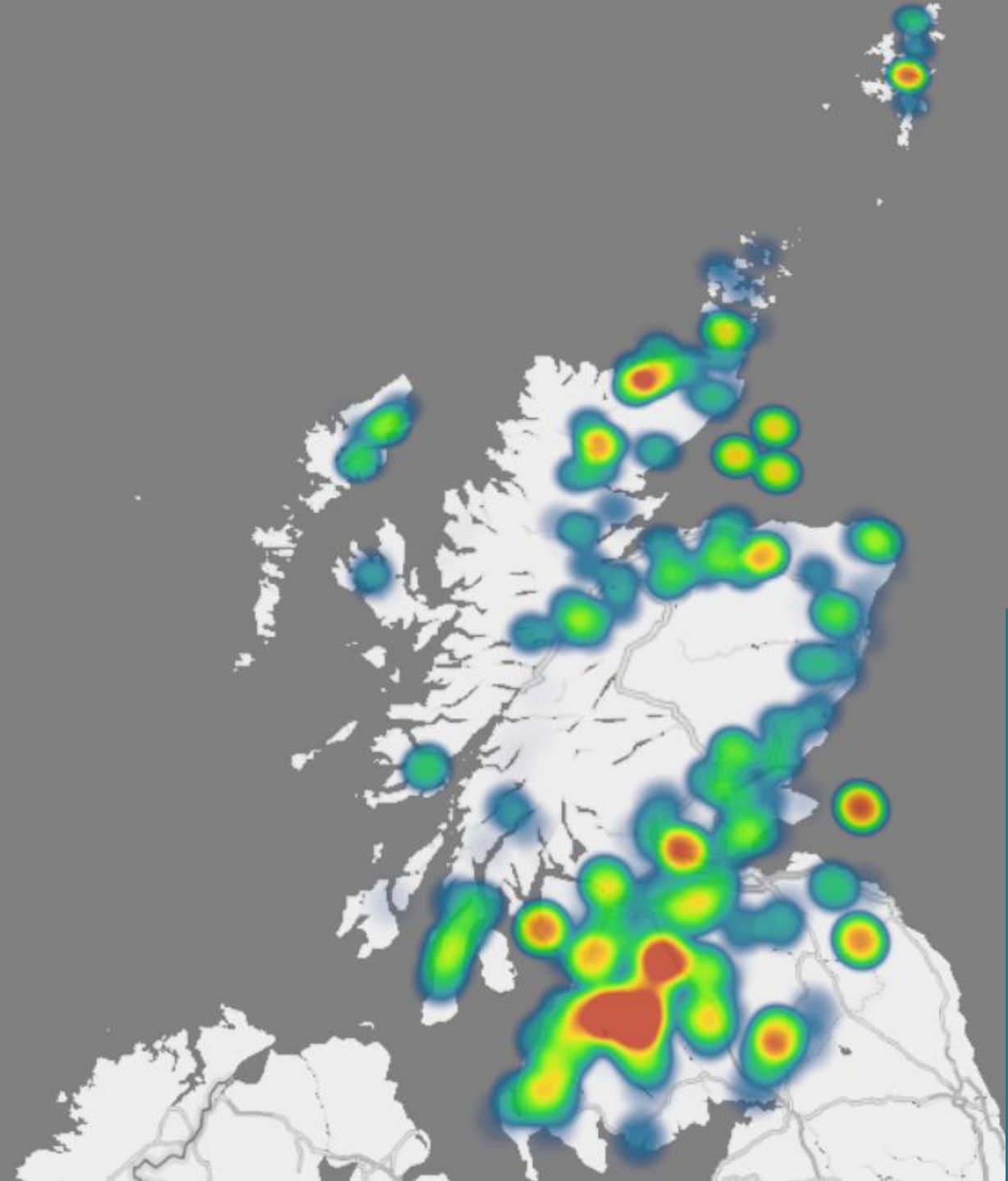
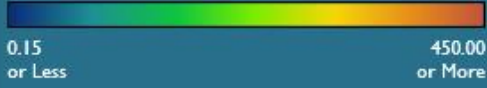


### Where are the next phases of renewable energy?

- Sites Under Construction
- Sites with Planning Permission
- Sites with Planning Submitted
  
- All major renewable technologies

Source: Renewable Energy Planning Database

Installed Capacity (MWelec) (Sum)

