

## WP2: Market architectures to integrate ancillary services from distributed energy resources

Juan M. Morales



# Agenda

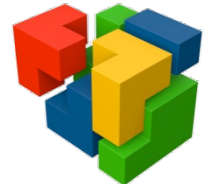


- Aim and goals of WP2
- WP2 location in SmartNet
- Activities description
- Key products

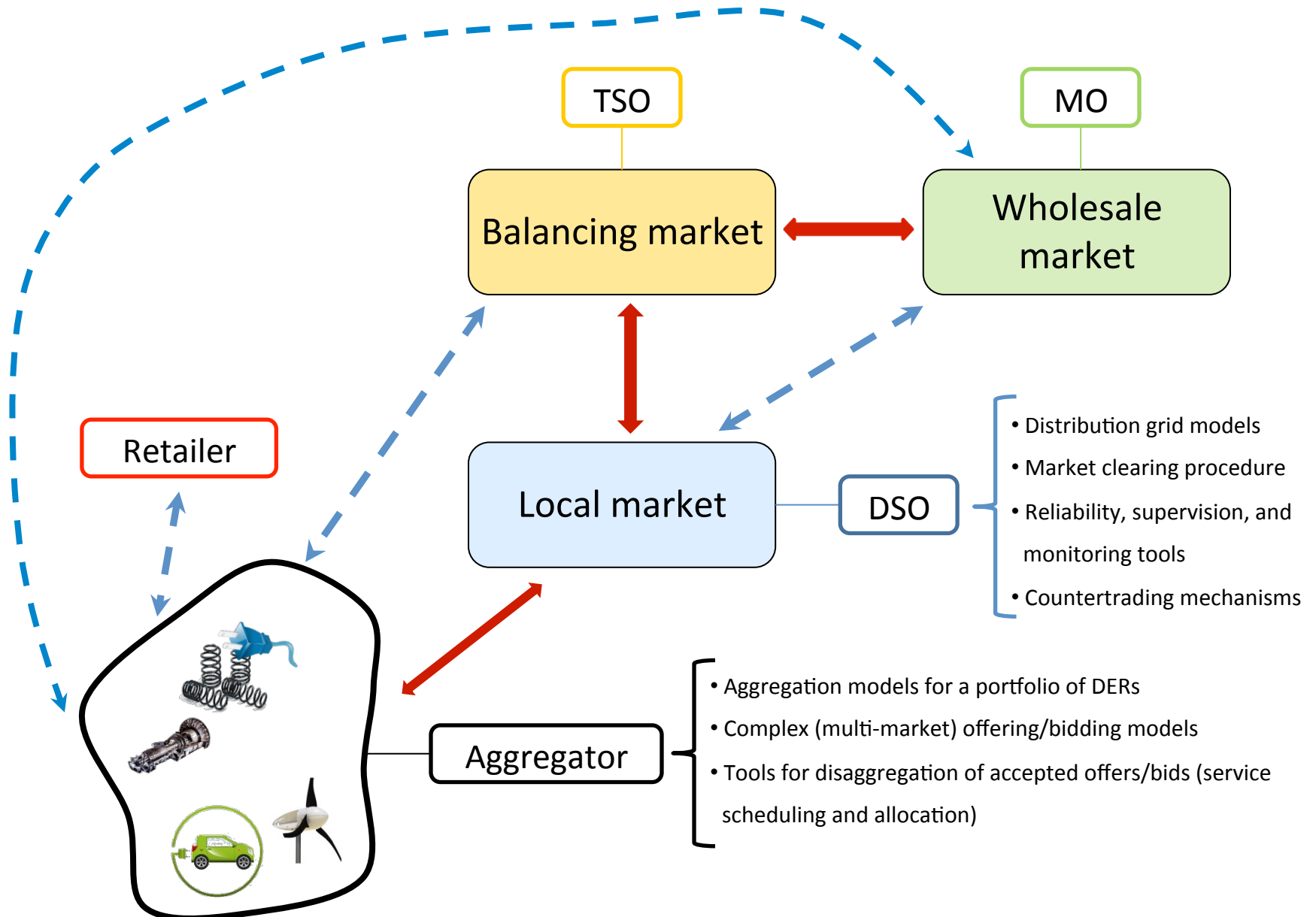


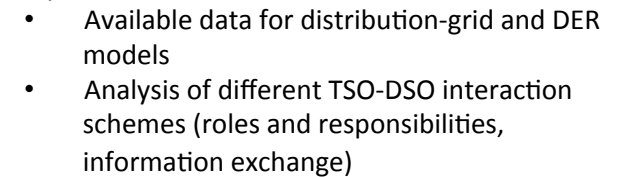
***Identify and build the mathematical models and tools that will constitute the “bricks” of the market architecture to integrate distributed energy sources***

*They will serve as the basic components of the software modules that the lab-test environment in WP4 will integrate (optimization and simulation models, procedures and algorithms, etc.)*



