

# Farm Explorer: A Tool for Calculating Transparent Greenhouse Gas Emissions

Milan Markovic<sup>1</sup>, Stefano Germano<sup>2</sup>, Daniel Garijo<sup>3</sup>, Peter Edwards<sup>1</sup>, Andy Li<sup>1</sup>, Tewodros Alemu Ayall<sup>1</sup>, Rachael Ramsey<sup>4</sup> and Georgios Leontidis<sup>1</sup>  
<sup>1</sup>Univeristy of Aberdeen, <sup>2</sup>University of Oxford, <sup>3</sup>Universidad Politécnica de Madrid, <sup>4</sup>Scotland's Rural College

Contact: milan.markovic@abdn.ac.uk



## Background

Calculating Green House Gas (GHG) emissions requires real-world data observations quantifying various aspects of business activities and methodologies for transforming activity data into GHG estimates.

Reported emissions estimates may differ depending on:

- calculation methodology
- software used
- geopolitical location
- applicable emissions conversion factors (ECFs)
- the type of reported GHG emissions

### Calculation Formula

$$\text{Activity Data} \times \text{Emissions Conversion Factor} = \text{Emissions Score}$$

## Problem

Provenance of emissions calculations in machine-understandable formats could enhance the transparency of GHG reporting; however, no domain-specific models for describing such traces exist.

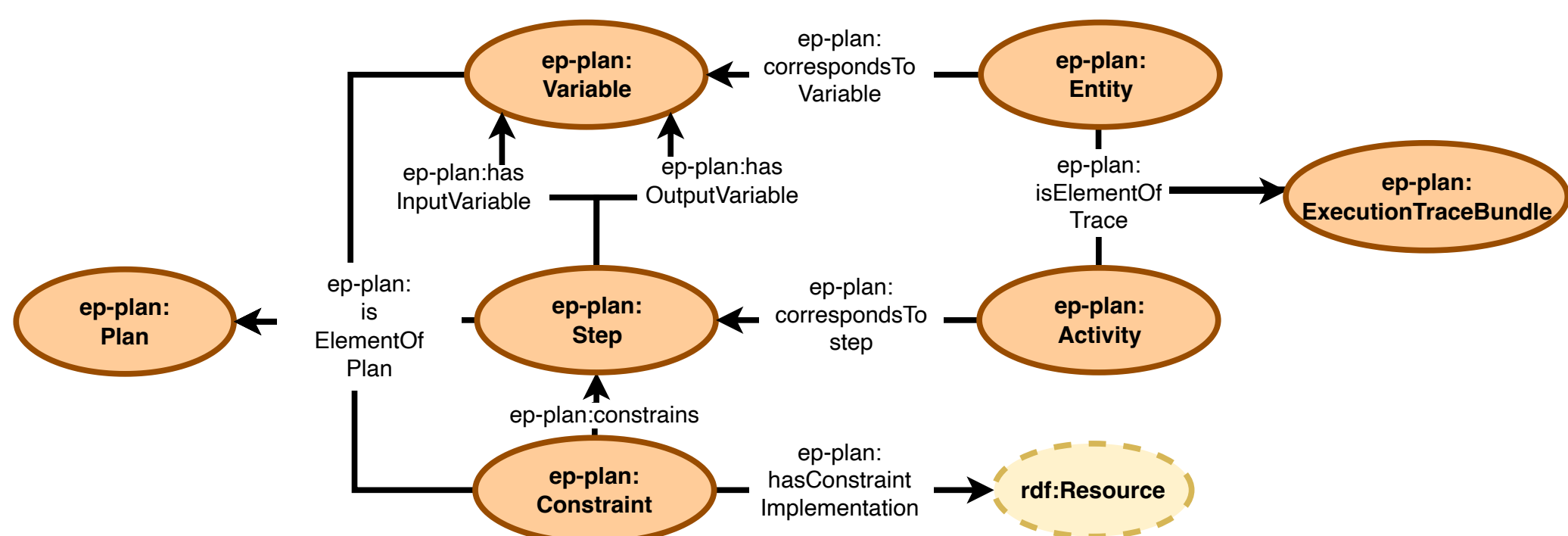
## Solution - <https://tec-toolkit.github.io>

Transparent Emissions Calculations (TEC) toolkit enables modelling, sharing, querying, and validation of semantic provenance descriptions of GHG emissions calculation processes.

