Carbon Reporting SPS Demonstrator
Intension and target

Intension

- Present the **value and interoperability of applications employing machine profiles** from both CESMII and AAS (Asset Administration Shell) including OPC UA
- **Use carbon reporting (in a simple way) as attractive content**, but not as the main purpose of the demonstrator

Target

- Demonstration of **how a sample machine can manage different machine profiles** and provide data to it
- Demonstration of **Processing of the profiles**
- **Display**
- **View the results of proactive changes to the machine**: statically and also interactively based on changes at the machine

Result

- Diagram: Next slide

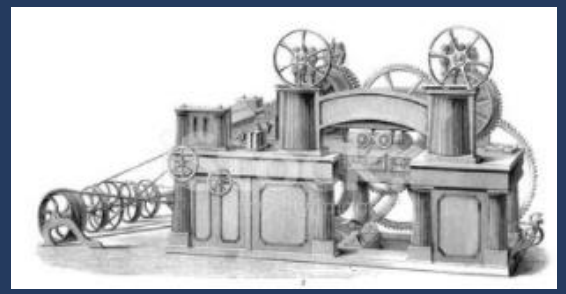
Update as of Oct 12th, 2021

Update as of Oct 19th, 2021

General Business Diagram Demonstrator for Machine Profile Interoperability

Example Carbon Reporting

Machine provider / Asset	Hyper Scaler (e.g. Microsoft Azure Cloud)	Customer / User



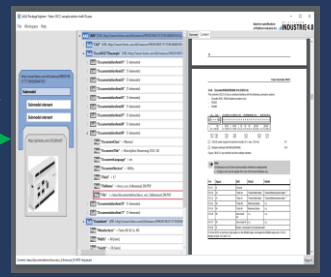
Option 1

Consumption Telemetry

Asset Admin Shell Server / Repository (Azure App Service)

Asset Admin Shell (Sub Model etc)

CO2 Emission Reporting



Option 2

Consumption Telemetry

Asset Admin Shell Server / Repository (on premise or Cloud Services)

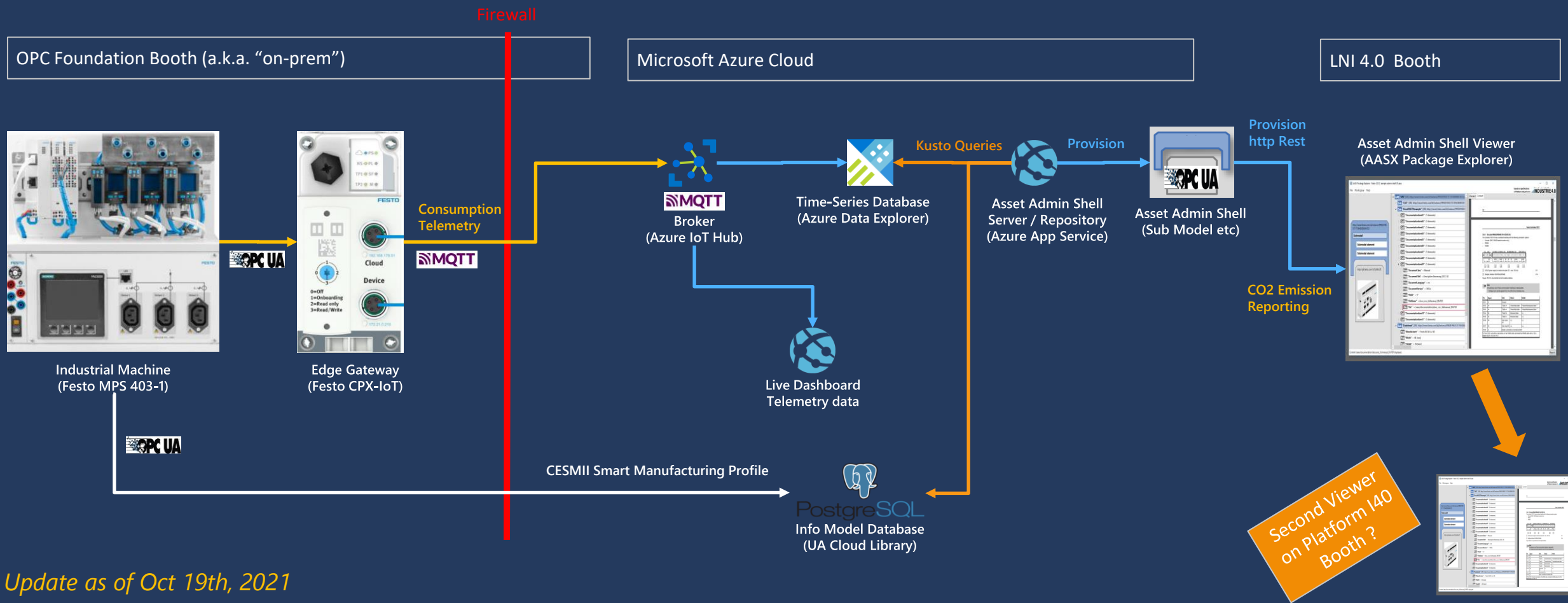
Asset Admin Shell (Sub Model etc)