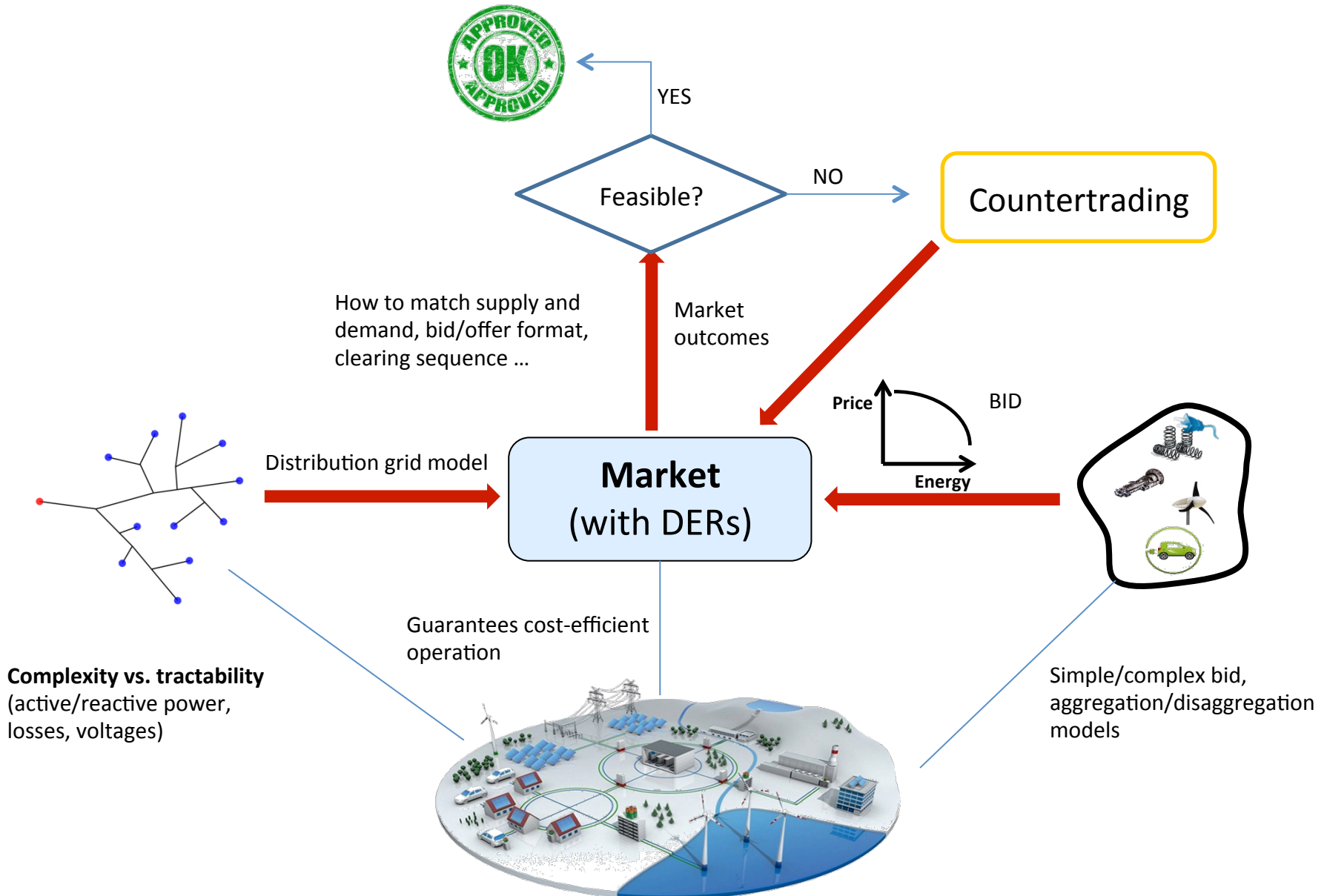
*The essential ingredients of the novel market environment (should be adaptable to any specific market configuration, any national case)*