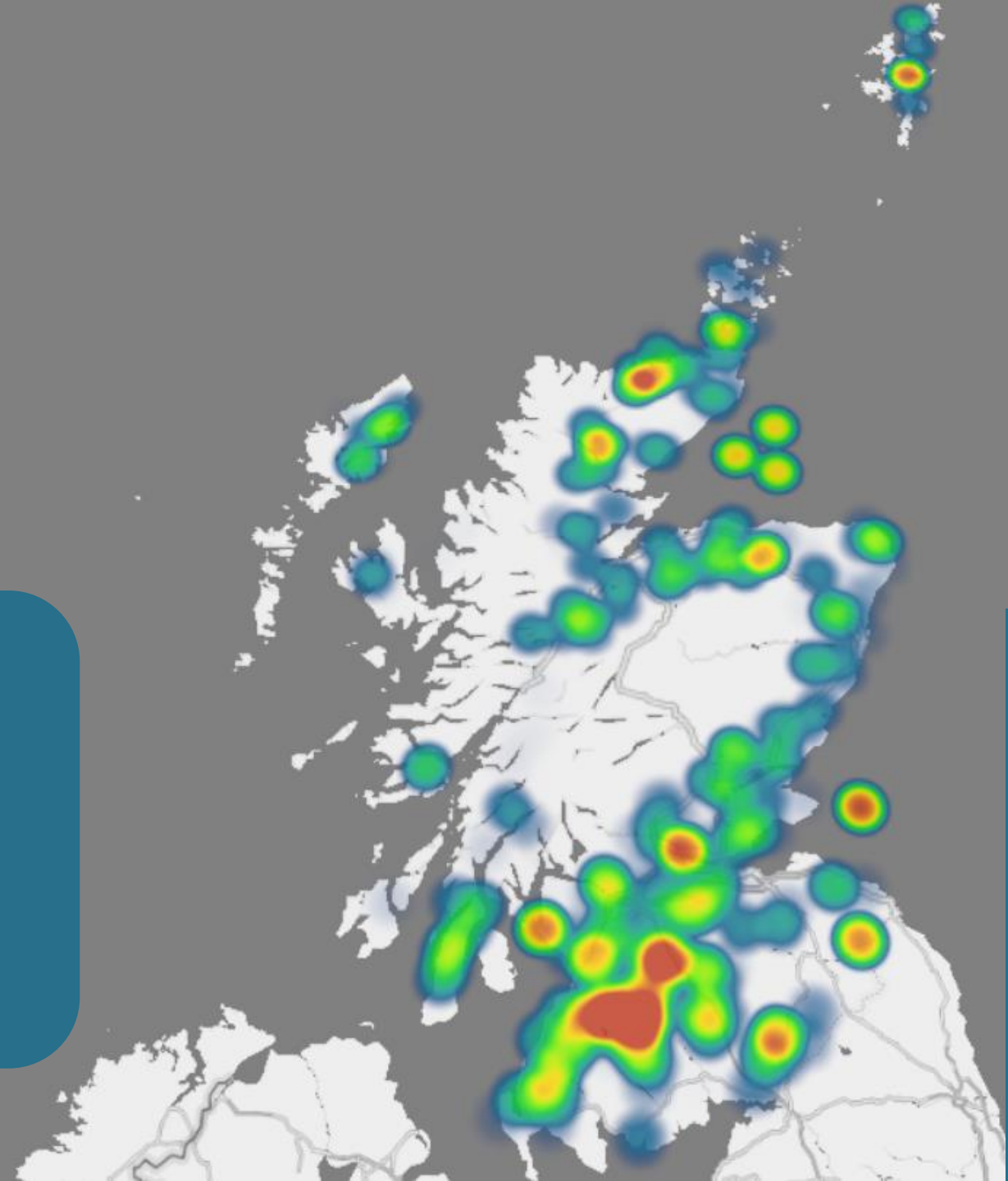


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Are these planned projects connected to the Grid?

At what capacity?

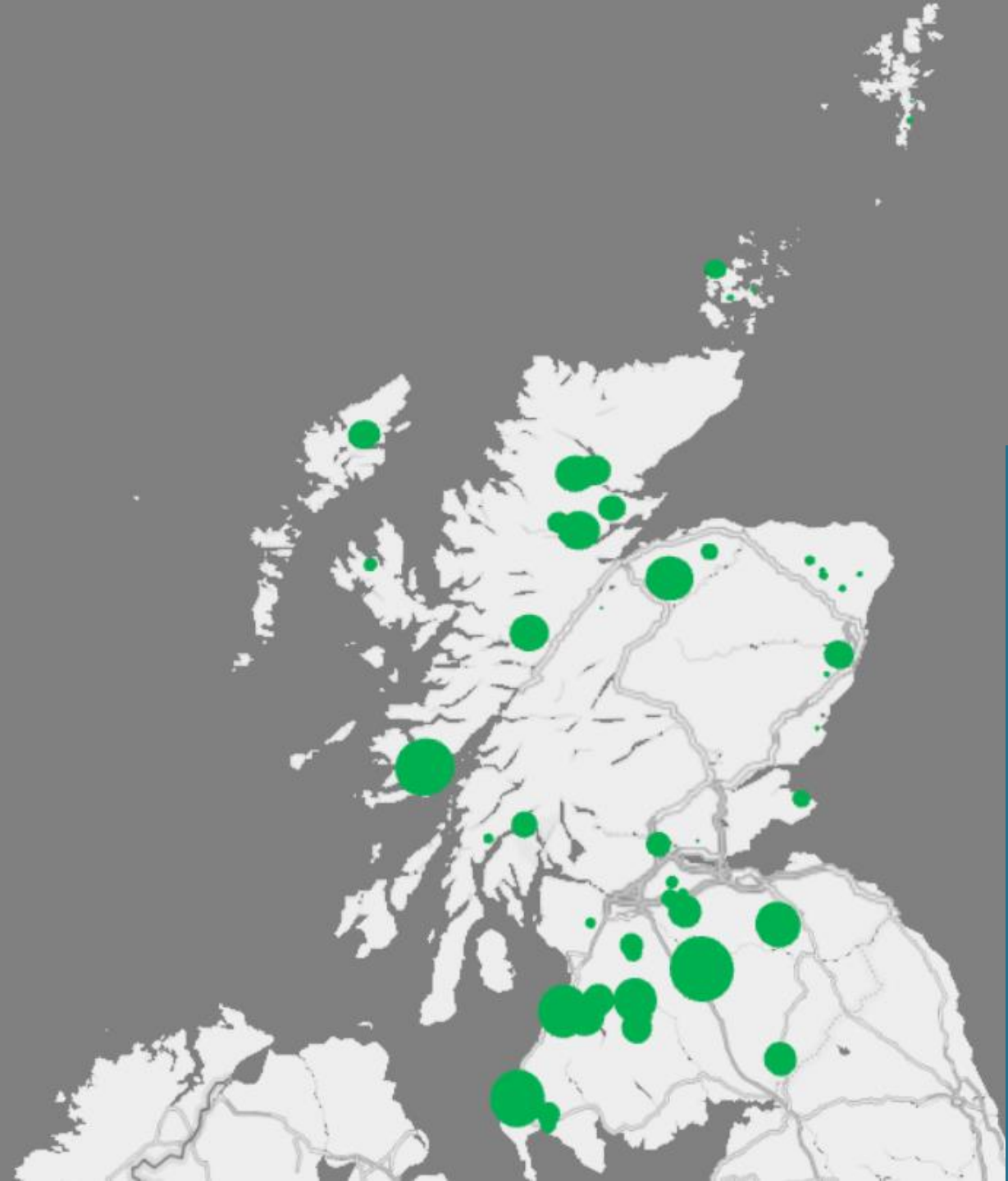
Is there opportunities for Hydrogen production?

