

# SuedLink

Euro Electro Highway  
und  
Energie System Integration

Study Complex

Thomas Prüfling

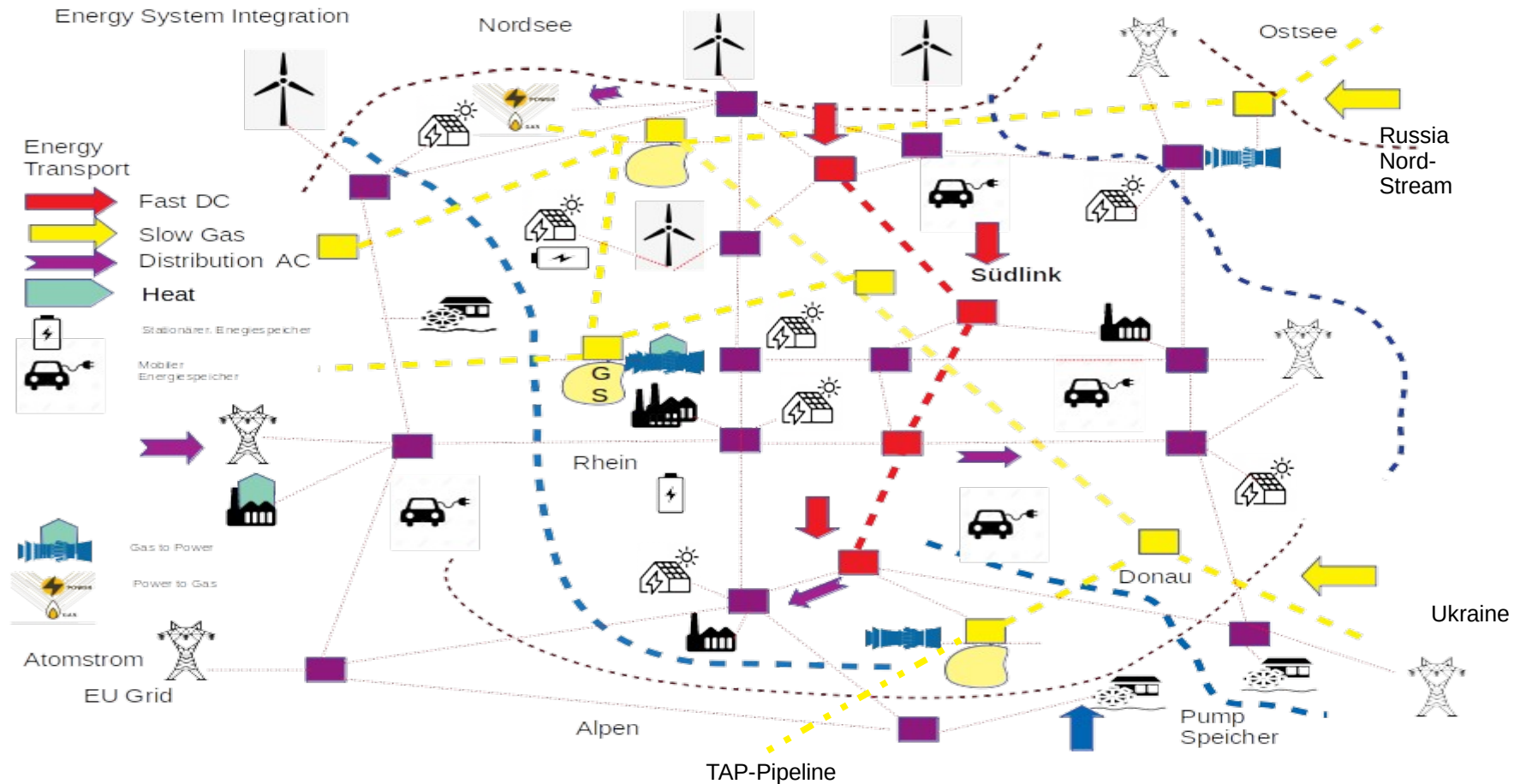
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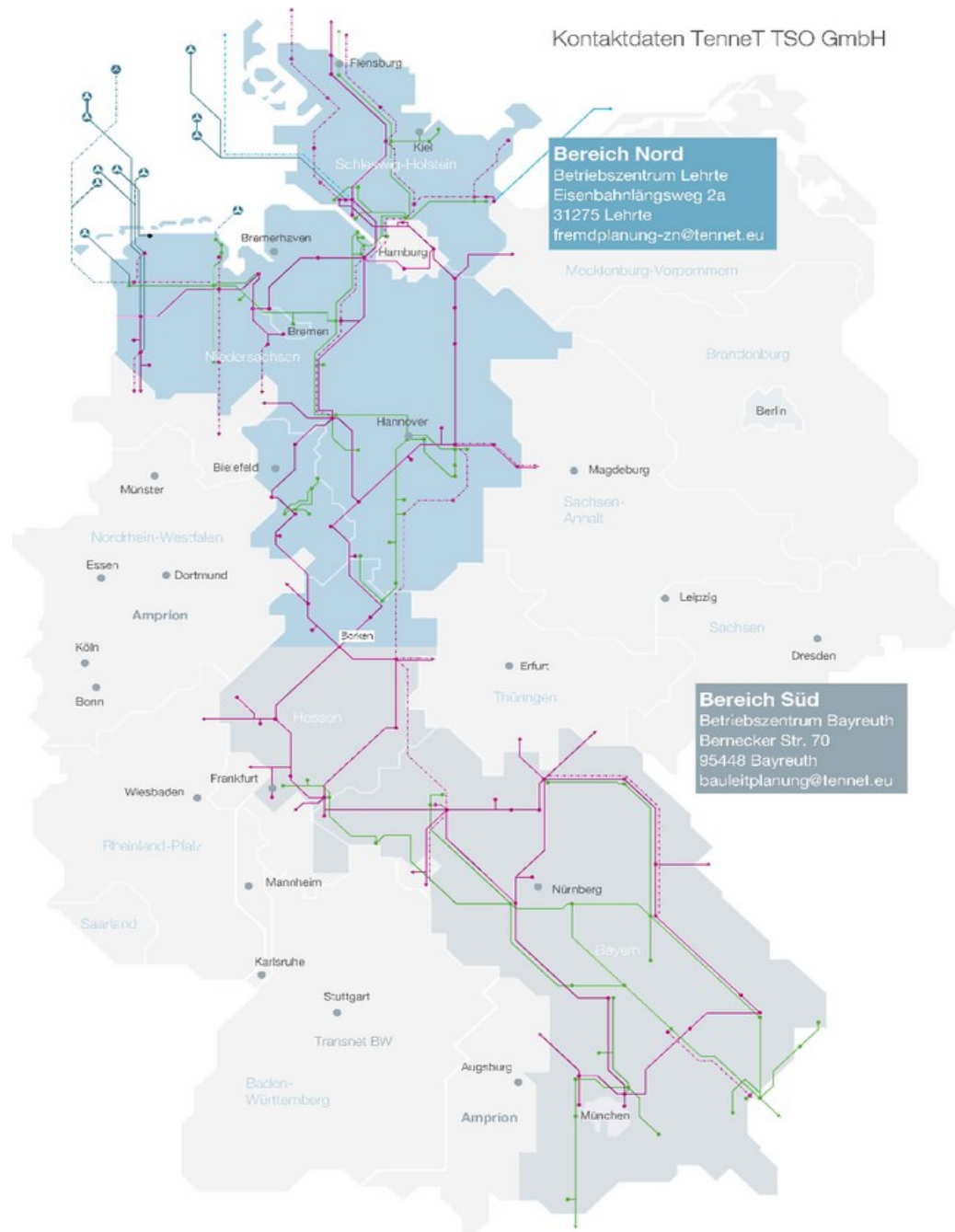
8-2020