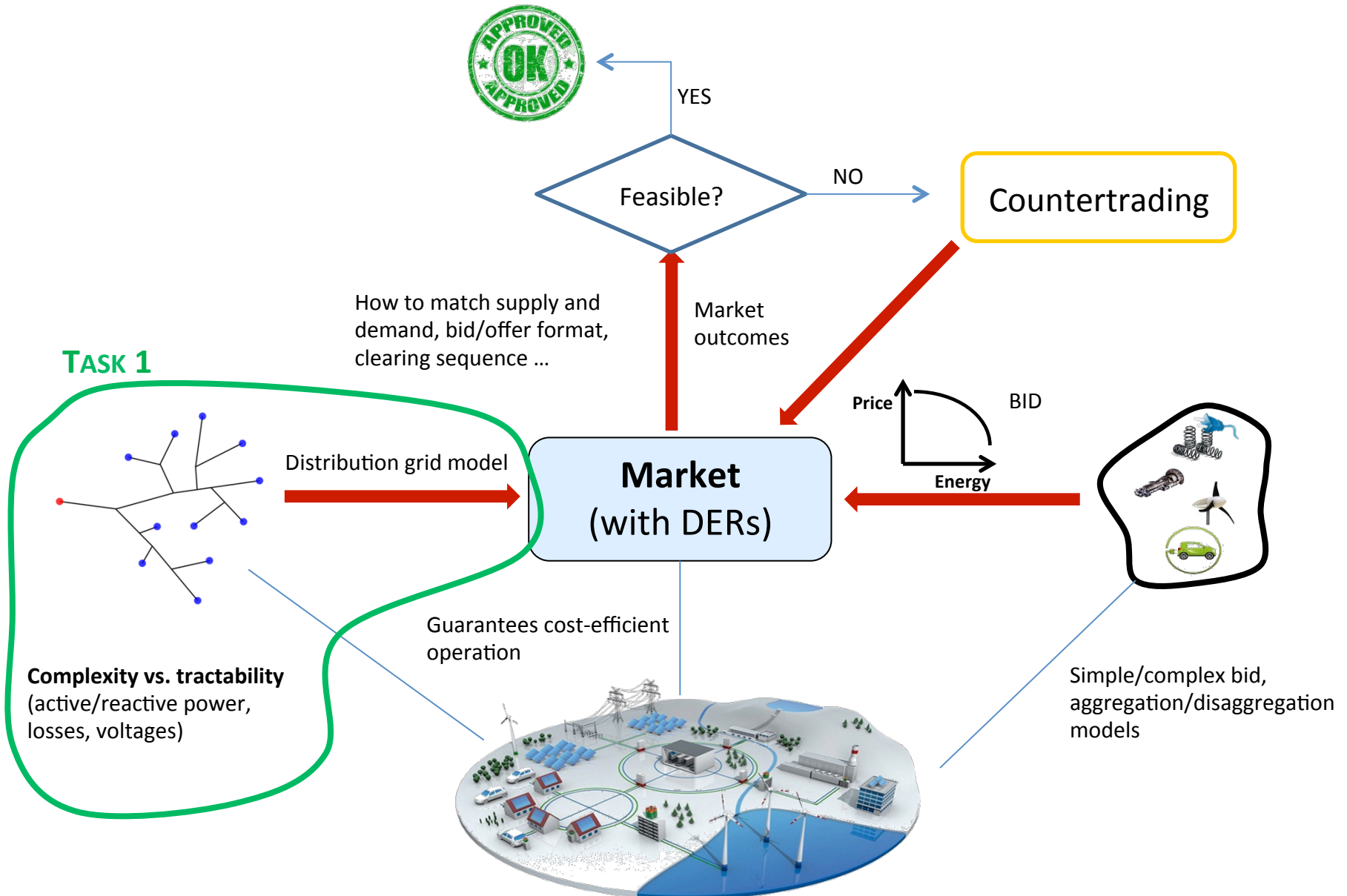




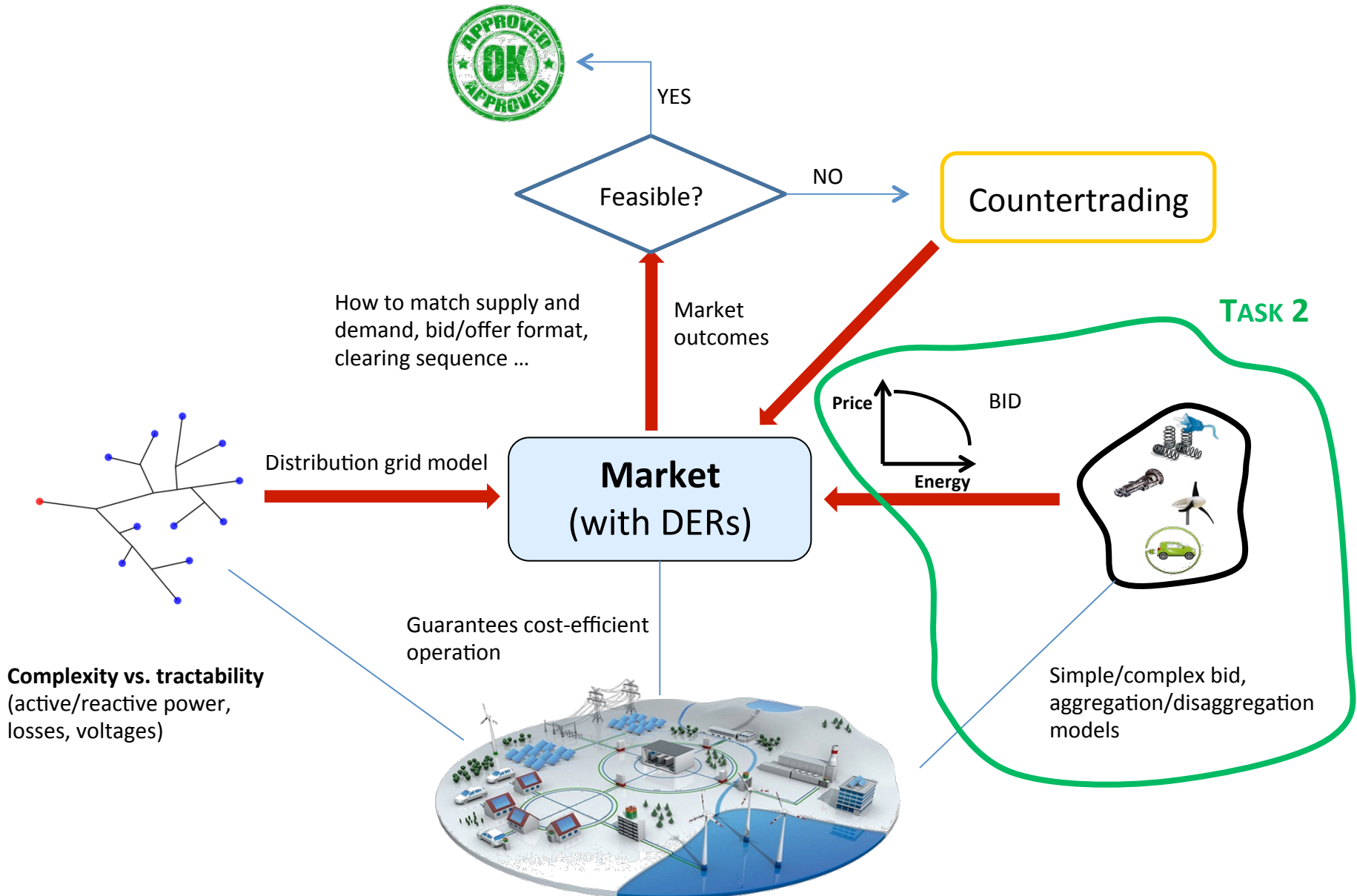
**Revised** models, tools, algorithms based on feedback