GridSens & Smart Grid II Meeting – Strathclyde – 3 Feb 2016

Energy Transition towards a Cellular Smart Grid

Community – Grid Edge – Flexibility & Power Quality

- Empowering Energy Citizens
- Building Regulated Smart Community Energy
- Enabling the higher-levels of Stable Renewable Energy (RE) Penetration needed
- Enabling local small-scale Inertia-rich Flexible Plant
- Developing, from Small-scale, Cellular Smart Grid Systems
- Providing Structured Test Beds for Smart Energy Systems
- Increasing Skills Pool for Smart Energy Engineering & Business

Smart Cell by SMART Cell – Making the Grid easier to manage
Through Smart Community Local energy Balancing
And Community-based Grid Support Systems

Presented By:
Dudley Stewart C. Eng.

January 21, 2016

The Struggle Ahead

- **Climate change**: Eliminate Greenhouse Gases
- **Security of supply** concerns: economic and political dependency on imported fuels

…a major pillar of Europe's energy policy is

to increase the contribution of low-carbon and locally or regionally available fuels i.e. Community & **Distributed Clean Energy Generation**.

STRICT OBLICATION TO ACHIEVE NEAR-ZERO CARBON ENERGY BY 2050

Is there a Community Solution?

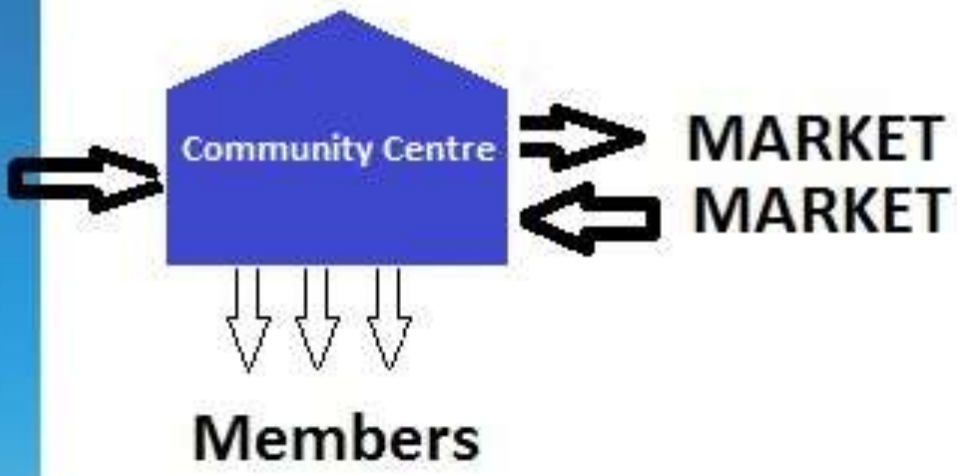
Can Communities create the Secret Ingredients to Tip the Balance in favor of Success?

Community Energy Solution Types	Issues or Advantages
A: Community/Co-op invests in generation, exports to market divides profits. No change to Retailer.	**Grid Capacity Limits** – Long-term Balancing , Stability & Market issues.

Community Energy Model 1

Community Energy Solution Types	Issues or Advantages
B: Community/Co-op invest in generation and supply license exports to market sells lower cost energy to members and divides profits. Retailers churned.	**Grid Capacity Limits** – Costs of Supply System. Balancing , Stability & Market issues.

Community Energy Model 2



The Challenge of Community & Distributed Energy Generation

Unregulated Distributed Generation can cause disturbances in the distribution network, e.g.:

- Congestion when local production is higher than the maximum local consumption
- Increased local phase imbalances
- Reversed power flows from the distribution network to the transmission network
- Voltage disturbances.

This limits the amount that the DSO (ESBN) will allow.

Unregulated Community & Distributed Generation also can cause system imbalances:

- Virtually impossible to forecast/invisible to Grid
- Mostly based on asynchronous technology and therefore reduces the total synchronous power and inertia in the grid.

Has to be compensated by increased flexibility from producers and/or consumers.