# EU -ESI Integration

1920 Elektricitiy is Future, Lenin  
2020 Energy Integration is Future

ENTSO-E  
Regelungen



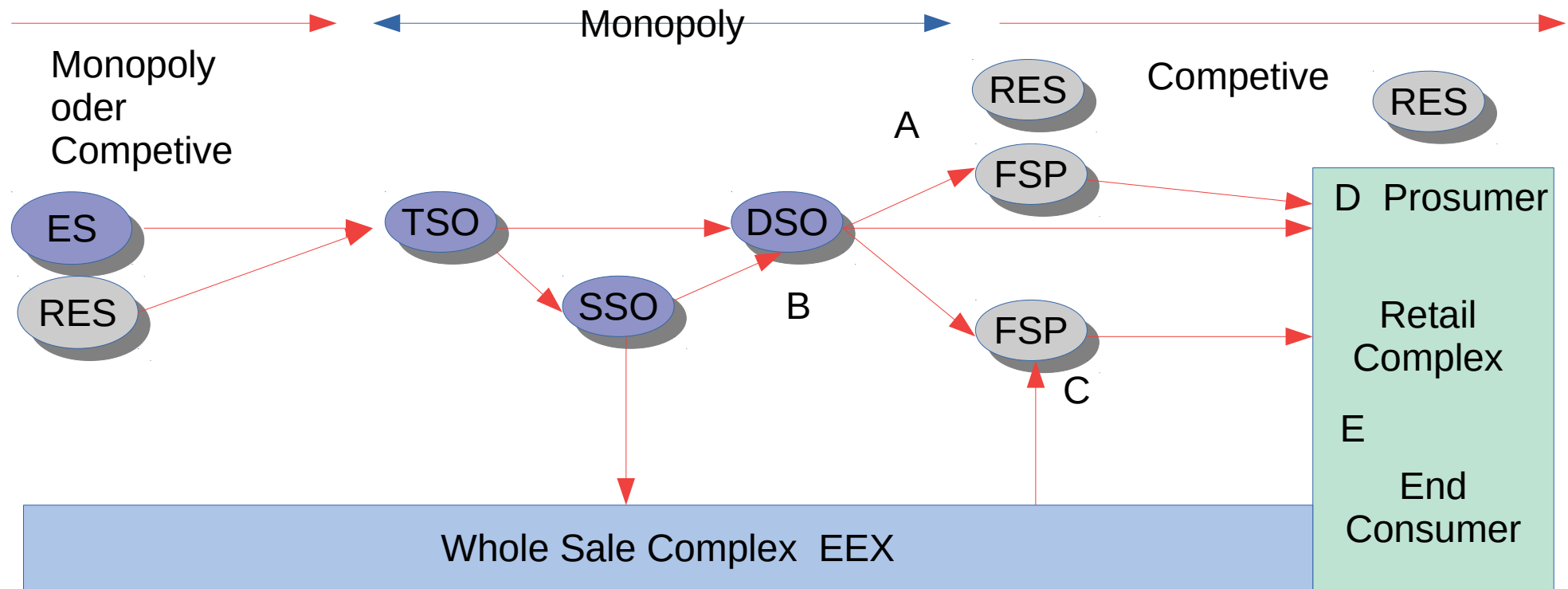


## Südlink Projekt 2020

Advantage of HVDC is about higher Efficiency

Die Vorteile von HV-DC Transmissionen bestehen in der höheren Effizienz (Geringere Übertragungsverluste) und umweltverträglichere Trassenbildung.

## DER Energy Price Wholesale and Retail



### 5 Weisen der Preisbildung

A. FSP hat eigene RES. Smart City

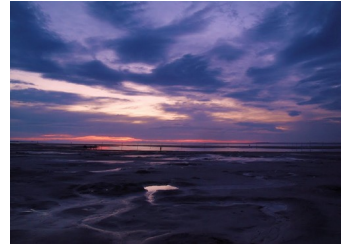
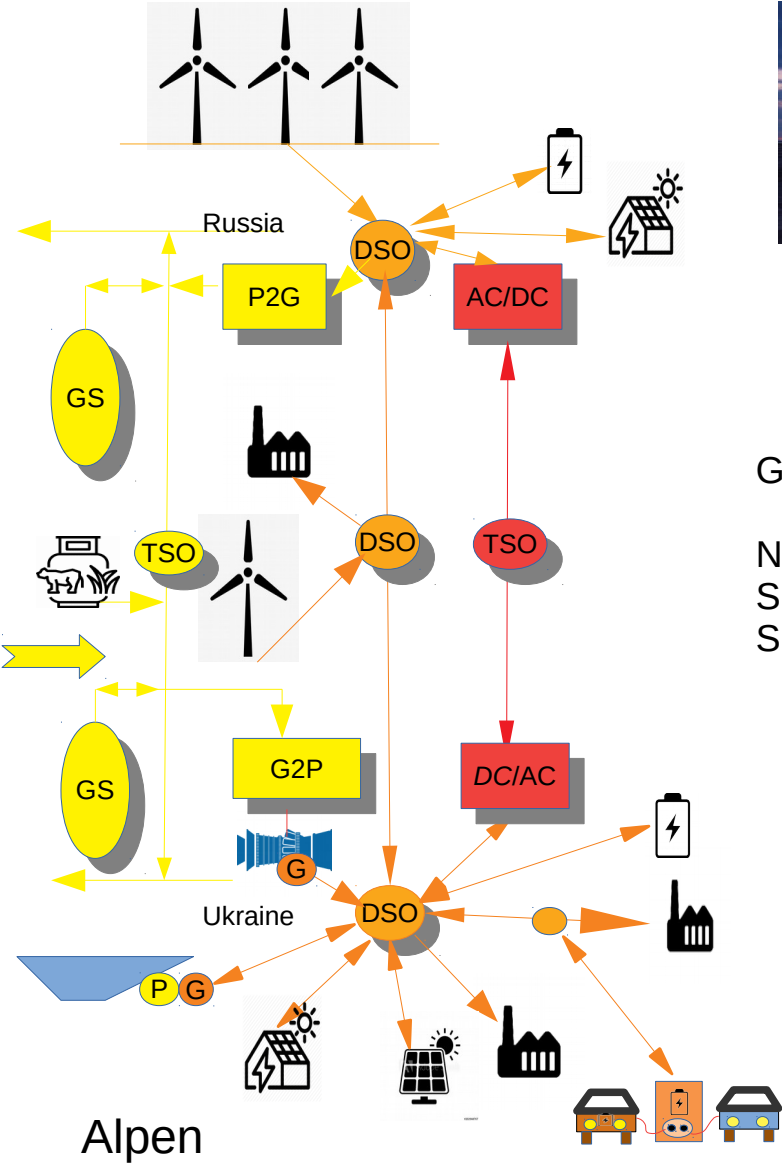
B. Preis von DSO