CO2 Emission Reporting

Update as of Oct 19th, 2021

Technical Diagram Demonstrator for Machine Profile Interoperability

Example Carbon Reporting



Update as of Oct 19th, 2021

Carbon Reporting SPS Demonstrator
Roles and tasks

Status as of Oct 4th, 2021

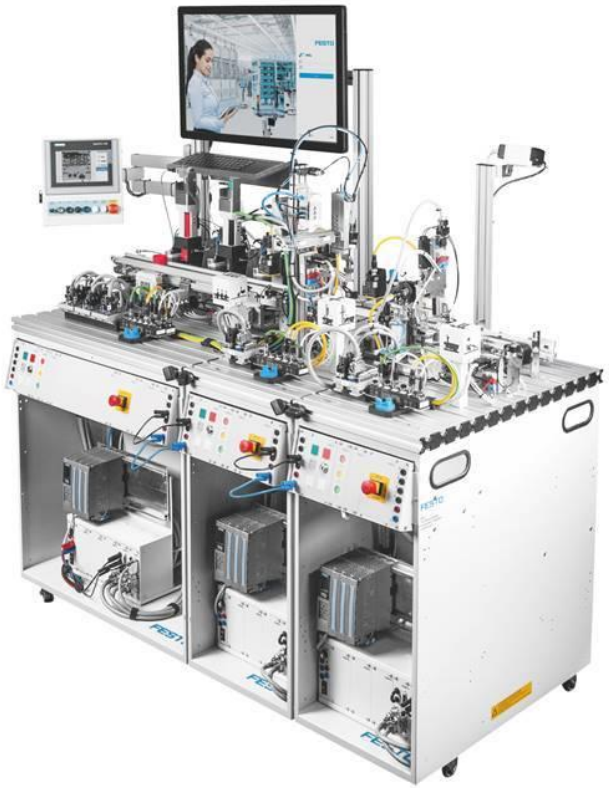
Joint SPS Demonstrator

	Any further actions?
Platform Industrie 4.0 (Anna-Lena Laub, Nazim Benghomrani)	Marketing Material Narrative and general Marketing Material Communication to Platform I40 - specific target audience
CESMII (John Dyck, Jonathan Wise)	Arrangement of CESMII-Smart Manufacturing Profile of CES Communication to CESMII - specific target audience
LNI 4.0 (Anja Simon)	Organizational set-up for preparation of Demonstrator / on behalf of Plattform Industrie 40 Communication to LNI4.0- specific target audience Presentation at the SPS
Microsoft (Erich Barnstedt)	Arrangement Azure Cloud Communication to Microsoft- specific target audience
Festo (Michael Hoffmeister, Stefan Kapp)	Arrangement Demo Machine incl. Gateway Communication to Festo specific target audience Arrangement data for calculation of Machine Profiles (OPC UA + AAS)
OPC Foundation (Stefan Hoppe)	Arrangement of the booth at SPS (place, internet, energy, compressed air) Arrangement of Transport to the booth at SPS and back / together with Festo