from WP4 (lab test) and WP5 (pilots)

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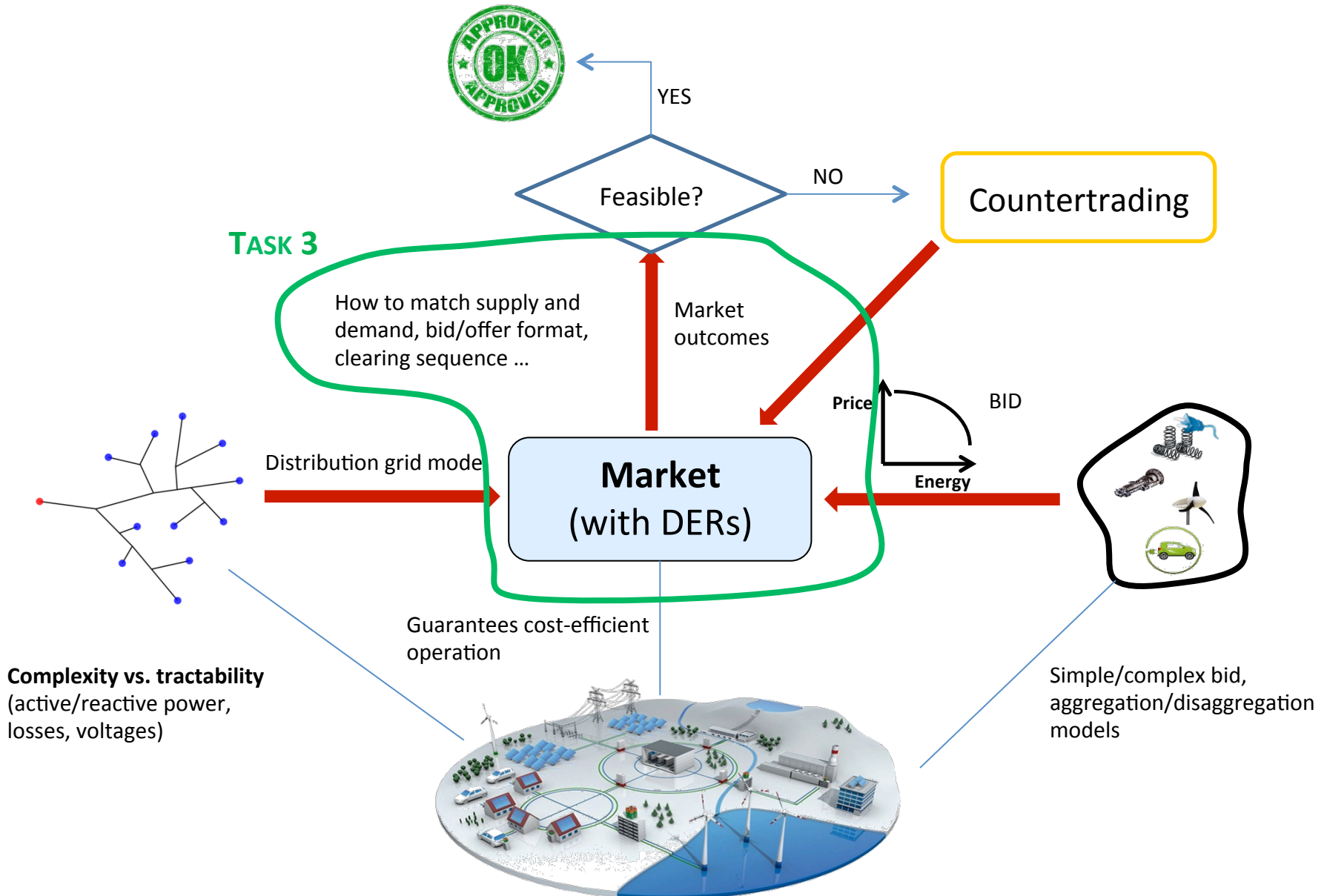