C. FSP Anbieter kauft von EEX

D. Prosumer hat RES oder Insel mode Active Prosumer

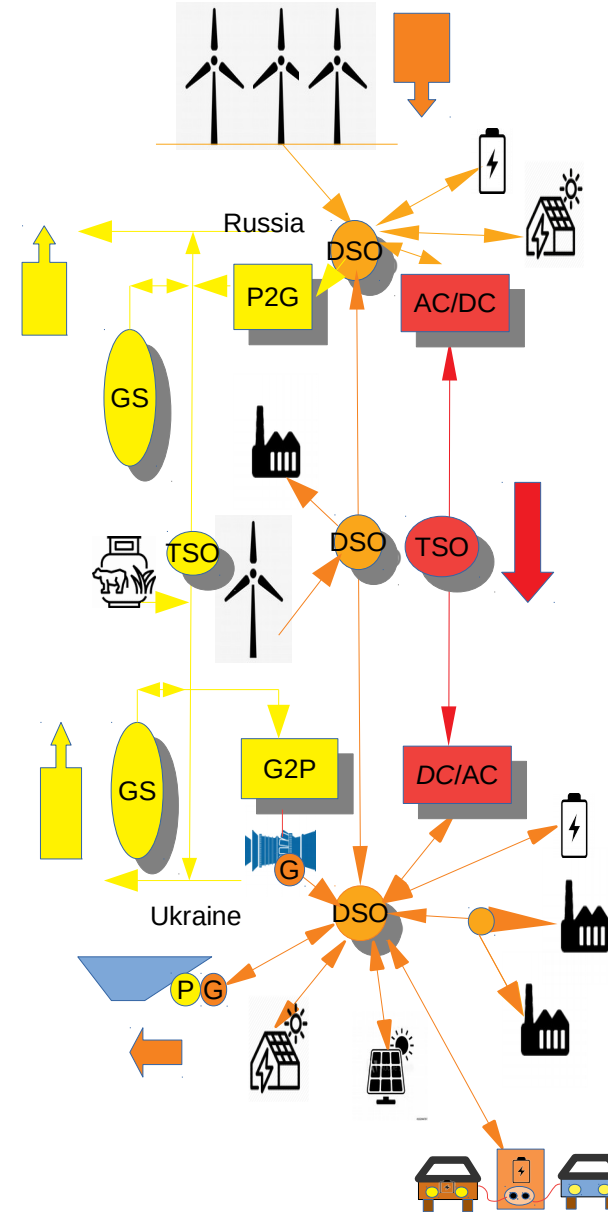
E. Passiver Consumer. Ohne RES

Nordsee



Grund Szenario

Norden hat keinen Überschuß  
Süden normal  
Speicher Auffüllung



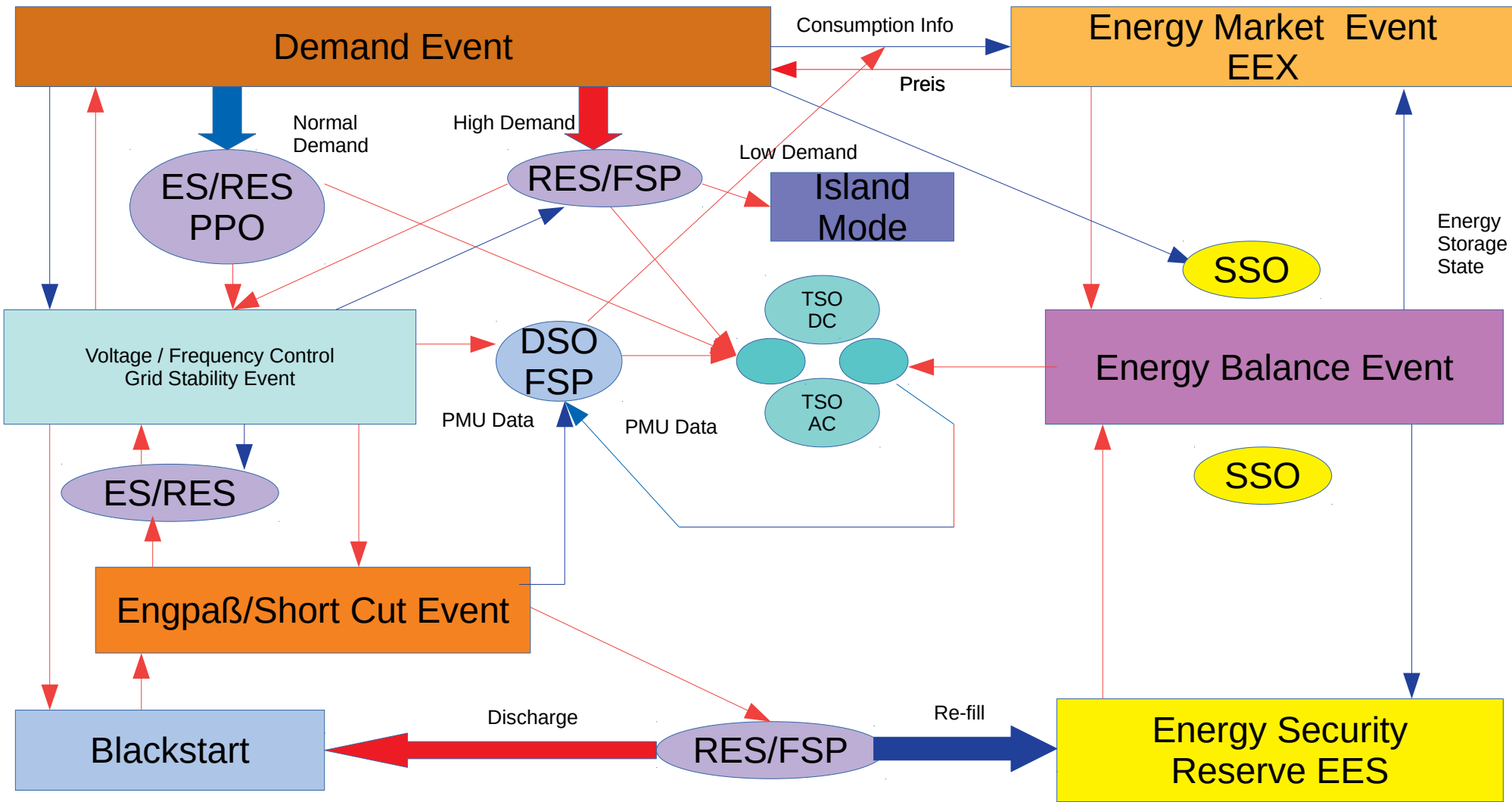
Grund Szenario

Norden hat viel Überschuß  
Süden hat keinen Überschuß



Schnelle Energieverlagerung  
Speicher Auffüllung



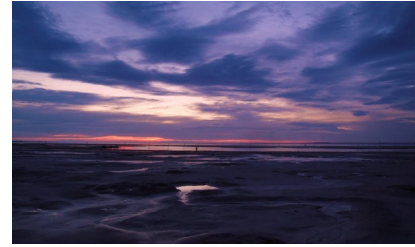
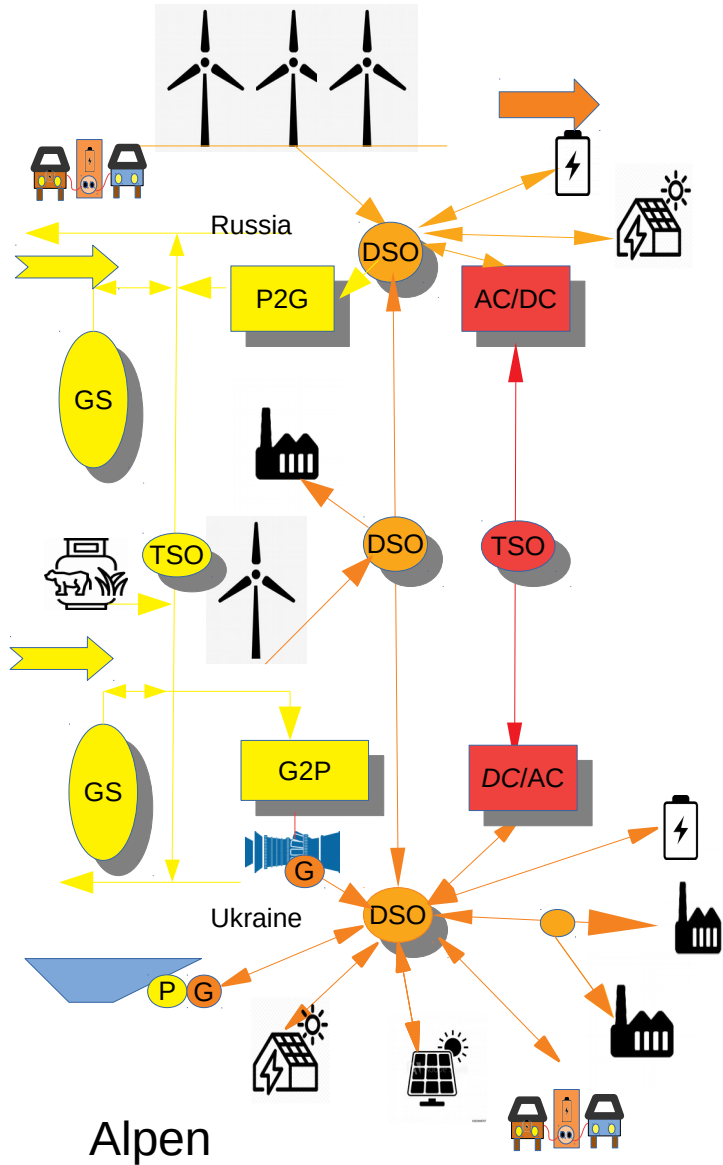
# DER fordet Flexible Service Provider (FSP)