Intended Uses: (1) Integrating data resources required to perform and analyse the results of emissions calculations from heterogeneous sources, and support their comparison; (2) Supporting transparency by providing tools to record provenance of reported emissions values; (3) Supporting the automated validations of emissions calculations to reduce errors.

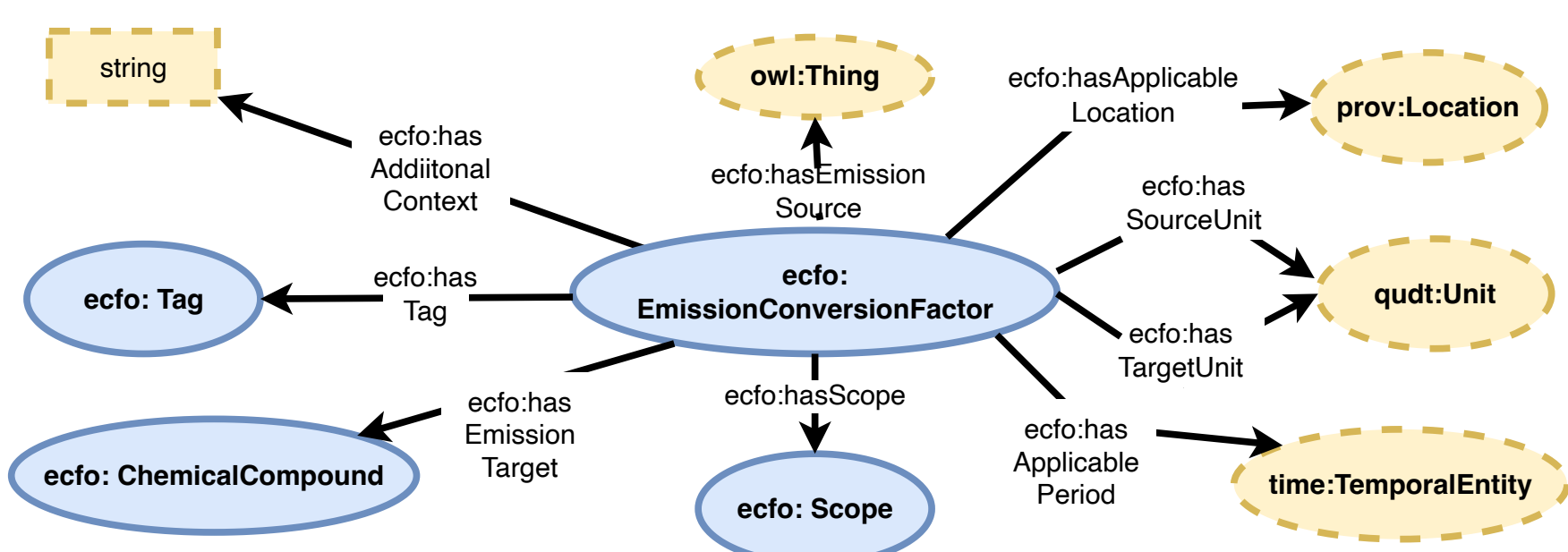
## EP-PLAN - Extended Provenance Plan Ontology

EP-Plan (<https://w3id.org/ep-plan>) extends W3C PROV-O to enable descriptions of abstract plans and corresponding execution traces. Furthermore, constraints associated with planned steps may be defined which we use to guide the execution of the emissions calculation formulas.