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Source: Renewable Energy Planning Database





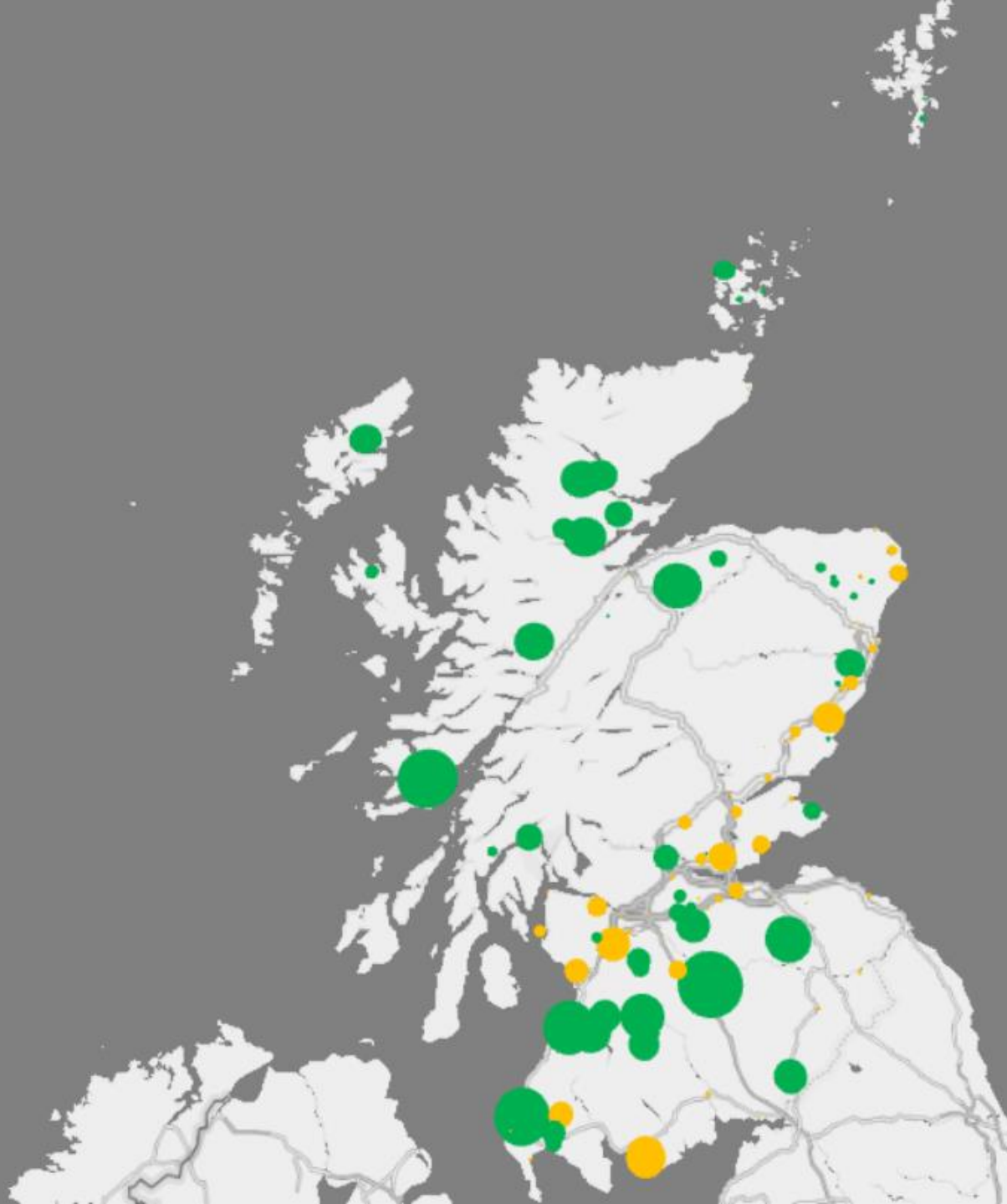
**Where are the next phases of renewable energy?**

- Sites under construction, planning approved, or planning submitted.
- Where are planned projects that do not appear to have an agreed Grid Connection (as listed by SPEN / SSEN / NG).

**Planned renewable energy sites that do not currently have grid connection are potentially strong candidate sites for further investigation**