Update as of Oct 12th, 2021

Link to the Festo – Demo Machine

https://www.festo-didactic.com/de-de/lernsysteme/fabrikautomation-industrie-4.0/lernfabriken/mps-400-anlagen-i4.0/mps-system-403-1,umfassendes-lernsystem-im-bereich-mechatronik-und-industrie-4.0.htm?fbid=ZGUuZGUuNTQ0LjEzLjE4LjE3ODYuMTAzMjMw



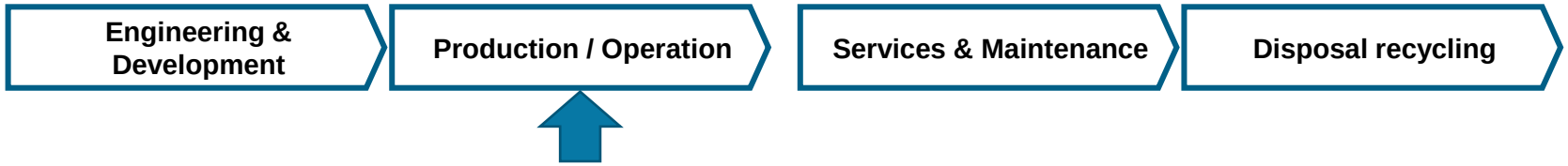
Update as of Oct 12th, 2021

Carbon Reporting SPS Demonstrator
Scoping and Formula

General Guidelines / Standards:

1. PAS 2050 (based on ISO 14040) –> entire Lifecycle (Cradle to grave)
2. **GHG Protocol** (GreenHouseGas Protocol) –> entire Lifecycle (cradle to grave) **-> Recommendation because of popularity**
3. ISO 14067 –> no entire Lifecycle

Scoping – which phase we want ot present at SPS:



a. For entire Lifecycle all information are required for calculation of PCF (Product Carbon Footprint)

b. Recommendation for simplicity –> to present the USE of the machine for the Production of the product
   - Use phase is mainly the core cause of emissions
   - Other life cycle phases of manufacture, distribution and disposal of the product are not taken into account

c. Use the same period for measurement of power consumption and compressed air consumption.

Update as of Oct 12th, 2021

Input for specific emission factor of the *German electricity mix*

1. **Consideration of the individual greenhouse gases that contribute to climate change**

Spezifische Emissionsfaktoren für den Deutschen Strommix

Schadstoff	Einheit	1990	2000	2019
Schwefeldioxid	g/kWh	4,796	0,569	0,196
Stickstoffdioxid	g/kWh	1,055	0,490	0,373
Staub	g/kWh	0,745	0,026	0,009
PM_{10}	g/kWh	nicht berichtet	0,023	0,009
Kohlenmonoxid	g/kWh	0,389	0,205	0,176
Kohlendioxid*	kg/kWh	0,764	0,644	0,408
Lachgas	g/kWh	0,020	0,015	0,011
Methan	g/kWh	0,016	0,030	0,183
NMVOC	g/kWh	0,013	0,014	0,014
Quecksilber	mg/kWh	0,028	0,015	0,007

2. **Multiplication of these greenhouse gases with the characterization factors from the publication of the Intergovernmental Panel on Climate Change**
   (Assessment Report AR5 from 2014 - see GHG Protocol https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values % 20 (Feb% 2016% 202016) _1.pdf)
   and adding all of them = 514,9 *g* CO2-e (g CO2 equivalents)

	Charakterisierungsfaktor in kg CO2-e/kg	g/kWh (Emissionsfaktoren für Deutschen Strommix 2019)	Schadstoffbeitrag in g CO2-e/kWh
CO2	1	408	408,0
CH4	28	0,183	5,1
NOx	265	0,384	101,8
NMVOC	4,23	0,014	0,06
Summe			514,9