DER- Distributed Energy Resources  
 ES -Energy System Classical  
 RES- Renewable Energy System  
 TSO – Transport System Organisation  
 DSO- Distribution Ssystem Organisatiion  
 SSO. Storage System Organisation  
 ESI – Energy Integration System  
 FSP- Flexible Service Provider  
 EEX- European Energy Exchange  
 PPO Power Plant Operator

 Cause  
 Effect

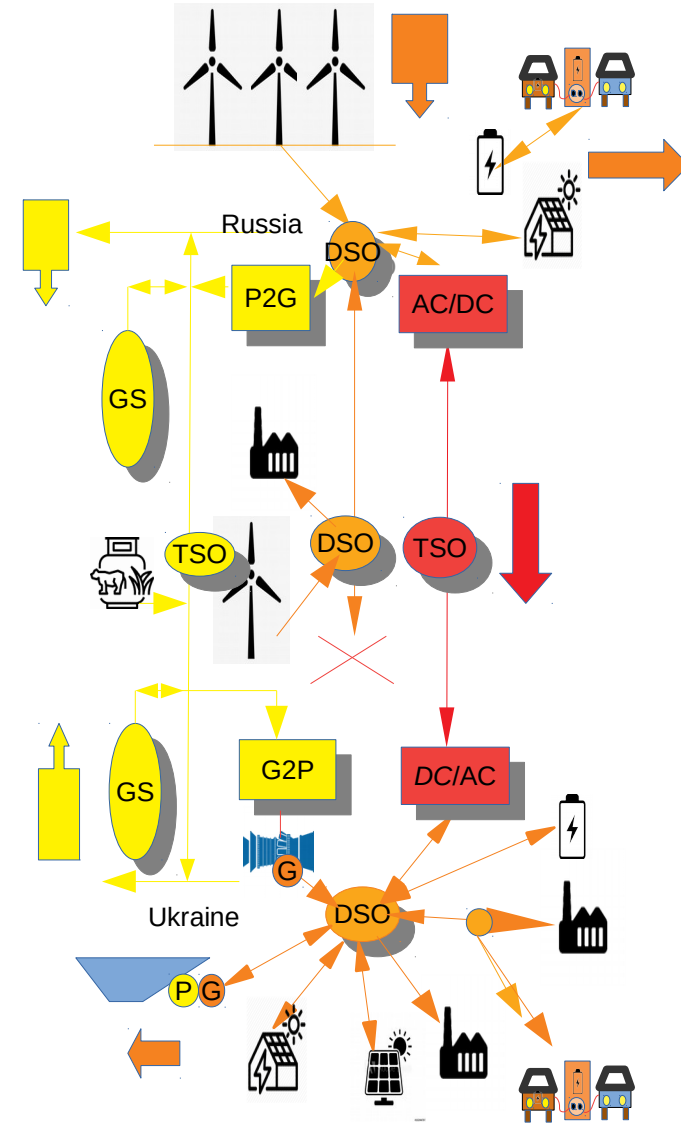
Nordsee



Grund Scenario

Norden hat Engpaß  
Süden hat Engpaß

Speicher Entnahme



Grund Scenario

Norden hat viel Überschuß  
Süden hat Störung u Engpaß



# Uncertainty, Complexity and Controlability

The design scenerio is not limited on 100, but 10000 or more RES

Typical uncertainty is created by local and global weather change, un-intentional load drop

Other design criteria are RAMS IEC 62278. Other design criteria  
Controlability, Affordabilty

ESI could have advantage is creating energy security, backup storages and controlabilty

Data exchange on different ESI, TSO, DSO, SSO levels are complex



# ESI Energy Conversion

- Power2Gas Synthetic Gas und H2 hydrogen
- Gas2Power Classical Gas turbines, Gas Motoren
- Water2Power Hydro Power Plant
- Bio2Gas Biogas PP Methangas
- Gas2Heat Heat Recovery
- Power2Cool Chiller
- Gas2H2 Blue Hydrogenf CSS
- Bio2H2 Dark green H2
- PowerH2 Green H2 RES Elektrolyse



# Scaling of Energy Systems (ES) , Organisation, Planing

Energy system are scaled in KJ,MJ,GJ,TJ PP-Types

Conventional ES for basic load and energy security.

Organisation PPO,TSO,DSO,SSO

For planing weather reports are needed

Long term Balance and Energy reserves

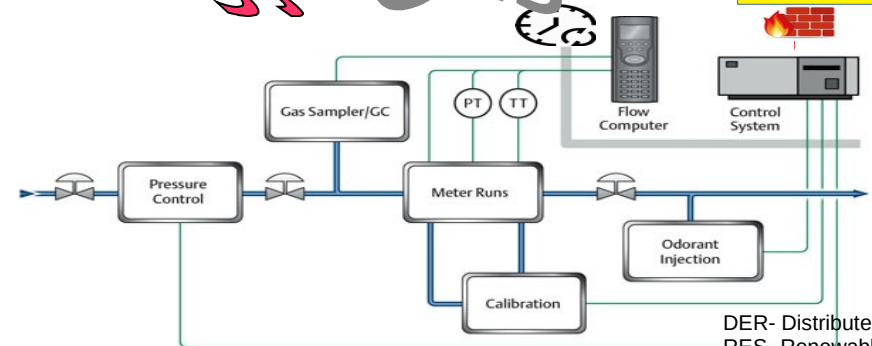
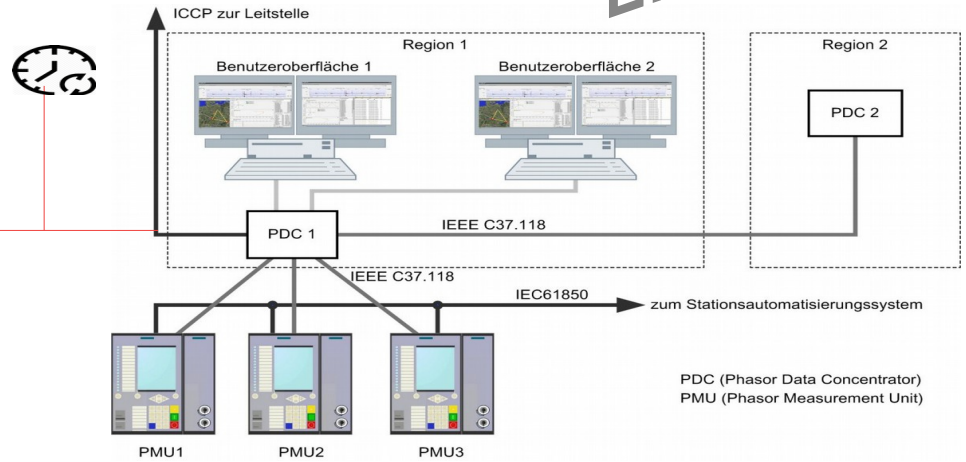
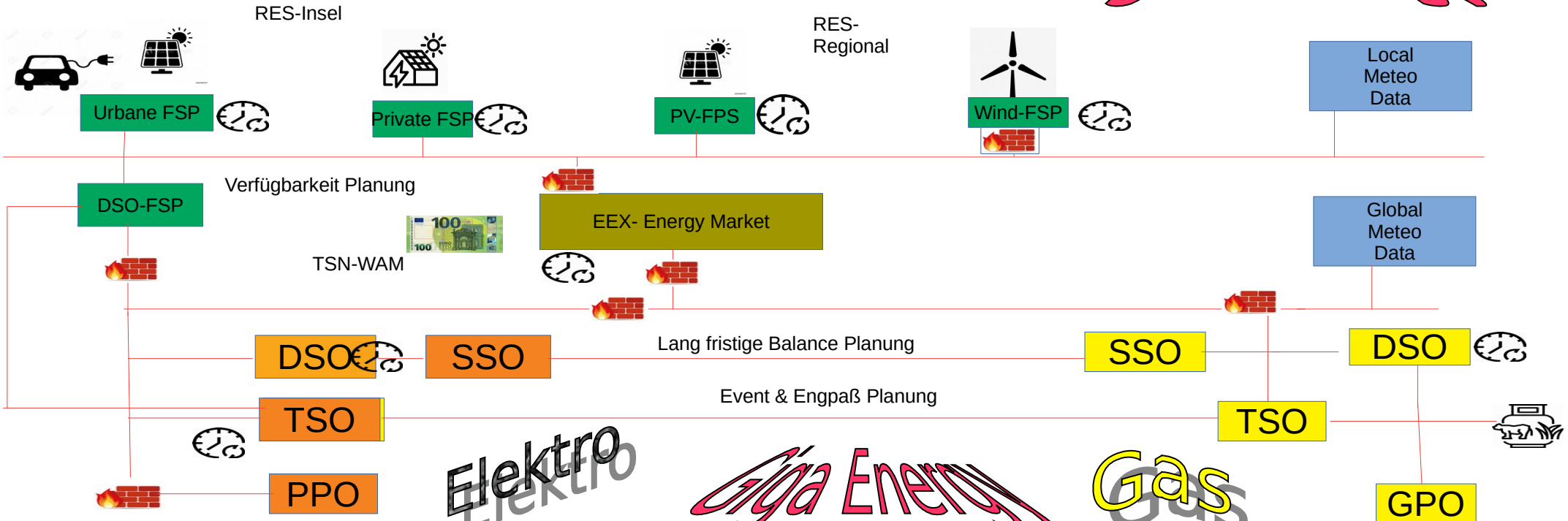
Renewable RES for flexible Load.