Solar Photovoltaics

Wind Onshore

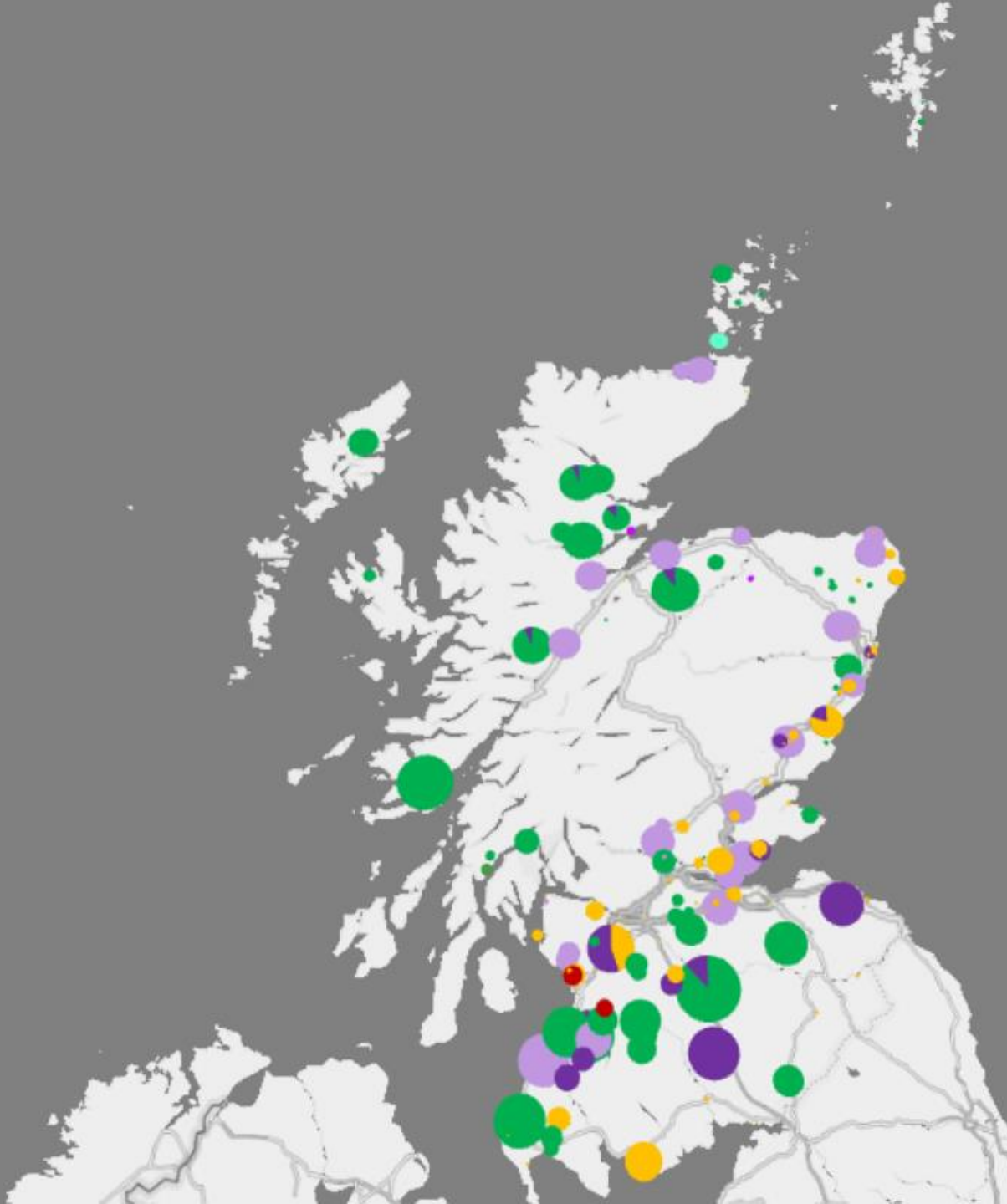


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-  Advanced Conversion Technologies
-  Anaerobic Digestion
-  Battery - RE Co-Located
-  Battery - Stand-Alone
-  EfW Incineration
-  Shoreline Wave
-  Solar Photovoltaics
-  Wind Onshore