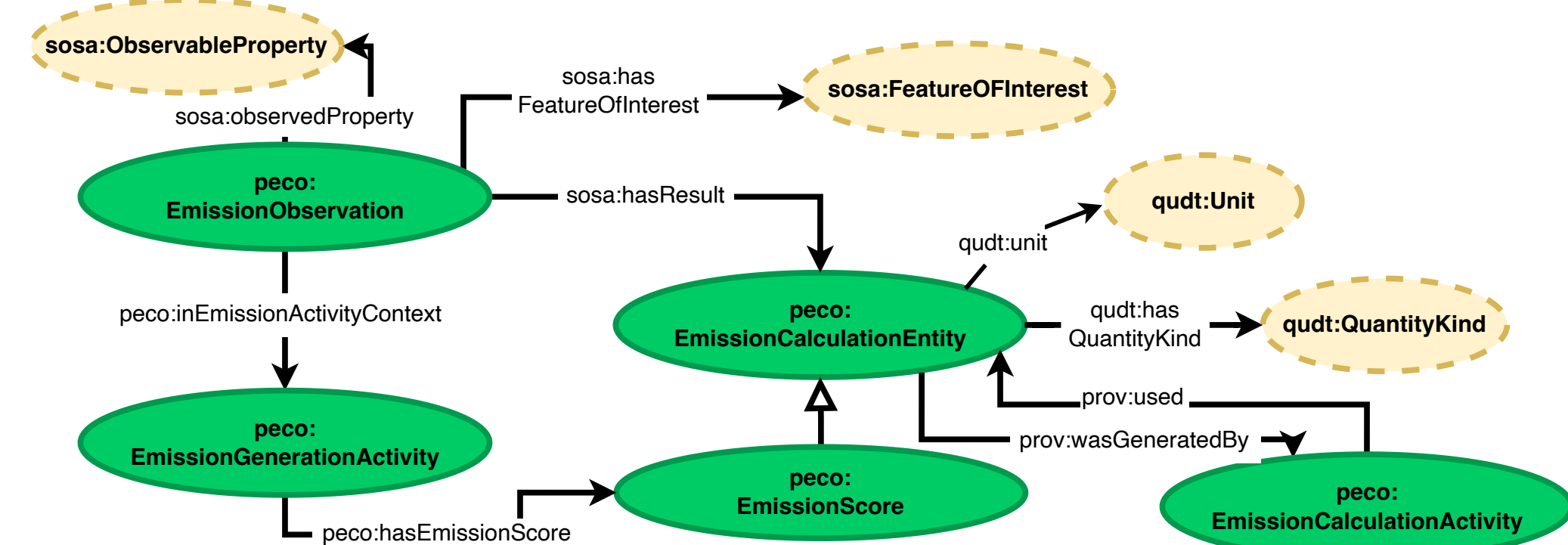
## ECFO - Emission Conversion Factors Ontology

ECFO (<https://w3id.org/ecfo>) aims to provide a generic model for describing the values of ECFs and their metadata.



## PECO - Provenance of Emissions Calculation Ontology

PECO (<https://w3id.org/peco>) describes provenance traces of carbon emissions calculations by capturing the activity data and calculation steps used to estimate the emissions.



## Applications & Current Work

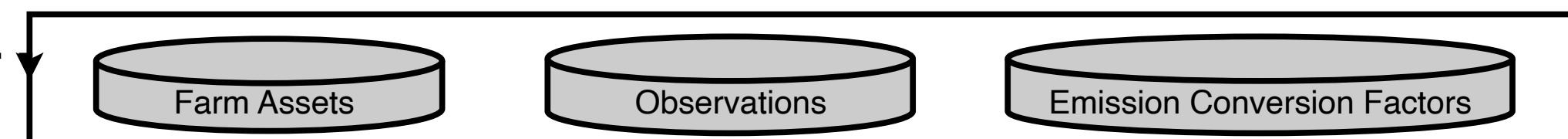
To demonstrate and evaluate our solutions, we are developing a semantic data management tool with UK farmers to enable detailed and automated transparent analysis of carbon footprint associated with individual parts of the farm operation.