Organisation FSP, DSO,TSO,SSO

FSP are regional or urbane ES with DSO .

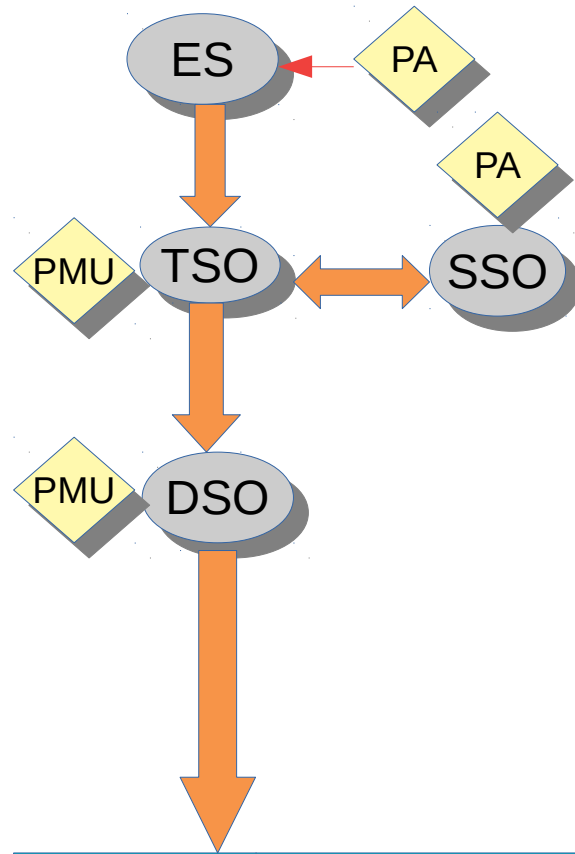
The FSP will simplify RES complexity for DSO

# ESI Integration Elektro und Gas, Organisation und Netzwerk



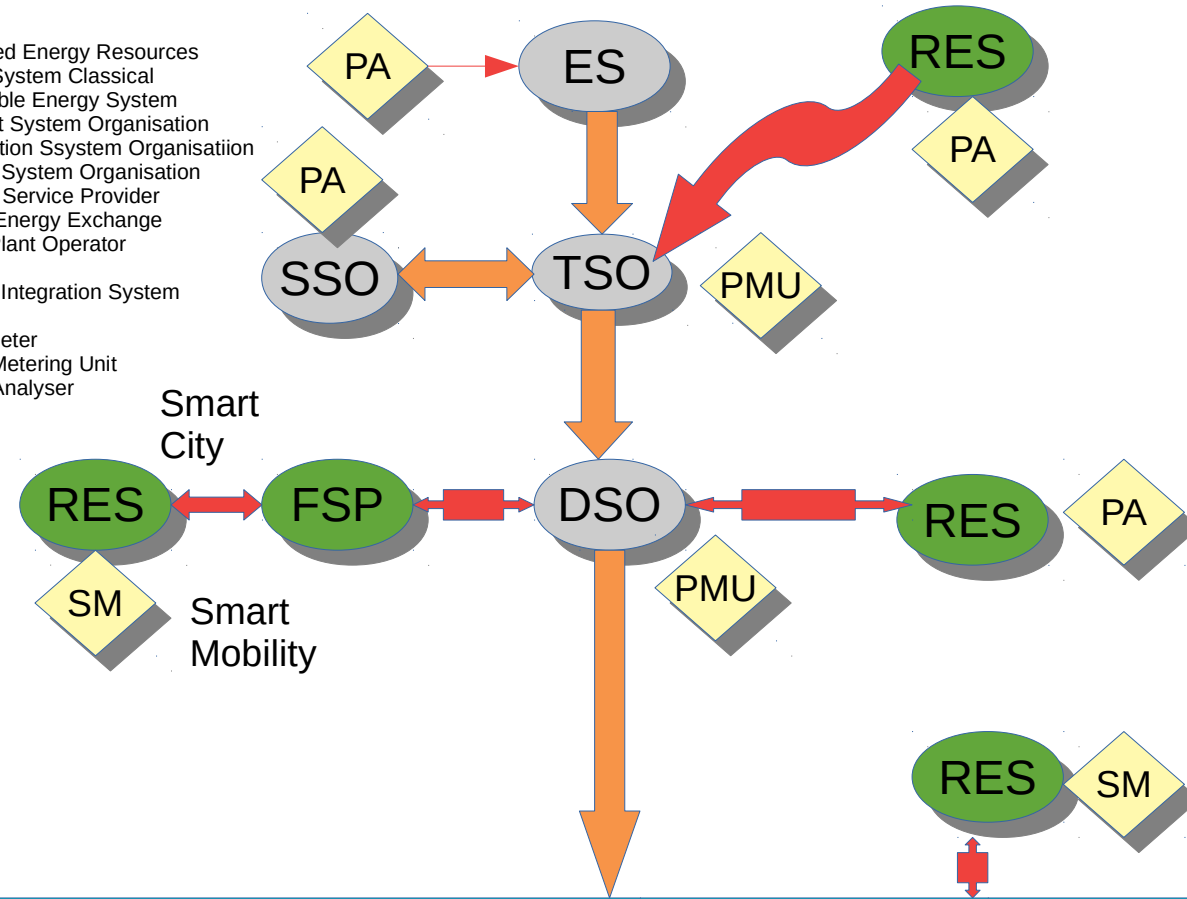
- DER- Distributed Energy Resources
- RES- Renewable Energy System
- TSO - Transport System Organisation
- DSO- Distribution System Organisation
- SSO. Storage System Organisation
- ESI - Energy Integration System
- FSP- Flexible Service Provider
- EEX- European Energy Exchange
- PPO Power Plant Operator

# Klassisches Energie ES Konzept



# Modernes DER Konzept mit RES

- Organisationen  
 DER - Distributed Energy Resources  
 ES - Energy System Classical  
 RES - Renewable Energy System  
 TSO - Transport System Organisation  
 DSO - Distribution System Organisation  
 SSO - Storage System Organisation  
 FSP - Flexible Service Provider  
 EEX - Europe Energy Exchange  
 PPO - Power Plant Operator
- Methode  
 ESI - Energy Integration System
- Metering  
 SM - Smart Meter  
 PMU - Phase Metering Unit  
 PA - Power Analyser