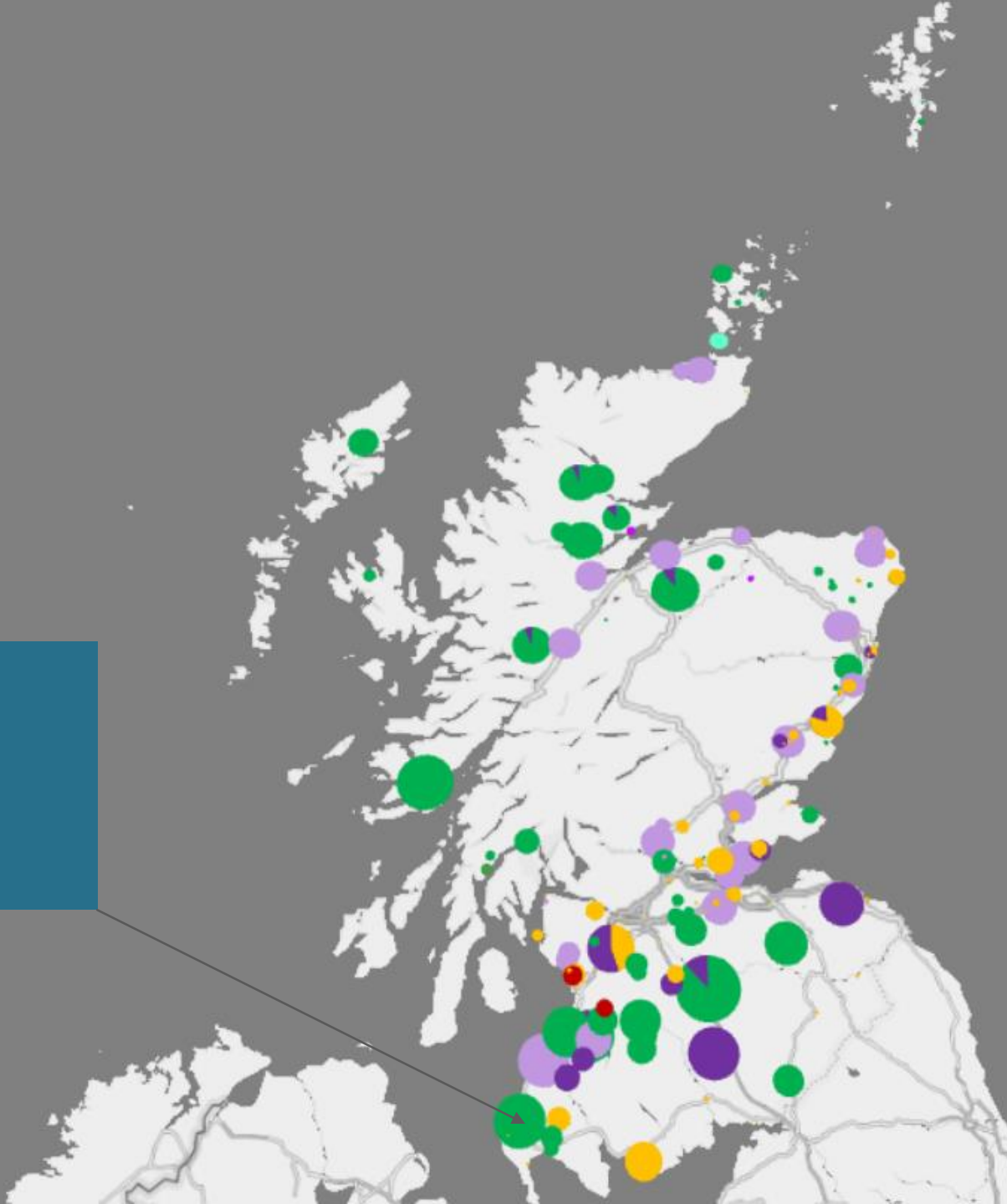


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Mid Moile Wind Farm  
 Planning App Submitted Feb '22

99.4MW (15 turbines)

EnergieKontor UK Ltd.

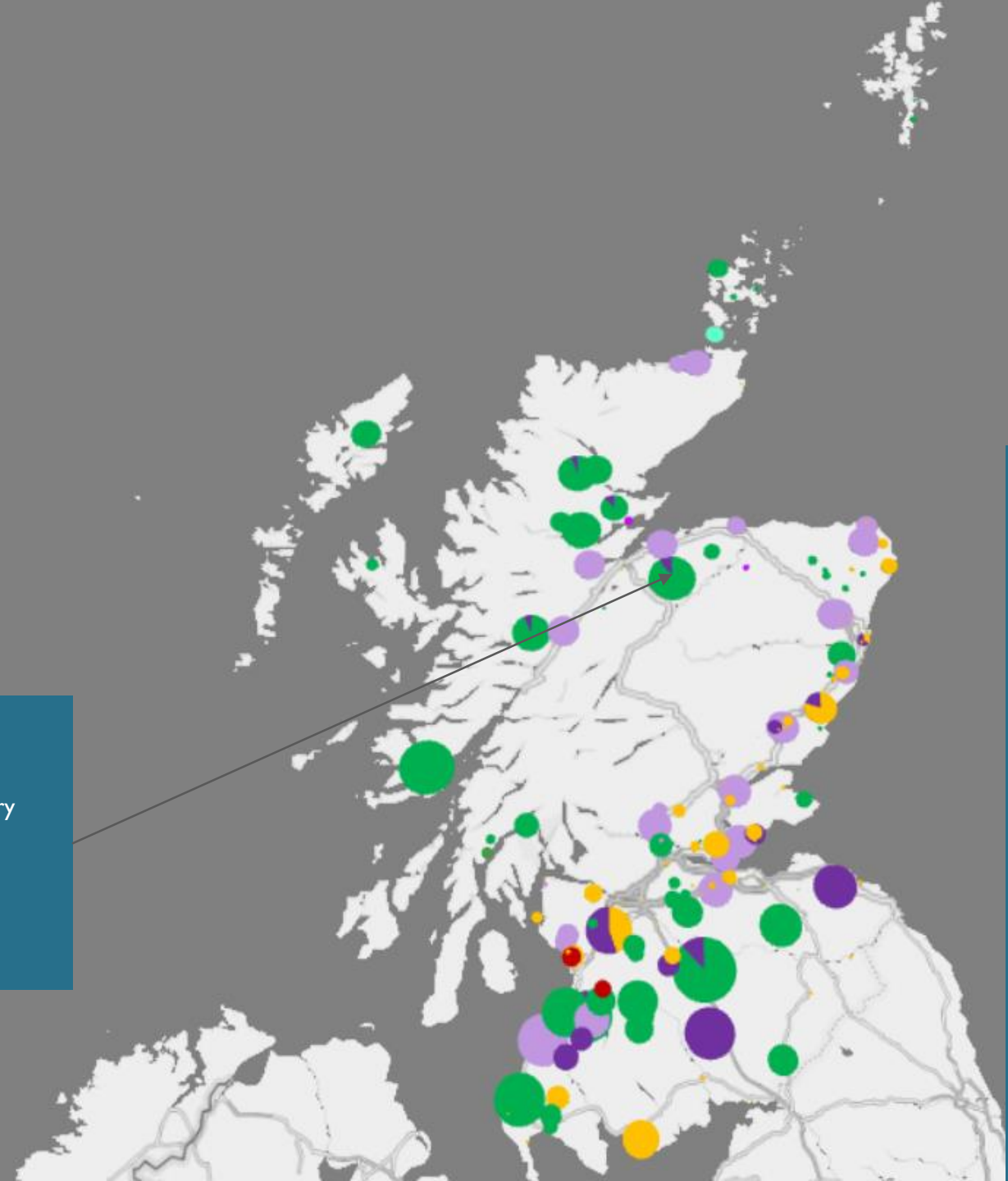
No current grid connection

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Lethen Wind Farm  
 Planning App Submitted Jan '22

102MW (17 turbines) + on-site battery storage 10MW.

