

## **Appendix**

### ***A.1. Description logic (DL) representation of ontologies***

#### **A.1.1. OntoGasGrid**

Bold text names denote concepts that build on existing concepts from other ontologies. The full ontology, including definition of all namespaces and references to other ontologies, is provided as part of the research data supporting this publication. See the University of Cambridge data repository (<https://doi.org/10.17863/CAM.72550>[doi:10.17863/CAM.72550](https://doi.org/10.17863/CAM.72550)).

**GridPipelineSegment**  $\sqsubseteq$  NetworkSystem  
NetworkSystem  $\sqsubseteq$  CompositeSystem  
CompositeSystem  $\sqsubseteq$  T  
Gas  $\sqsubseteq$  T  
IntakenGas  $\sqsubseteq$  Gas  
OfftakenGas  $\sqsubseteq$  Gas  
StoredGas  $\sqsubseteq$  Gas  
StoredGas  $\sqsubseteq$  Gas  
LongTermStoredGas  $\sqsubseteq$  StoredGas  
MediumTermStoredGas  $\sqsubseteq$  StoredGas  
ShortTermStoredGas  $\sqsubseteq$  StoredGas  
GridPipeline  $\sqsubseteq$  DirectedConnection  
DirectedConnection  $\sqsubseteq$  Connection  
Connection  $\sqsubseteq$  System  
GridComponent  $\sqsubseteq$  Device  
Device  $\sqsubseteq$  System  
System  $\sqsubseteq$  T  
GasPipelineStart  $\sqsubseteq$  DirectedConnection  
GasPipelineEnd  $\sqsubseteq$  DirectedConnection  
GasPipelineTube  $\sqsubseteq$  Device  
GasPipeConnection  $\sqsubseteq$  Device  
GridComponent  $\sqsubseteq$  Device  
CompressionStation  $\sqsubseteq$  GridComponent  
Intake  $\sqsubseteq$  GridComponent  
Offtake  $\sqsubseteq$  GridComponent  
Storage  $\sqsubseteq$  GridComponent  
ContinentalPipeline  $\sqsubseteq$  Intake  
GasTerminal  $\sqsubseteq$  Intake  
LiquefiedNaturalGasImport  $\sqsubseteq$  Intake  
Export  $\sqsubseteq$  Offtake  
IndustrialUser  $\sqsubseteq$  Offtake  
LocalDistribution  $\sqsubseteq$  Offtake  
PowerStation  $\sqsubseteq$  Offtake  
CavernStorage  $\sqsubseteq$  Storage  
HighPressureStorage  $\sqsubseteq$  Storage  
LiquiefiedNaturalGasStorage  $\sqsubseteq$  Storage  
 $\exists$ atUTC.T  $\sqsubseteq$  T