The Situation Today in Ireland

Ireland is facing into a period of severe complications – complications which will see Growth in Renewable Energy causing severe problems for the Grid

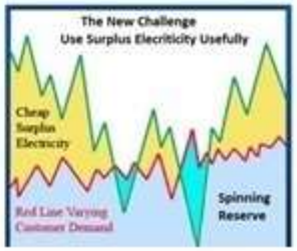
Vast Windpower Growth in Search of useful Markets

Pressure from Communities for Access to Local Energy

The SEAI Roadmap Signals Massive Growth in RE/Wind

SEAI + IEA Smart Grid Road Map

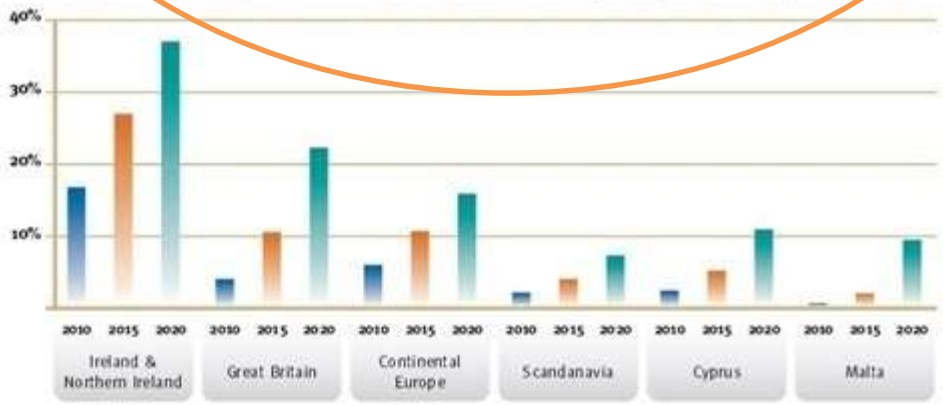
Radical Change to Electricity System



Growing Need for Flexible & Synchronous Power

Power-matching Communities serve this New Need

Penetration of non-synchronous renewables in each European synchronous system 2010-2020



Rapidly developing problem in the National Electricity System:

- Critical Reductions in Synchronous (Inertia) Power -> Grid Instability.

(weather-prone) asynchronous must be balanced by User Participation (Demand Response), Power Quality & Synchronous Services - Community Services.

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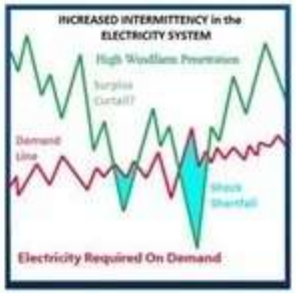
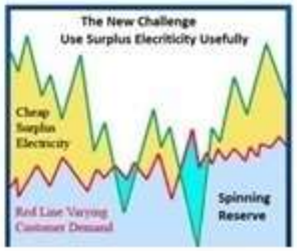
The SEAI Roadmap Signals Massive Growth in RE/Wind





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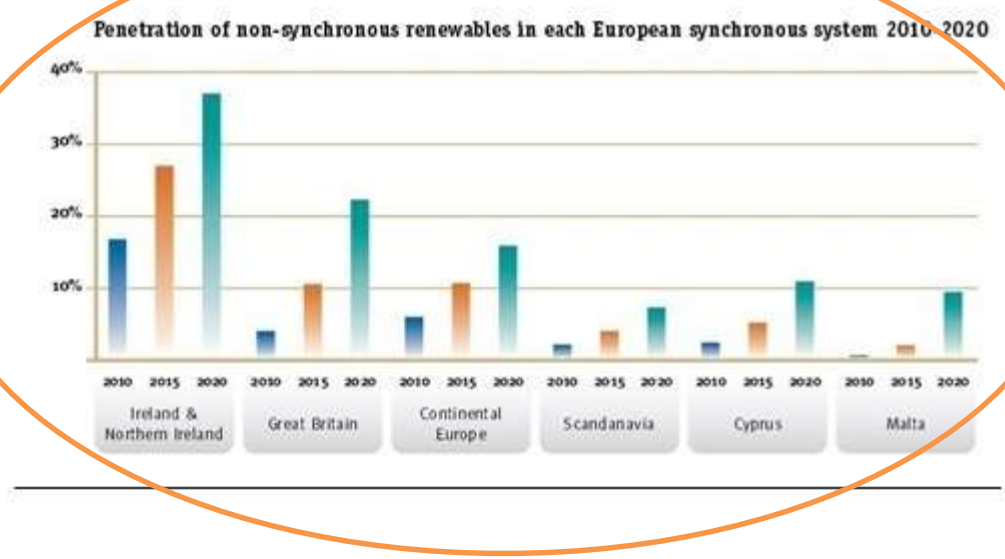