Fred Olsen Renewables

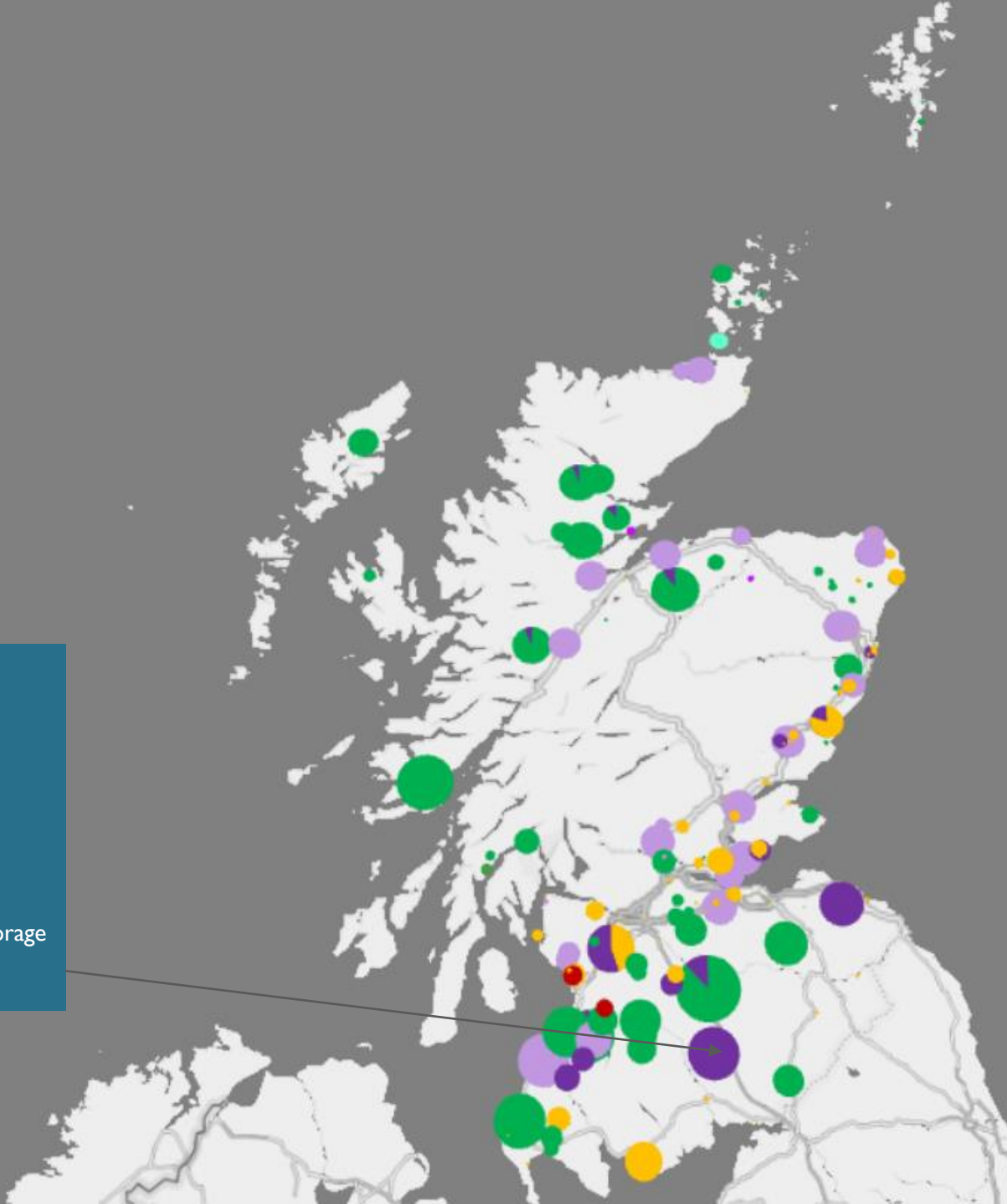
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Harestanes Battery  
 Permission expired Dec 2022

50MW – co-located to renewable energy

Scottish Power Renewables

No current grid connection

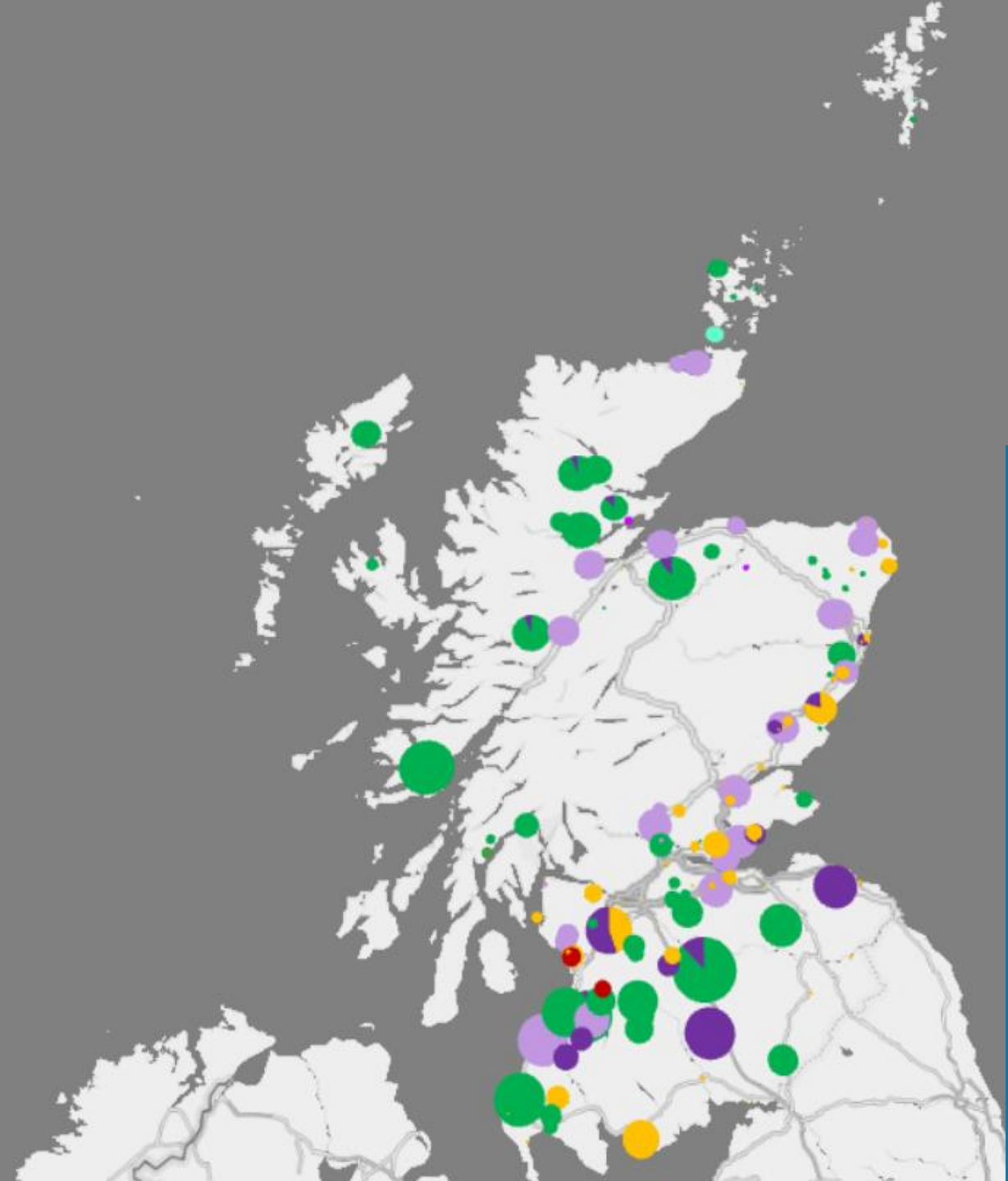
Surplus energy – exploring options for storage and diversification