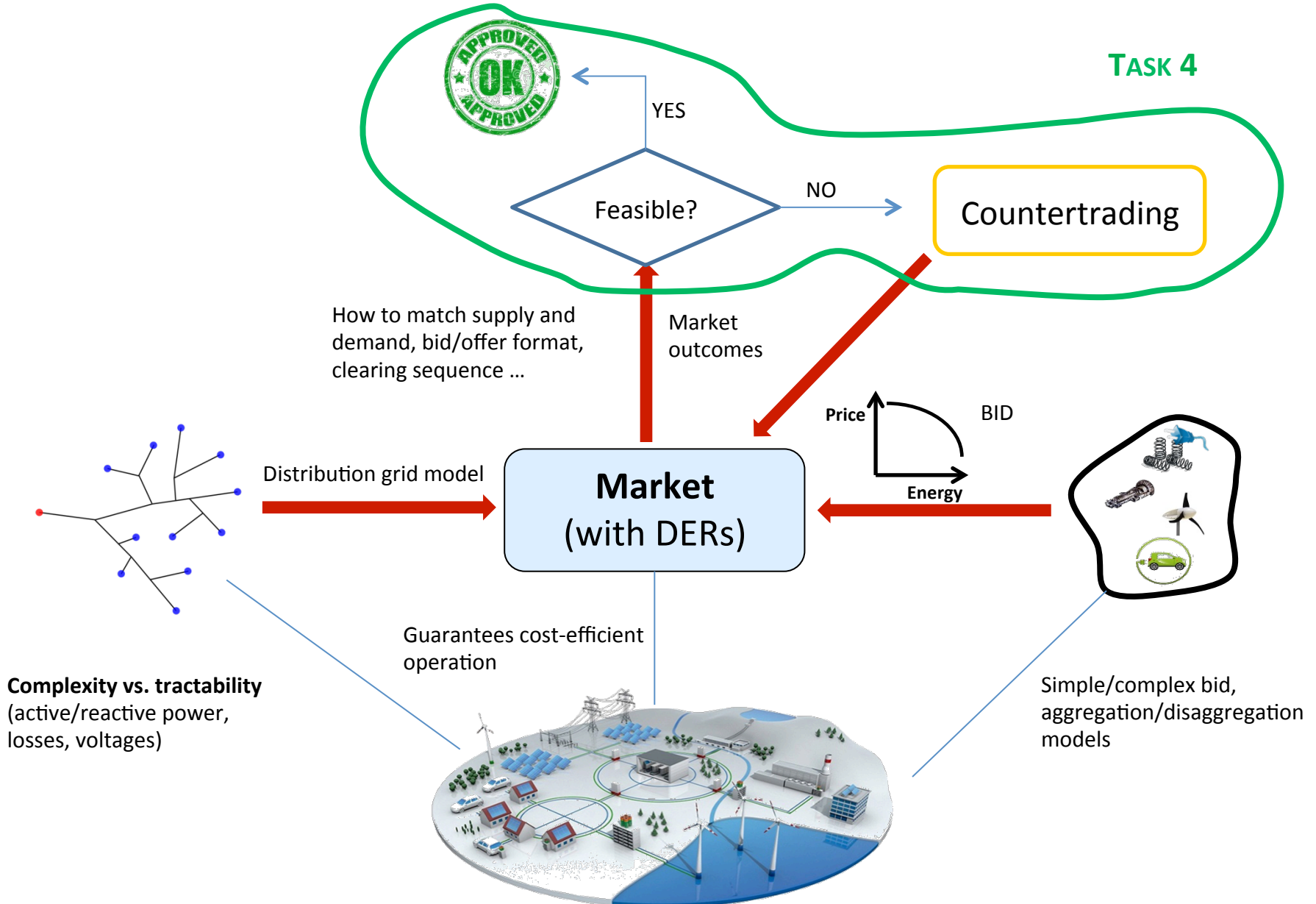
# Activities description



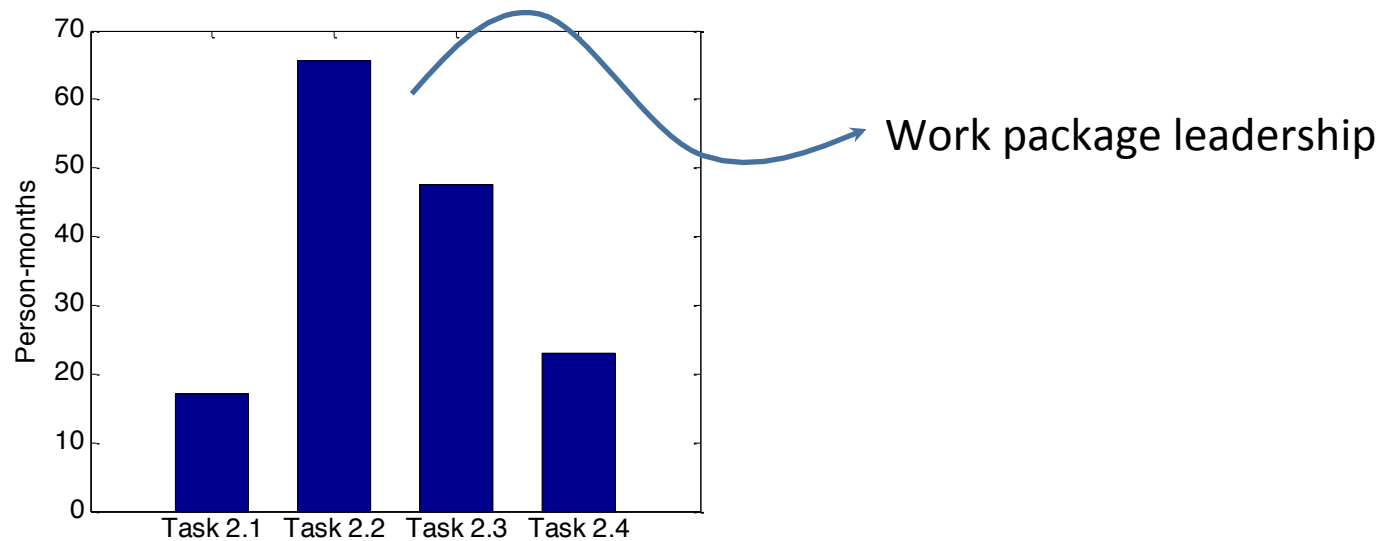




# Activities description



	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 2.1								
Task 2.2								
Task 2.3								
Task 2.4								

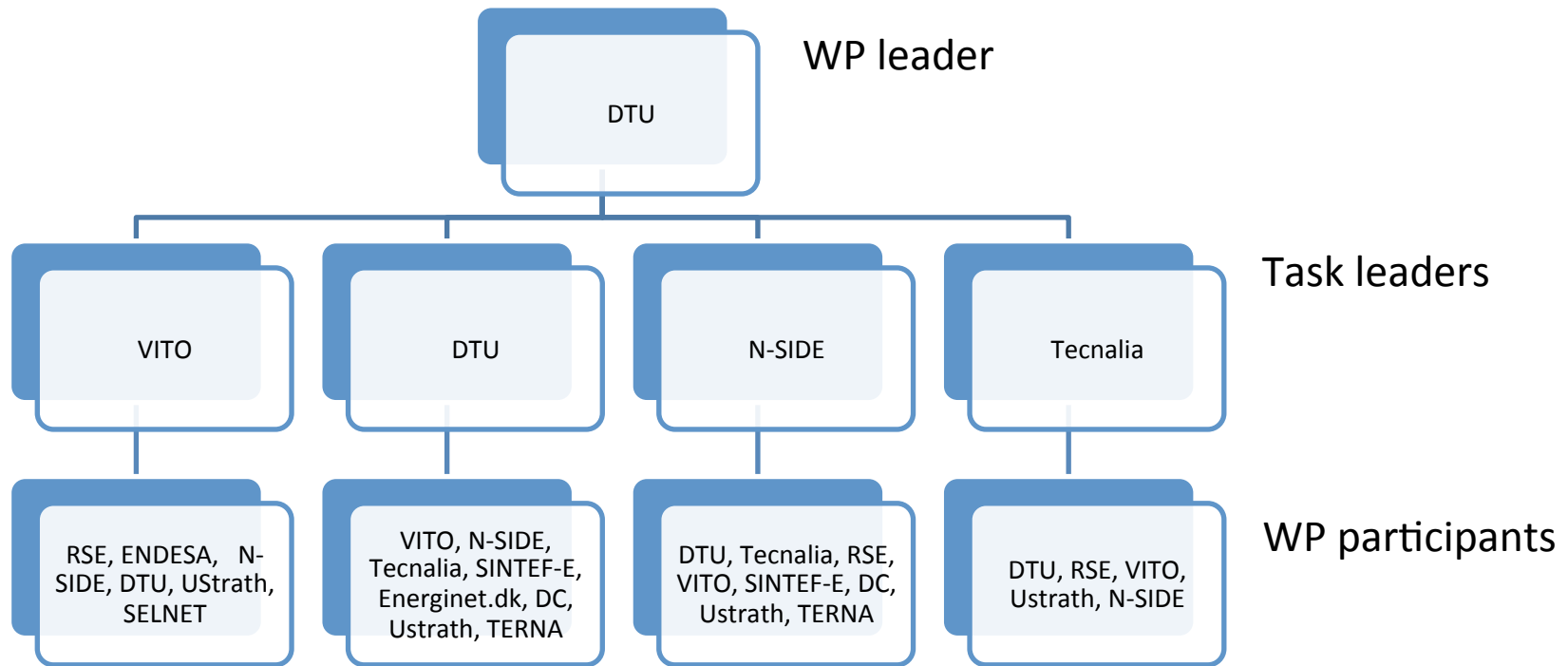


Planning and coordination of subtasks for the short term

When should we meet (●) ? Coordination with WP1?

		Year 1					
		M1	M2	M3	M4	M5	M6
Task 2.1	2.1.1 Define distribution grid characteristics (coordination with WP1)						
	2.1.2 Review of state of the art on (approximate) modeling of distribution grids: Define degree of approximation						
	2.1.3 Approximate model of distribution grid to be used for market clearing (coordination with Task 2.3)						
Task 2.2	2.2.1 Review of state of the art on aggregation models for a portfolio of DERs						→
	2.2.2 Coordinate with WP1 on synthetic data on price response of individual DERs						→
	2.2.3 Simplified modeling (LP/MIP) of individual DERs						→
Task 2.3	2.3.1 Review of state of the art on “distributed markets”						→
	2.3.2 Definition of a <u>basic</u> market architecture (coordinate with Task 2.2)						
	2.3.3 Mathematical modeling of the basic market architecture						
Task 2.4	2.4.1 Review of state of the art on AC-OPF algorithms for transmission networks and analysis of their applicability to distribution grids?? (Why not to study AC-OPF algorithms for distribution grids directly?)						→

# Communication within the work package



## Task 2.1: Simplified modelling of distribution grid

- **Task leader:** VITO
- **Participants:** RSE, ENDESA, N-SIDE, DTU, Ustrath, SELNET
- **Overall aim:** Development of a computationally tractable distribution-grid model to be used for market clearing (Task 2.3)
- **Goals:**
  - Analysis of the trade-off between model tractability/complexity and level of detail.
  - Identification and estimate of relevant network variables (active and reactive power flows, voltages, losses, etc.).
  - Evaluation of the cost of modelling errors in terms of economic efficiency and system reliability.