The screenshot shows a web interface for a farm named 'Example Farm'. It lists 'Farm Emissions Sources' including 'Tunnel 25', 'Irrigation Rig', 'Automated Observations' (Irrigation Rig Electricity Meter, Tunnel 25 Flow Meter), and 'Manual Observations' (Fertiliser 15.5% N). The 'Actuator Details' section shows 'Irrigation Rig' with 'Actuator type: Lowara Hydrovar SCH 60.25' and 'Feature of interest: Tunnel 25'. A 'Calculate Carbon Footprint' button is visible at the bottom.

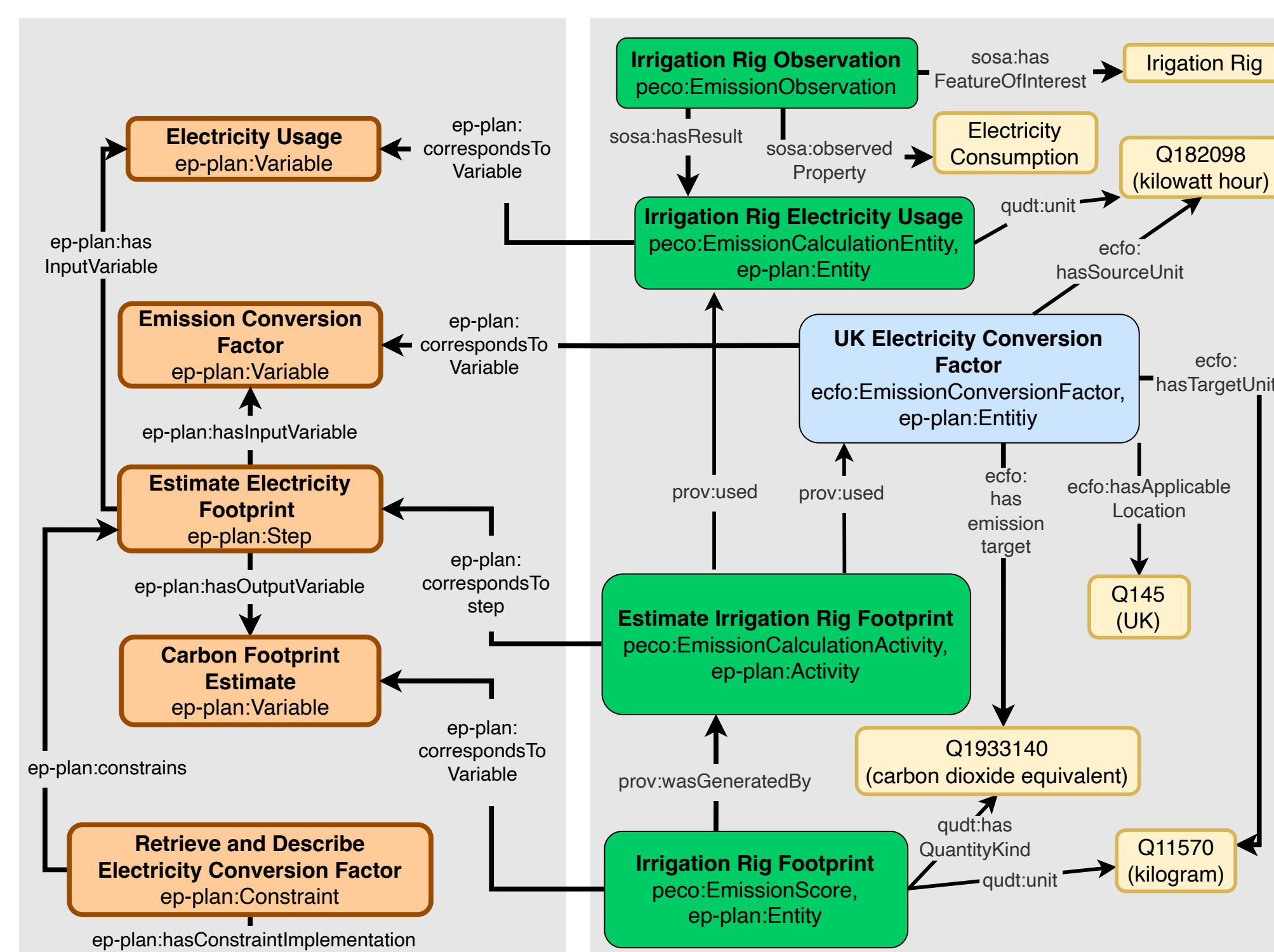
The 'Carbon Footprint Estimate' section shows 'Emissions Calculation Steps':  
1. Apply CF to Electricity Usage: Input 'Electricity Usage - 1928.68kWh [electricity]', Output 'Footprint Estimate - 372.97kg [carbon dioxide equivalent]'.  
2. Electricity Conversion Factor: Input 'Electricity Conversion Factor - 0.19kg [carbon dioxide equivalent]'.  
The 'Conversion Factors' table below shows details for the UK electricity conversion factor:

Source Unit	Target Unit	Applicable Period Start	Applicable Period End	Applicable Location	CF Value	CF IRI	Source	Warnings
kWh	kg	2022-01-01T00:00:00	2022-12-31T23:59:59	United Kingdom	0.19338	<a href="#">link</a>	<a href="#">link</a>	Out-Of-Date

## Farm Data



## Emissions Calculation Method



```
Queries

PREFIX ecfo: <https://w3id.org/ecfo#>
PREFIX ep-plan: <https://w3id.org/ep-plan#>

CONSTRUCT {
  ?id ep-plan:correspondsToVariable ?var.
  ?id ?p ?o.
  ?o2 ?p3 ?o3.
  ?o3 ?p4 ?o4.
}
WHERE {
  ?id a ecfo:EmissionConversionFactor;
  ecfo:hasApplicableLocation/rdfs:label "United Kingdom"@en;
  ecfo:hasScope ecfo:Scope2;
  ecfo:hasTag <https://w3id.org/ecfkg/UK%20electricity>;
  ecfo:hasEmissionTarget <http://www.wikidata.org/entity/Q1933140>;
  ecfo:hasTargetUnit <http://www.wikidata.org/entity/Q11570>.
  ?id ?p ?o.
  OPTIONAL {
    ?id ecfo:hasApplicablePeriod ?o2.
    ?o2 ?p3 ?o3.
    ?o3 ?p4 ?o4.
  }
}
VALUES (?var) { (<urn:ngsi-Id:EmissionCalculationMethod:Plan:Electricity%20Irrigation%20Rig:Var:ECF>)}

----- Component Interaction -----> Object Property
```

## Future Work

Unresolved challenges include:

- automatic alignment of appropriate conversion factors to specific assets/activities
- descriptions and the integration of process-based and machine learning components for emissions estimates within semantic pipelines
- automatic generation of data processing queries and calculation explanation from provenance traces (e.g., using Large Language Models)

## Acknowledgements

This work was supported by the UK Engineering and Physical Sciences Research Council [grant numbers EP/V042270/1, EP/V050869/1, EP/S019111/1].

## Related Publications

- Markovic, M., Garijo, D., Germano, S., Naja, I. (2023). TEC: Transparent Emissions Calculation Toolkit. In: Payne, T.R., et al. The Semantic Web – ISWC 2023. ISWC 2023. Lecture Notes in Computer Science, vol 14266. Springer, Cham.
- Markovic, M., Garijo, D., Edwards, P. and Vasconcelos, W., 2019, October. Semantic modelling of plans and execution traces for enhancing transparency of IoT systems. In 2019 Sixth International Conference on Internet of Things: Systems, Management and Security (IOTSMS) (pp. 110-115). IEEE.