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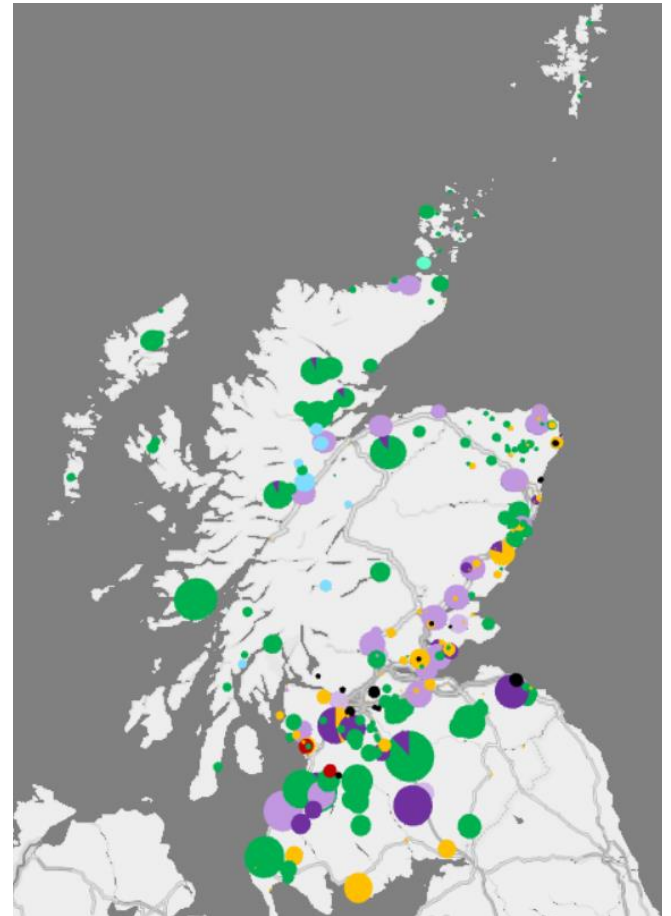
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# EMERGING FINDINGS

- There is complexity in defining site-specific constraint – dynamic variables around grid operation / connections, operational models, subsidies and wider economic incentives that influence generation and levels of curtailment.
- **Approximately 90 potential candidate sites emerging from analysis**
  - 30 sites participating in balancing mechanism w/curtailment >50MWh day (84 total)
  - 12 sites with flexible / non-firm grid connection
  - 40 planned sites currently w/o grid connection
- Emerging clusters in Dumfries & Galloway, South & East Ayrshire, Ross-Shire.
- Further investigation to review water availability, site deliverability, local demand and/or export capability. Narrow to preferred candidate sites for De-Centralised Hydrogen Production.
- Adding to this analysis with understanding of wider context, issues, opportunities for Green Hydrogen production to support site identification.









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6. Round-Up & Review







# TOPIC AREA: KEY SITE REQUIREMENTS

Hydrogen Production Site Requirements							
		10MW	20MW	50MW	100MW		
<b>Power (MWe)</b>		10+	20+	50+	100+		
<b>Water (tonne/hr)</b>		3.25	6.5	16	32		
<b>Area (ha)</b>		<0.5	<0.5	0.75-1.5	1.5-3		
<b>Demand / Export</b>		<ul style="list-style-type: none"> <li>Local industrial / transport use suitable for hydrogen integration</li> <li>Pipeline connection / existing gas network blending</li> <li>Connection to port infrastructure – marine export</li> </ul>					

Hydrogen Production & Export Locations – Site Requirements Study (February 2021) (WOOD on behalf of SE / HIE / SOSE)

- **Power** – direct connection to renewable energy source for green hydrogen production via electrolysis.
- **Water** – potentially significant water requirement as electrolysis feedstock. Mains supply and/or water abstraction.
- **Land** – Deliverable land (and infrastructure) for electrolysers and associated equipment, conversion, compression and storage.