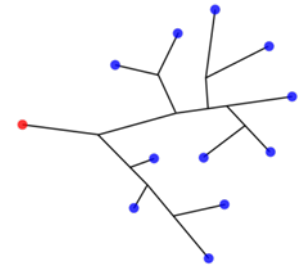
## Task 2.1: Discussion (background, starting point, plan)

### 1. Define distribution grid characteristics/assumptions:

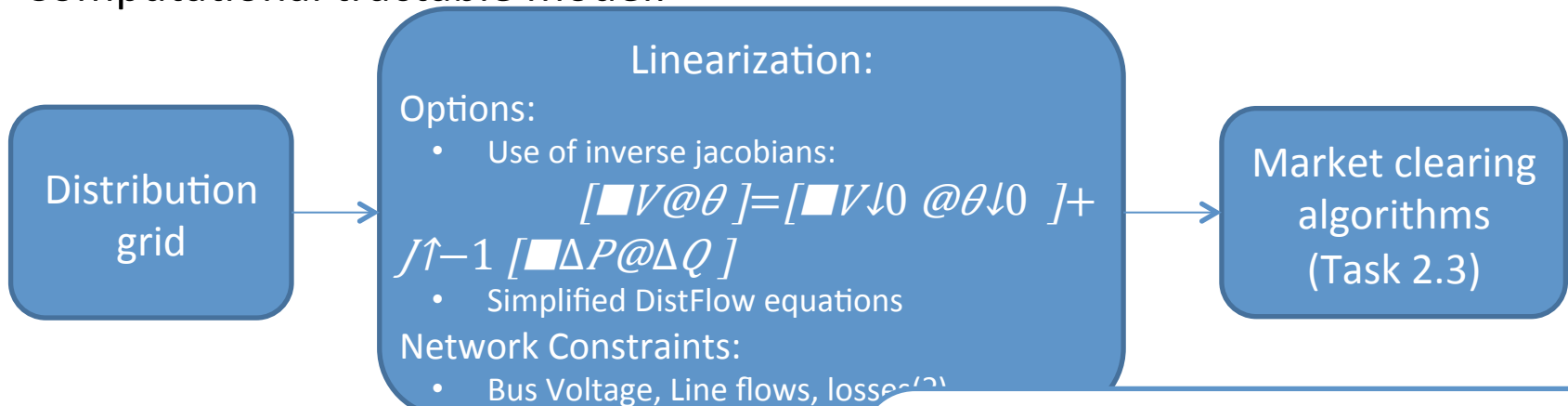
E.g. radial/meshed, 3phase balanced/unbalanced, LV/MV, ...

➔ Universal model, or diversified modeling?

➔ Collaboration with T1.4?



### 2. Computational tractable model:



We assume a **linearization** of the LoadFlow equations:

➔ to be compliant with market clearing algorithms.

➔ Collaboration T2.3

What is the reference/operating point for linearization?

- known/not known? Depends on how market architecture is defined (WP1)
- If not known: iterative approach or piece-wise linearisation might be necessary.

➔ Collaboration T2.3 and WP1

## Task 2.2: Offering models for a cluster of DERs

- **Task leader:** DTU
- **Participants:** VITO, N-SIDE, TECNALIA, SINTEF-E, Energinet.dk, DC, Ustrath, TERNA
- **Overall aim:** Development of mathematical models for a portfolio of DERs to bid in the market proposed in Task 2.3
- **Goals:**
  - Development of models that describe the aggregated dynamic behavior of a portfolio of DERs.
  - Devise procedures to translate the aggregated behavior of the pool of DERs into market offers and bids.
  - Design of a procedure to disaggregate the offers and bids cleared in the market into a power schedule for the individual DERs in the pool

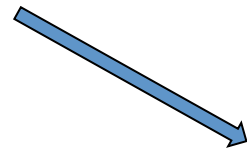


## Task 2.2: Discussion (background, starting point, plan)

- Two different approaches:
  - Data driven: we assume that the market price is directly passed on to the DERs

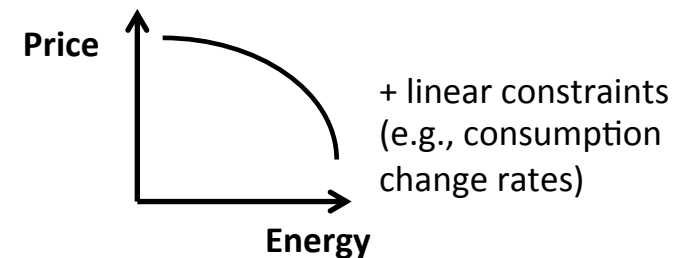
Time	Price	Consumption	Outside temperature	Wind speed

This data can be obtained from simulation of accurate dynamic models for individual DERs



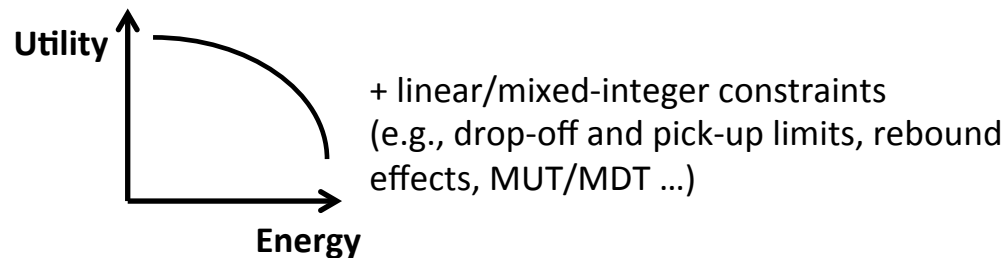
Complex offer

Based on paper “A Data-driven Bidding Model for a Cluster of Price-responsive Consumers of Electricity”, currently under review



## Task 2.2: Discussion (background, starting point, plan)

- Two different approaches:
  - Physical models: we assume that the aggregator has a simplified, but accurate enough LP/MIP model describing the dynamic behavior of DERs (e.g., shifting and load reduction capabilities of demand response units)



Based on:

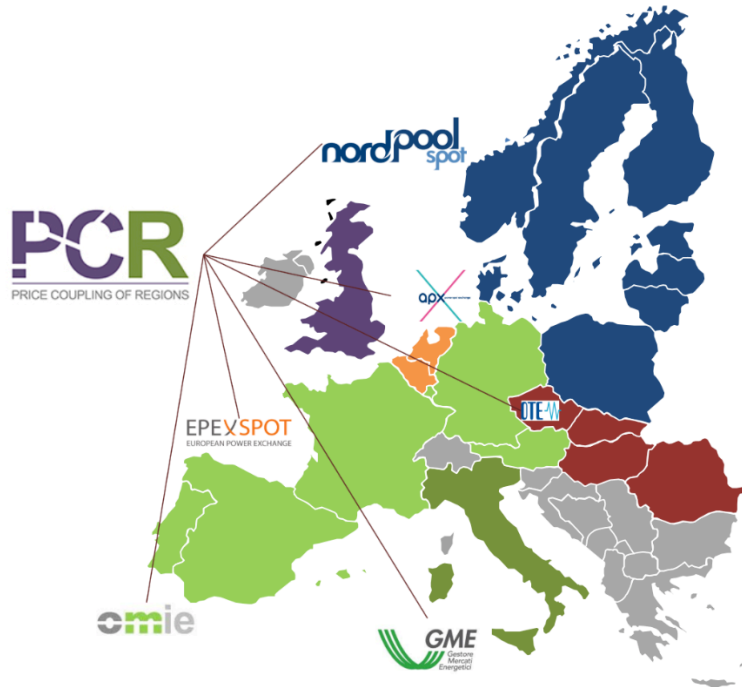
- Paper "Trading flexible electricity consumption in spot markets under demand response uncertainty", currently under review
- Working paper "Prosumer bidding and scheduling in electricity markets" by Ottesen, Tomasgard & Fleten (NTNU)

In both cases, we will need to get simplified dynamic models for the portfolio of DERs out of more complex ones (WP1)

## Task 2.3: Market-clearing mechanisms

- **Task leader:** N-SIDE
- **Participants:** DTU, TecNALIA, RSE, VITO, SINTEF-E, DC, Ustrath, TERNA
- **Overall aim:** Development of mathematical models to clear the market with DERs at the transmission and distribution levels under different setups.
- **Goals:**
  - Development of market-clearing mechanisms for the different TSO-DSO coordination schemes (clearing sequence, types of offers and bids, etc.).
  - Analysis of clearing algorithms in terms of computational requirements, degree of tractability and complexity, and economic efficiency.
  - Proposal of a system of prices for the billing process.
  - Formulation of market specifications for the national pilots and analysis of how the developed market architectures fit in with the pan-European view

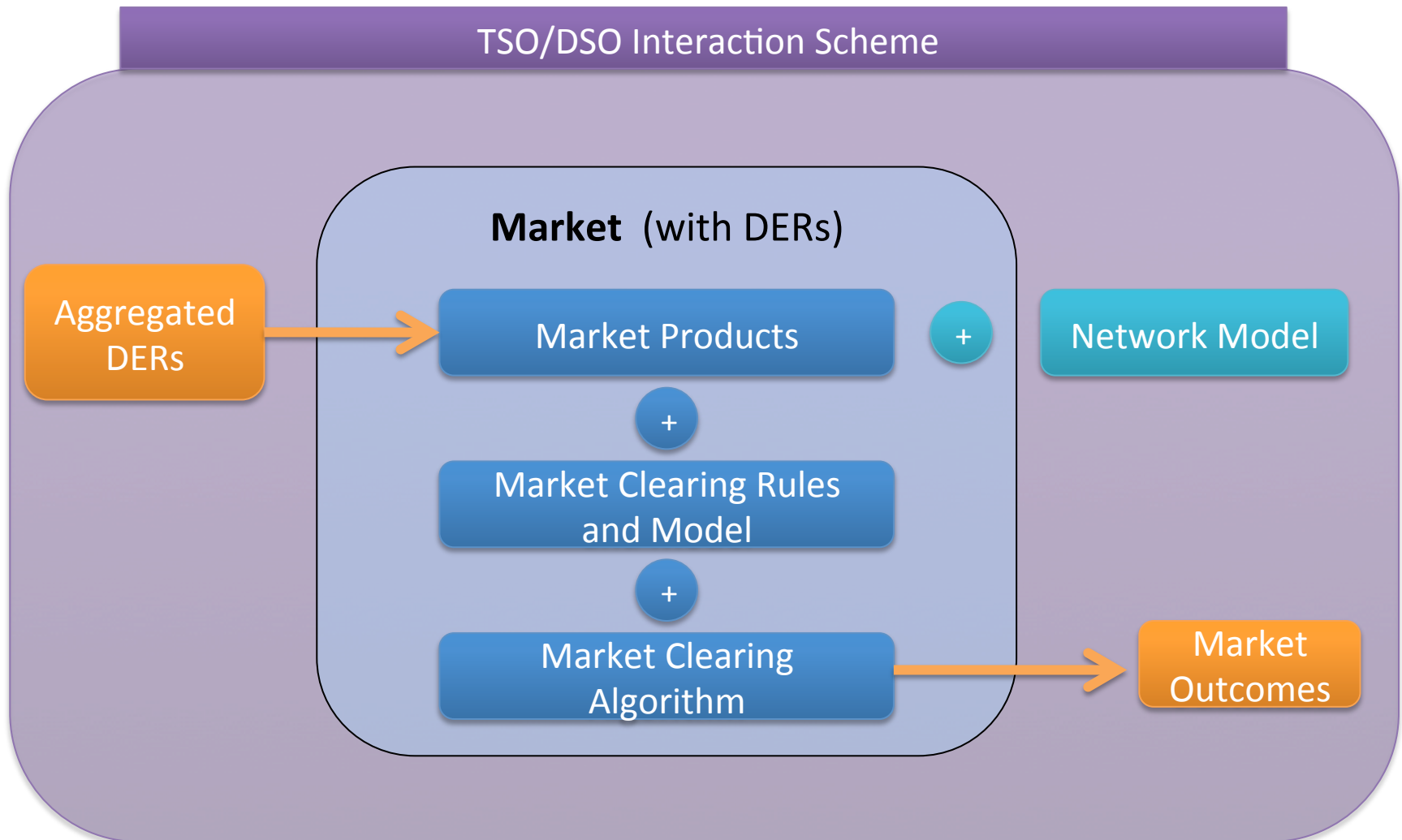
## Task 2.3. Background



- > **EUPHEMIA**, the market coupling algorithm owned and used by power exchanges of the PCR project, determines day-ahead electricity prices in **19 EU countries** every day.
- > **EUPHEMIA** is **developed in-house** by N-SIDE, from theory to operations
- > **It computes market prices & volumes** by:
  - coupling national markets
  - maximizing total economical welfare
  - optimizing network capacity utilization
  - modeling complex economical constraints

- > Through collaboration with universities N-SIDE also has contacts with researchers active in distribution systems (e.g. [www.gredor.be](http://www.gredor.be)) and flexibility optimization (Industore)

## Task 2.3. Structuration



## Task 2.3. Methodology

### Key questions to address

Market Products

- Different products for different DER types?
- Different products for different ancillary services?
- Block Orders ? Curtailable/Non curtailable bids?
- Orders with exclusivity or linking constraints?
- DSO/Country specificities?