$T \sqsubseteq \forall \text{atUTC}.\text{Datetime}$   
 $\exists \text{hasDiameter}.T \sqsubseteq \text{GasPipelineTube}$   
 $T \sqsubseteq \forall \text{hasDiameter}.\text{DatatypeString}$   
 $\exists \text{hasEndUTC}.T \sqsubseteq T$   
 $T \sqsubseteq \forall \text{hasEndUTC}.\text{Datetime}$   
 $\exists \text{hasName}.T \sqsubseteq T$   
 $T \sqsubseteq \forall \text{hasName}.\text{DatatypeString}$   
 $\exists \text{hasObjectId}.T \sqsubseteq \text{GridPipeline}$   
 $T \sqsubseteq \forall \text{hasObjectId}.\text{DatatypeString}$   
 $\exists \text{hasOrder}.T \sqsubseteq \text{GasPipeConnection}$   
 $T \sqsubseteq \forall \text{hasOrder}.\text{DatatypeString}$   
 $\exists \text{hasLatitude}.T \sqsubseteq T$   
 $\exists \text{hasLongitude}.T \sqsubseteq T$   
 $T \sqsubseteq \forall \text{hasLatitude}.\text{DatatypeString}$   
 $T \sqsubseteq \forall \text{hasLongitude}.\text{DatatypeString}$   
 $\exists \text{hasLinepackZone}.T \sqsubseteq \text{Offtake}$   
 $T \sqsubseteq \forall \text{hasLinepackZone}.\text{DatatypeString}$   
 $\exists \text{hasLocalDistributionZone}.T \sqsubseteq \text{LocalDistribution}$   
 $T \sqsubseteq \forall \text{hasLocalDistributionZone}.\text{DatatypeString}$   
 $\exists \text{hasNTSExitArea}.T \sqsubseteq \text{Offtake}$   
 $T \sqsubseteq \forall \text{hasNTSExitArea}.\text{DatatypeString}$   
 $\exists \text{hasNTSExitZone}.T \sqsubseteq \text{Offtake}$   
 $T \sqsubseteq \forall \text{hasNTSExitZone}.\text{DatatypeString}$   
 $\exists \text{hasStartPart}.T \sqsubseteq \text{GridPipelineSegment}$   
 $T \sqsubseteq \forall \text{hasStartPart}.\text{GasPipelineStart}$   
 $\exists \text{hasTubePart}.T \sqsubseteq \text{GridPipelineSegment}$   
 $T \sqsubseteq \forall \text{hasTubePart}.\text{GasPipelineTube}$   
 $\exists \text{hasEndPart}.T \sqsubseteq \text{GridPipelineSegment}$   
 $T \sqsubseteq \forall \text{hasEndPart}.\text{GasPipelineEnd}$   
 $\exists \text{entersPipeConnection}.T \sqsubseteq \text{DirectedConnection}$   
 $\exists \text{entersSegmentPart}.T \sqsubseteq \text{DirectedConnection}$   
 $\exists \text{entersSegmentPart}.T \sqsubseteq \text{DirectedArc}$   
 $T \sqsubseteq \forall \text{entersSegmentPart}.\text{Device}$   
 $T \sqsubseteq \forall \text{entersSegmentPart}.\text{Node}$   
 $T \sqsubseteq \forall \text{entersPipeConnection}.\text{Device}$   
 $T \sqsubseteq \forall \text{entersPipeConnection}.\text{Node}$   
 $\exists \text{hasConnectedComponent}.T \sqsubseteq \text{GasPipeConnection}$   
 $T \sqsubseteq \forall \text{hasConnectedComponent}.\text{GridComponent}$   
 $\exists \text{hasPipeConnectionOutput}.T \sqsubseteq \text{Node}$   
 $\exists \text{hasPipeConnectionOutput}.T \sqsubseteq \text{Device}$   
 $T \sqsubseteq \forall \text{hasPipeConnectionOutput}.\text{DirectedConnection}$   
 $\exists \text{hasSegmentPartOutput}.T \sqsubseteq \text{Device}$   
 $T \sqsubseteq \forall \text{hasSegmentPartOutput}.\text{DirectedConnection}$

$T \sqsubseteq \forall \text{hasSegmentPartOutput. DirectedArc}$   
 $\exists \text{hasStored. T} \sqsubseteq \text{Storage}$   
 $T \sqsubseteq \forall \text{hasStored. StoredGas}$   
 $\exists \text{hasTaken. T} \sqsubseteq \text{Intake}$   
 $T \sqsubseteq \forall \text{hasTaken. IntakenGas}$   
 $\exists \text{hasUsed. T} \sqsubseteq \text{Offtake}$   
 $T \sqsubseteq \forall \text{hasUsed. OfftakenGas}$   
 $\exists \text{isConnectedToPipeline. T} \sqsubseteq \text{GridComponent}$   
 $T \sqsubseteq \forall \text{isConnectedToPipeline. GasPipeConnection}$   
 $\text{GasMeters} \sqsubseteq T$   
 $\exists \text{hasConsumingGasMeters. T} \sqsubseteq \text{GasMeters}$   
 $T \sqsubseteq \forall \text{hasConsumingGasMeters. DatatypeString}$   
 $\exists \text{hasNonConsumingGasMeters. T} \sqsubseteq \text{GasMeters}$   
 $T \sqsubseteq \forall \text{hasConsumingGasMeters. DatatypeString}$

### A.1.2. OntoClimateObservations

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$\text{ClimateMeasurement} \sqsubseteq T$   
 $\text{ClimateVariable} \sqsubseteq T$   
 $\text{Statistical – Geography} \sqsubseteq T$   
 $\exists \text{hasClimateMeasurement. T} \sqsubseteq \text{Statistical – Geography}$   
 $T \sqsubseteq \forall \text{hasClimateMeasurement. ClimateMeasurement}$   
 $\exists \text{hasClimateVariable. T} \sqsubseteq \text{ClimateMeasurement}$   
 $T \sqsubseteq \forall \text{hasClimateVariable. ClimateVariable}$