End Consumer

# Role of Storage System and SSO

## Balance with Energy Storage

- Gas- Existing Gas storages
- Water - Existing Pump Sea Storages (Bayern, Österreich)
- Current Battary Storage
- new Battery System, salt water
- Car based Akkumulatoren

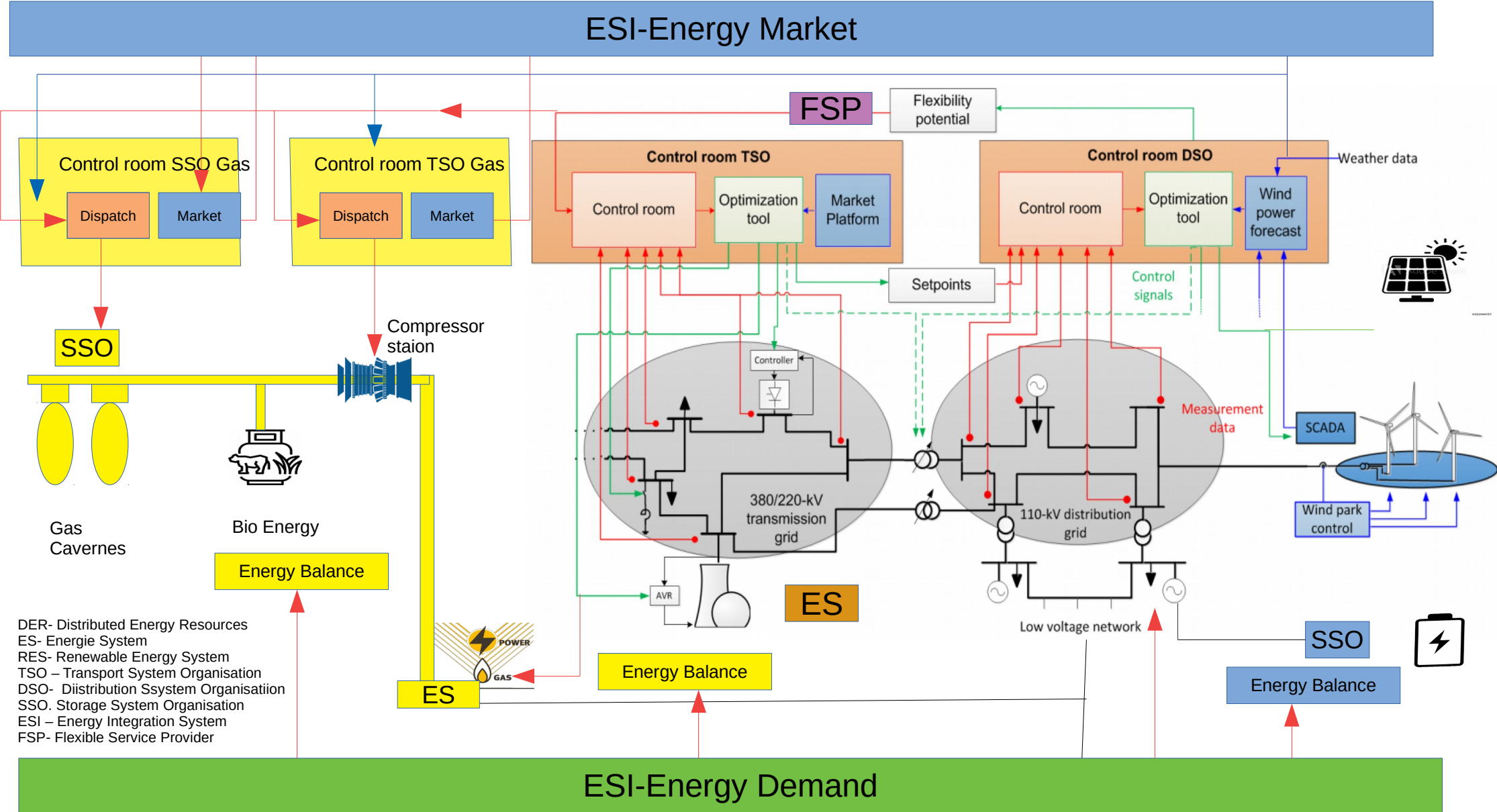
RES Island or grid

Urban solution with short term coupling

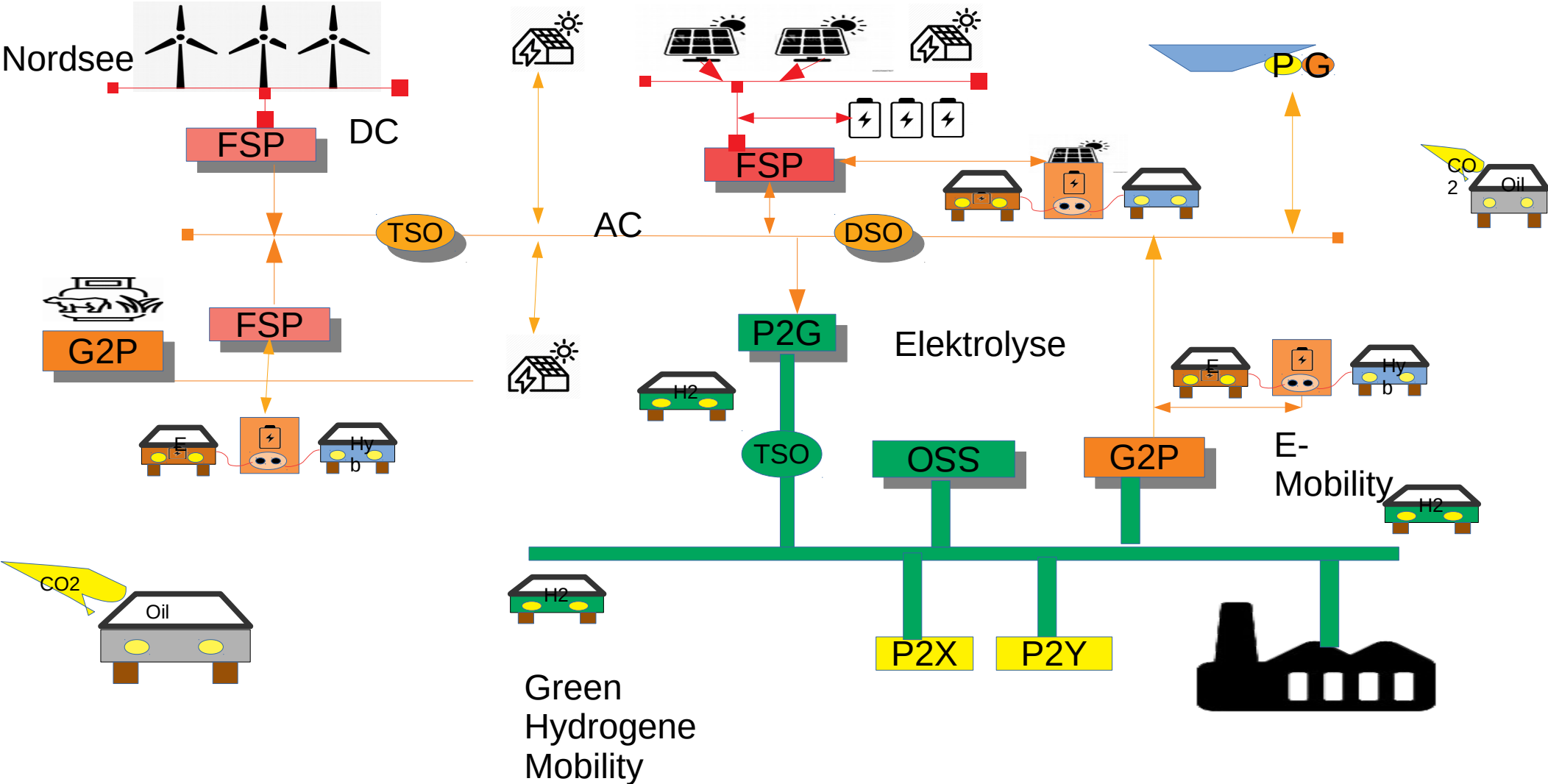
## Balance without Energy storage

Island Mode  
Shutdown

# DER Energy Control Komplexität



# Flexible Elektro und Hydrogen Mobilität mit FSP Entflechtung





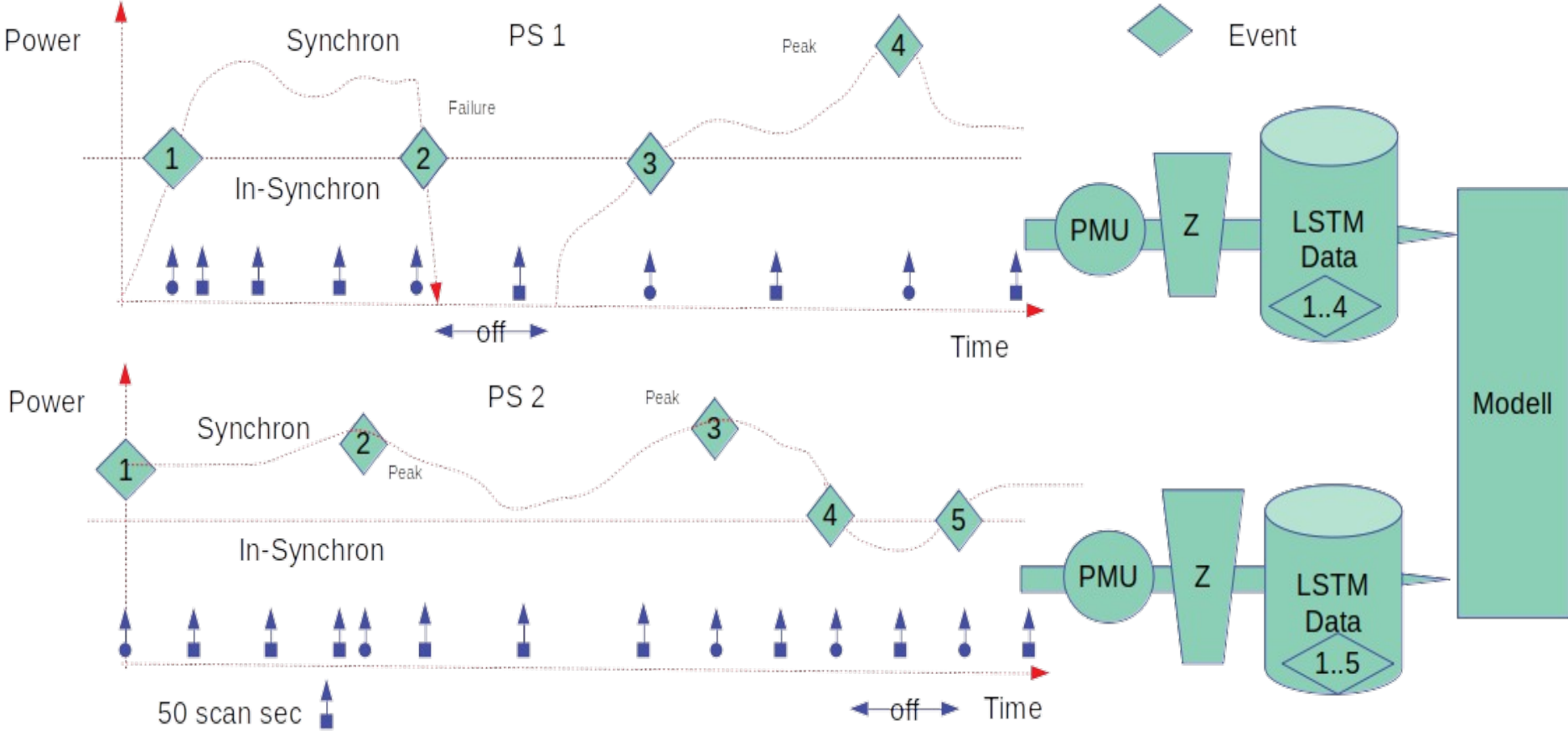
# DER-ESI Massen Daten

- Das DER ESI Netzwerk hat eine hohe Komplexität und ist von verschiedenen vorhersagbaren und nicht-vorhersagbaren Einspeisungen, Verbrauchsforderungen Ereignissen, Wetterlagen, Störungen abhängig.
- Für die Energie Balancierung und die Netzstabilität ist es notwendig auch die SSO Storage System Organisation mit einzubeziehen, Flexible Service Provide FSP können dezentral lokale Engpässe beheben.
- Eine Phase Measure Unit (PMU) für elektrische Netzwerk hat 50 Abtastungen in der Sekunde Eine Gas Measuring Unit (GMU) kann eine Abtastungen pro Minute haben.