# TOPIC AREA: KEY SITE REQUIREMENTS

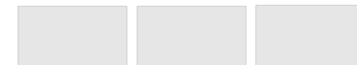
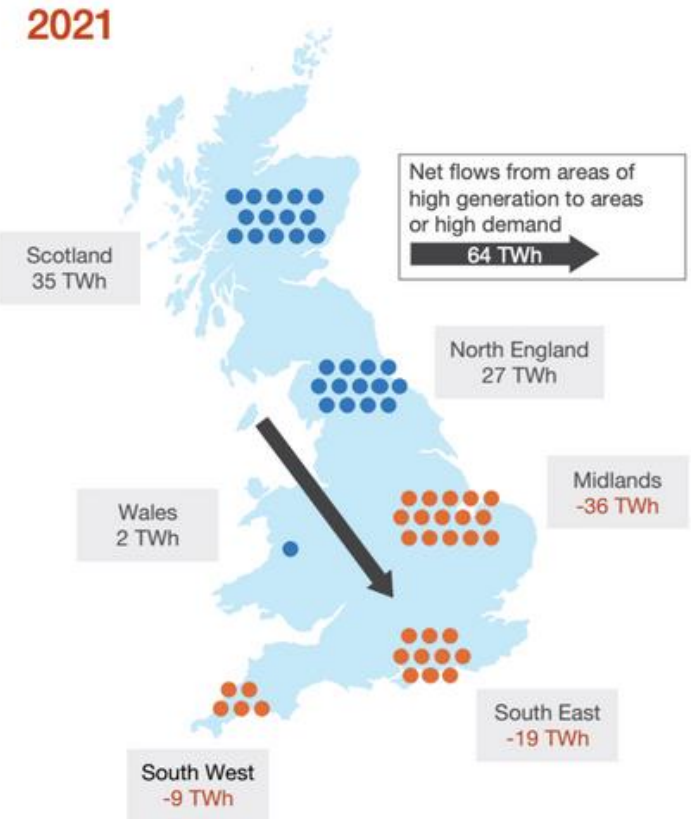
Hydrogen Production Site Requirements					Large-Scale Sites...		
		10MW	20MW	50MW	100MW	200MW	1000MW+
<b>Power (MWe)</b>		10+	20+	50+	100+	200+	1000+
<b>Water (tonne/hr)</b>		3.25	6.5	16	32	64	319
<b>Area (ha)</b>		<0.5	<0.5	0.75-1.5	1.5-3	3-5 Depending on mode of storage / export	15-20+ Depending on mode of storage / export
<b>Demand / Export</b>		<ul style="list-style-type: none"> <li>Local industrial / transport use suitable for hydrogen integration</li> <li>Pipeline connection / existing gas network blending</li> <li>Connection to port infrastructure – marine export</li> </ul>					

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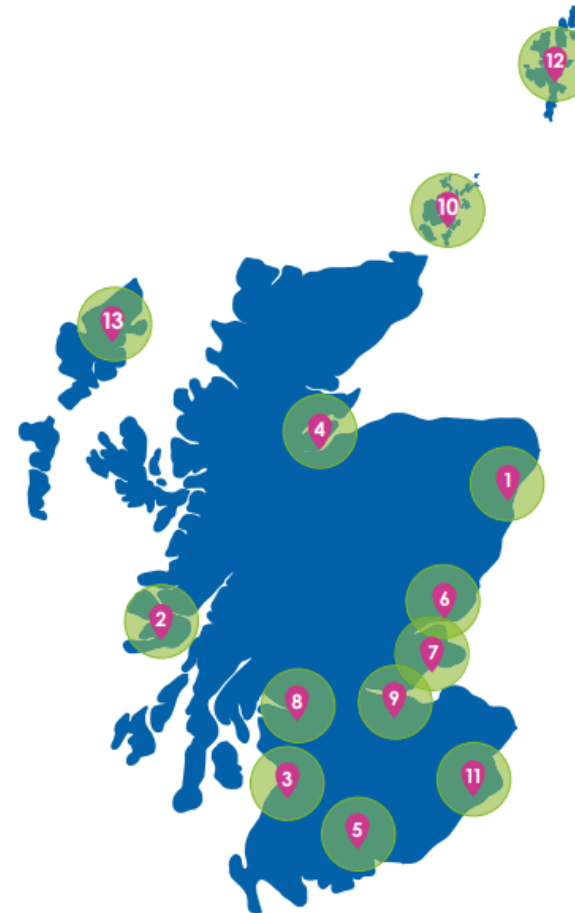
# TOPIC AREA: PRODUCING GREEN HYDROGEN

- **Grid Constraint / Curtailment** – identifying areas where grid infrastructure is (or will be) constrained and ‘excess’ renewable energy may be diverted to hydrogen production.
- **Emerging models / examples of Green Hydrogen Production** – technology and processes for production are continuing to evolve. How are early adopters approaching and are their ‘lessons learnt’?
- **Complementary or Competing Technologies** – How might Green Hydrogen production co-exist with other energy storage technologies – especially batteries?
- **Economics and Incentives** – How might wider economic incentives around Green Hydrogen production evolve - what are key issues on an individual site basis and for wider Hydrogen economy?



# TOPIC AREA: HYDROGEN DEMAND AND/OR EXPORT

- **Transporting Hydrogen for Export** – local transport via tube trailers. Shipping in the form of LOHC with proximity to deep-water port infrastructure.
  - LHyTS Project / /‘Hydrogen Backbone Link’
- **Gas Network Integration** – linking Hydrogen into existing gas network infrastructure. Blending c.20% into existing pipelines?
- **Emerging Demand Hubs** – Where are the centres of demand and future utilisation of Hydrogen identified across Scotland.  
“Regional Hubs” identified in the Hydrogen Action Plan (2022)
  - Aberdeen, Argyll & Islands, Ayrshire (Hunterston), Cromarty (North of Scotland H2), Dumfries & Galloway, Dundee (MSIP), Fife (HI00), Glasgow, Grangemouth, Orkney (Flotta), Scottish Borders, Shetland (Orion), Western Isles



“A Regional Hydrogen Hub is a geographic location (region, city, island, industrial cluster) that is host to the entire Hydrogen value chain, from production, storage and distribution to end-use. Regional Hydrogen Hubs will include multiple end-users with applications ideally covering more than one sector”

Map of potential Regional Hydrogen Hub Locations (Hydrogen Action Plan (2022))

# ROUND UP & REVIEW

- Are there any parallel / complementary areas of research relevant to this study?
- Are there case studies or examples that can support or inform site review and identification?
- Is there anything we haven't covered / "any other business"

Figure 10 : A Just Transition for Energy: Regional and National Opportunities