Market Model & Clearing Rules

- Which objective function?
- Which economical constraints or properties?
- How to take into account locational aspects?
- Which hierarchy between markets in terms of clearing? Sequential clearings or coupled clearings?
- How to deal with uncertainty?

Market Algorithm

- Which mathematical formulation?
- Level of optimality targeted?
- Targeted Resolution time?
- Replicability constraints?

Continuous coordination with WP 2.2. to ensure compatibility

Aggregated DERs

Iterative Process to ensure tractability

Network Model

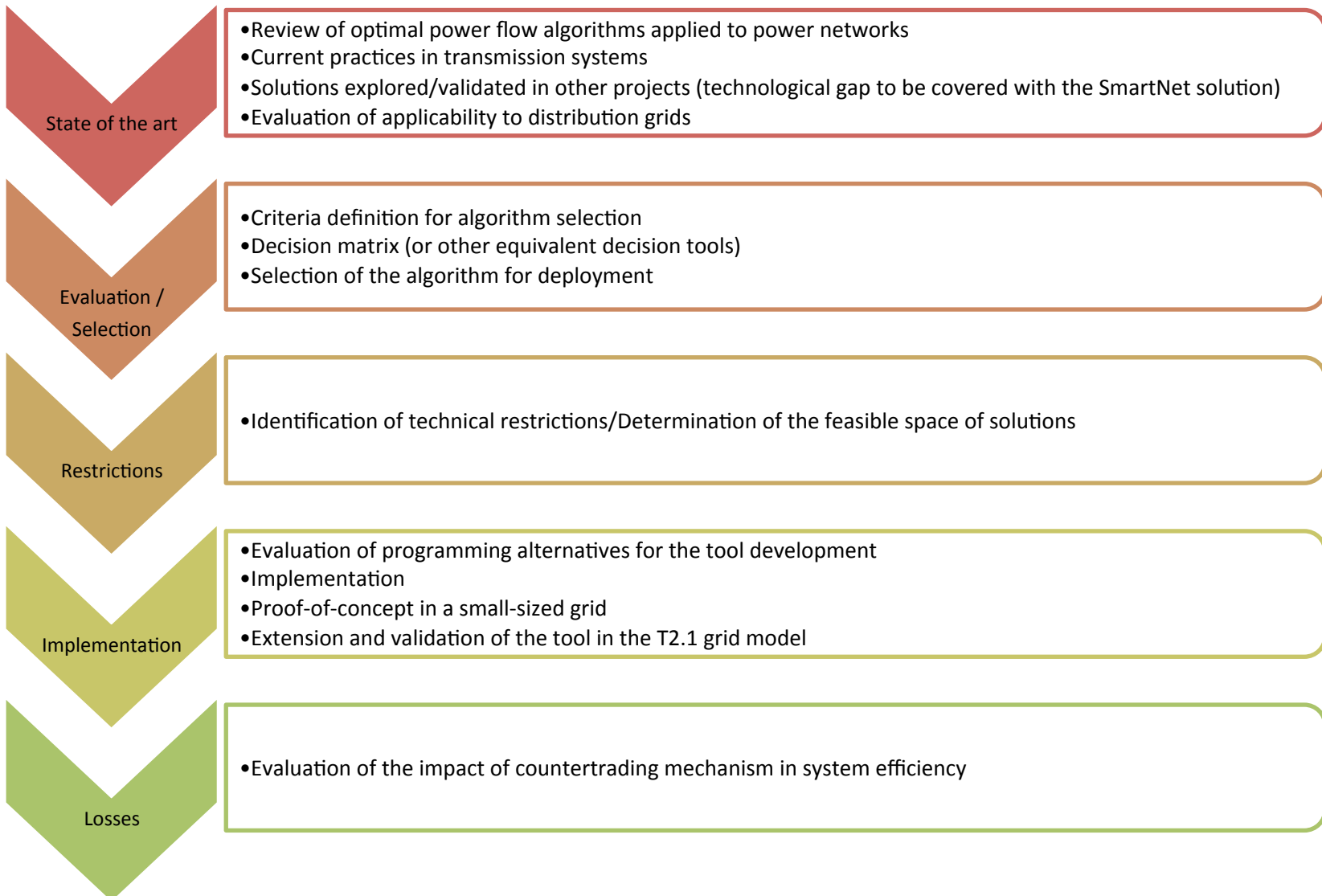
Continuous coordination with WP 2.1. to ensure tractability



## Task 2.4: Network management and countertrading mechanisms

- **Task leader:** Tecnalia
- **Participants:** DTU, RSE, VITO, N-SIDE, Ustrath
- **Overall aim:** Development of mathematical models and procedures to make market-clearing outcomes implementable in the distribution grid at a minimum cost (if needed).
- **Goals:**
  - Development of a full AC power flow model for the distribution network.
  - Development of countertrading mechanisms to re-dispatch DERs at a minimum cost if the full AC power flow model reveals that the pending market solution is not feasible.
  - Evaluation of efficiency loss due to countertrading.

## Task 2.4: Discussion (background, starting point, plan)





# WP participants: contact information

## WP leader

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## Task leaders

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# WP participants: contact information

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# WP participants: contact information

## Task 2.3

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## Task 2.4

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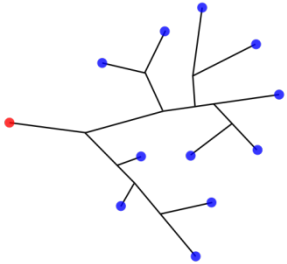
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UStrath			
RSE			

## WP2: Other practicalities

- How often should we meet? Who? WP + Task leaders only? How (e.g. Skype)?
- How exactly is each WP participant expected to contribute?
  - I gathered preliminary information on each partner's contribution to WP2 (available upon request): to be updated and further specified (Task leaders)
- Any other business?

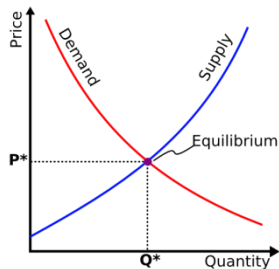
## Energinet.dk: Experience from other projects

# Key products



(Approximate) distribution grid models to be used by market clearing

Bidding and operational models for aggregators of DERs



Procedures to clear the market with DERs

Tools to check whether market outcomes are implementable in the distribution grid and corrective strategies (countertrading)



*Thank you for your attention...*

Juan M. Morales

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