3. **The carbon footprint of 1 kWh of electrical power consumed from the German power grid is therefore 0,515 *kg* CO2-e / kWh (2019, UBA).**

4. **Formula: CF [kg CO2-e] = Energy Consumption of the Machine [kWh] * 0,512 [kg CO2-e/kWh]**

Update as of Oct 12th, 2021

Source: German Federal Environment Agency = Umweltbundesamtes (UBA):
https://www.umweltbundesamt.de/themen/luft/emissionen-von-luftschadstoffen/spezifische-emissionsfaktoren-fuer-den-deutschen

Input for specific emission factor of the *German Compressed Air*

1. **LCA database (Ökobilanz-Database):**
   for 1 m³ of "Compressed Air Production @ 700 kPa Gauge" (= 7 bar)" a specific power requirement of 0.7663 MJ (MegaJoule) of was determined
   (Source: https://ecoinvent.org/ https://ecoinvent.org/the-ecoinvent-database/data-releases/ecoinvent-3-6/)

-> Converted = approx. 0,213 kWh /m³ Compressed Air (@ 7Bar)

2. **Energy Consumption for the usage of compressed air (@ 7Bar)**
   -> E [kWh] = 0,213 kWh/ 1.000 Liter * X (l/min) * Period length Y (min).

4. **Formula: CF [kg CO2-e] = Energy Consumption for compressed Air [kWh] * 0,512 [kg CO2-e/kWh]**

(carbon footprint of 1 kWh of electrical power consumed from the German power grid)

Update as of Oct 12th, 2021

Update of technical diagram as of Oct 19th, 2021
Data for carbon calculation not updated

Technical Diagram Demonstrator for Machine Profile Interoperability

Example Carbon Reporting

Measurement
Electrical power [W] @1/3 Hz
Air flow [l/min] @50 Hz

Aggregation to
Electrical consumption [W] @1 Hz
Pneumatic consumption [l/min] @1 Hz

Aggregation to
Electrical consumption Wh/min
Pneumatic consumption l/min

Conversion into
Emissions (electrical) kg CO_2
Emissions (pneumatic) kg CO_{2eq}

applying
Emission factor kg CO_{2eq}/kWh
Compressed air index kWh/m³
(constant or time varying)

Visualization on dashboard
Wh
kg CO_{2eq}

OPC Foundation Booth (a.k.a. "on-prem")

Microsoft Azure Cloud

LNI 4.0 Booth

Industrial Machine
(Festo MPS 403-1)

OPC UA

Edge Gateway
(Festo CPX-IoT)

Consumption Telemetry

MQTT

MQTT
Broker
(Azure IoT Hub)

Time-Series Database
(Azure Data Explorer)

Kusto Queries

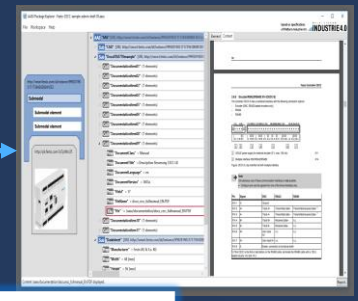
Asset Admin Shell
Server / Repository
(Azure App Service)

Provision

Asset Admin Shell
(Sub Model etc)

Provision
http Rest

Asset Admin Shell Viewer
(AASX Package Explorer)



CO2 Emission Reporting

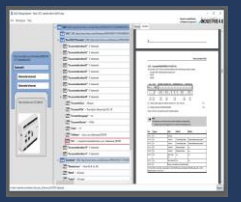
Live Dashboard
Telemetry data

CESMII Smart Manufacturing Profile

PostgreSQL
Info Model Database
(UA Cloud Library)

Report
Emissions (electrical) kg CO_2 per day
Emissions (pneumatic) kg CO_{2eq} per day

Second Viewer on Platform I40 Booth ?



Situation at the SPS booth