- Täglich würden mehr als 5 Millionen Datensätze anfallen.
- Aus diesen Grund wird eine Lösung aufgrund von neuronalen Netzwerken NW-AI und Deep Learning DL vorgeschlagen. Die Ereignisse in den Daten von den PMU und EMU können klassifiziert werden und so digitale Twins von Netzwerken geschaffen werden.
- Das NW trainiert alle möglichen ESI Szenarien und kann dann auf verteilte Datenspeicher zugreifen, Wenn das Ereignis Modell validiert ist , kann es Lösungen vorschlagen.

# Data integration

- Data integration can be based on fast TSN Internet, 5G and Wifi6
- Flexible Edge Integration of RES 5G/Wifi6 from FSP
- Sensor Daten Electric PMU Phase Measuring Unit
- Sensor Daten GMU Gas Metering Unit
- All data are time series based or Sensorflow

# Time Series Analyse



# Typical industrial AI-NI Model



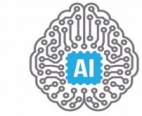
◆ ML Training  
Learning from existing data

◆ Interference Prediction  
Predict new data and connections

Digital Twin Training

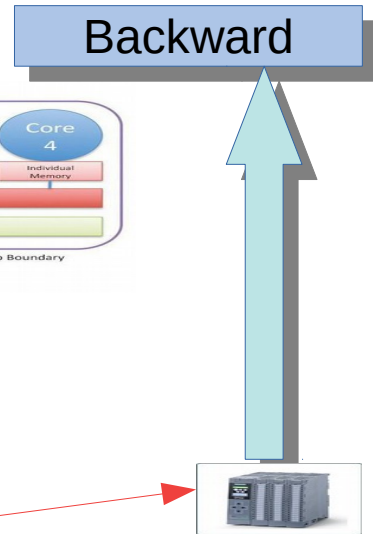
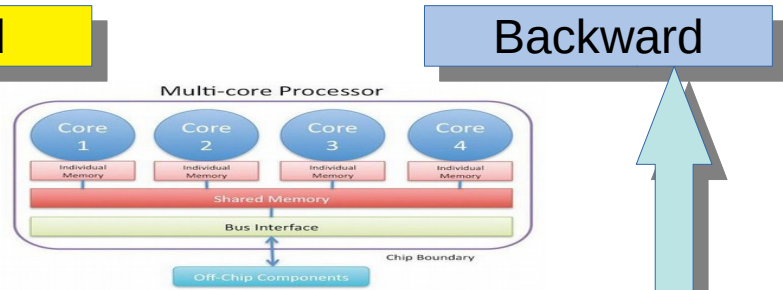
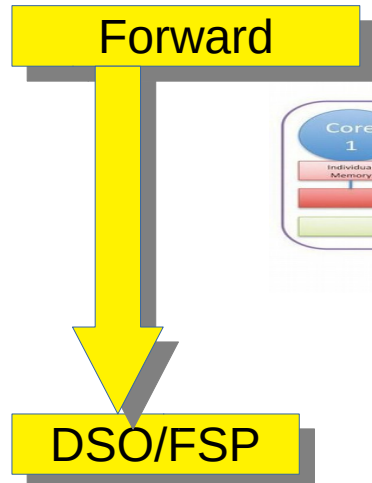


Validation

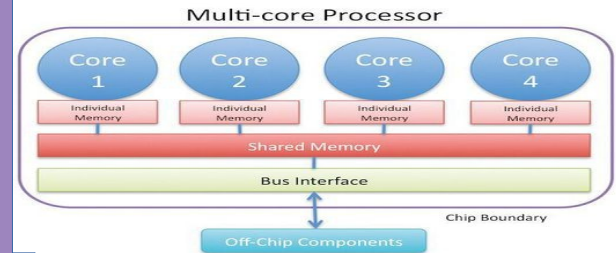
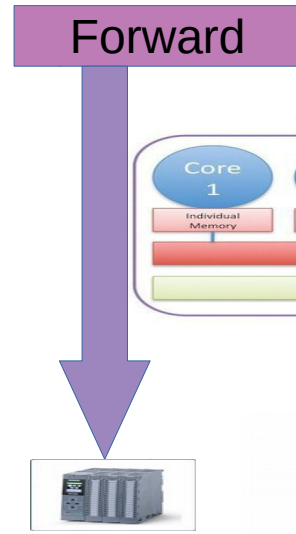


KI Modell

Enable



PMU Daten

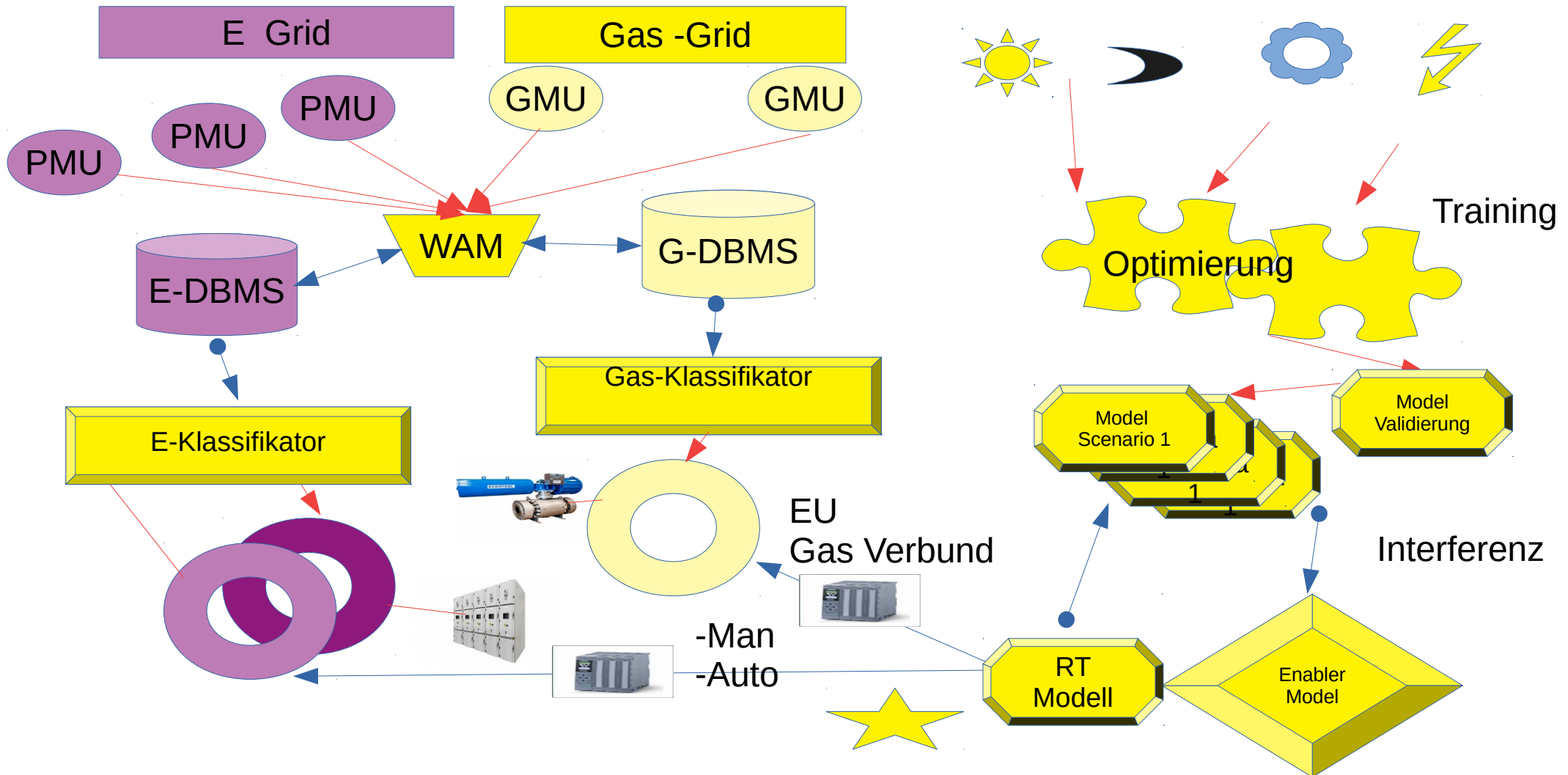


SCADA & NI



# Digital Twin & KI - Model

Frequenzabweichung -0,2 Hz  
 Spannungsabweichung 7 %  
 Phasenwinkelabweichung +/-20 %



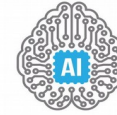
# NI time series Prognostic & AI Event Logic

NI



&

KI



The real time analysis of time series mass data makes complex scenarios

With NN many typical scenarios model can be trained

The validation of event logic is done with one model.

Many 1000 Models have to be trained .

If a similar case or nearest neighbor case is happening then AI can work in automatic

Or propose

Solution in Manual Operation Mode

## Disadvantage

High technologic use case and affordability

Cyber Security & Time Synchronization of Devices

Difficult Cause & Effect tracing in NN-layers

Additional Energy for HPC, Instruments, Networks

High cost and energy justice protests

## Advantages

Higher net stability, Availability and Controllability,

Less black out

Higher flexible adoptions

# References

- 1.Global Power Grids for Harnessing World Renewable Energy, Uni Liege
- 2.ESI Defining and Describing Value Proposition, 2020, Uni College Dublin
- 3.Sichere Stromnetze, 2020, Fraunhofer IITB-AST
- 4 Ereignislogik, 1994, Bertram Kienzle, Uni Rostock
- 5 TSO-DSO Smart Net Project EU
- 6 TSO-DSO, ETH Zürich Studie, 2018 Fuchs Alexander
- 7 TSO-DSO, EU SmartNet Debate, 2018, Mardino/Prado

## Links

### EU

<https://www.etip-snet.eu/energy-transition/concept/>

<https://www.entsoe.eu/data/map/>

### Deutschland

<https://www.tennet.eu/de/unser-netz/onshore-projekte-deutschland/suedlink/dialog/suedlink-news/>

### Frankreich

<https://www.enedis.fr/smartgrid-or-intelligent-network>



# Südlink und ESI Ideen Sammlung

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## Abkürzungen

|       |                                   |
|-------|-----------------------------------|
| AI-KI | Künstliche Inteligenz             |
| NI    | Natürliche menschliche Inteligenz |
| ESI-  | Energy System Integration         |
| EES-  | Electrical Energie System         |
| GES-  | Gas Energy System                 |
| DER-  | Distributed Energy Resources      |
| RES-  | Renewable Energy System           |

## Organisatitonen

|       |                                     |
|-------|-------------------------------------|
| TSO – | Transport System Organisation       |
| DSO-  | Diistribution Ssystem Organisatiion |
| SSO.  | Storage System Organisation         |
| ESI – | Energy Integration System           |
| FSP-  | Flexible Service Provider           |

## Meßgeräte

|       |  |
|-------|--|
| PMU – | Phase Measuring Unit Electric                |
| PA-   | Power Analyser für ES                        |
| PSM-  | Power Smart Metering für Verbraucher und RES |
| GMU-  | Gas Measuring Unit (fiscal /operational)     |