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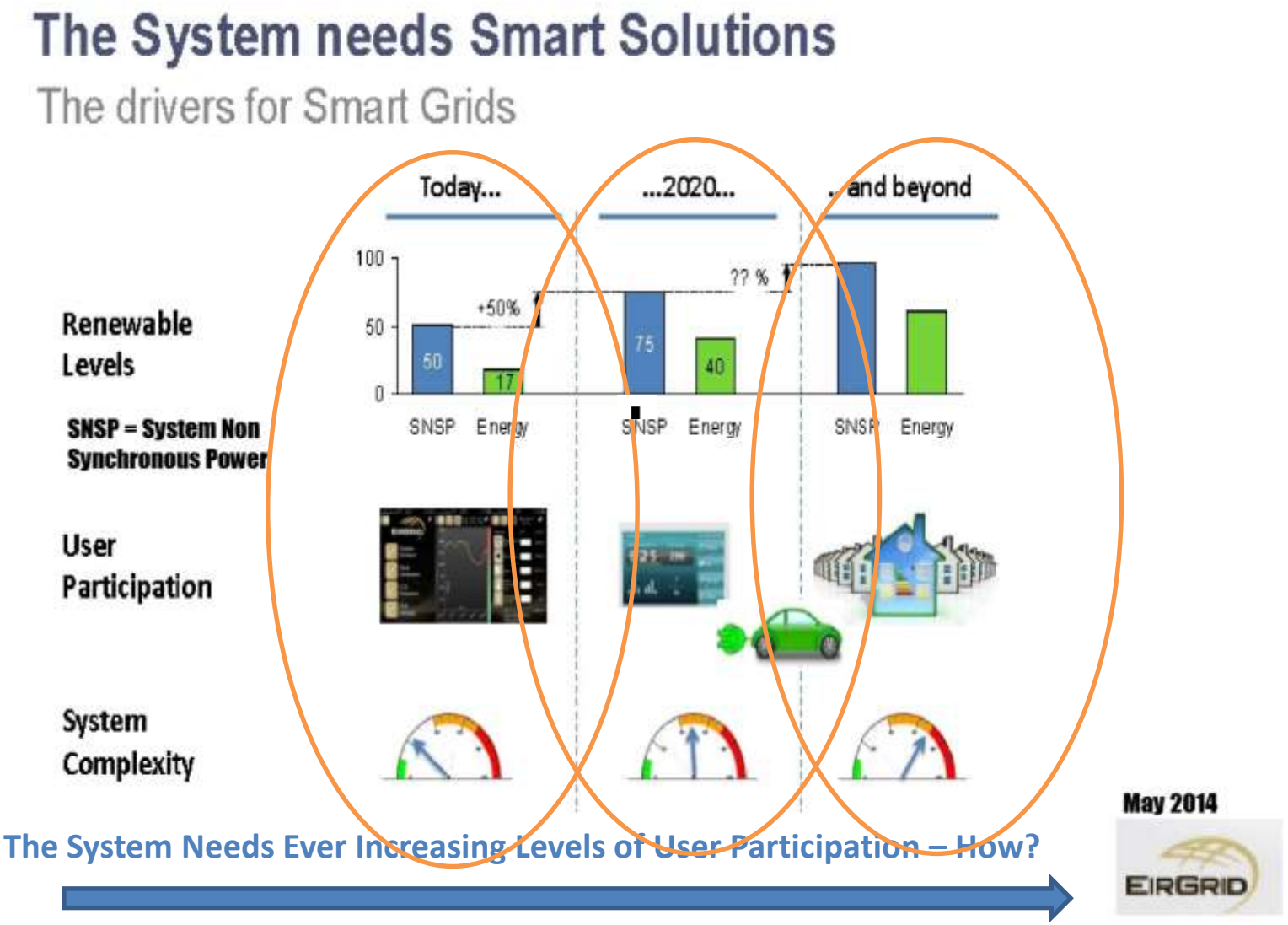
Important Insight

The National Grid is made possible by Synchronizing Power from many Synchronous Generators

In Ireland today most Renewable Energy Generators are Asynchronous – They produce Non Synchronous Power which eats up Synchronous Power – This is unsustainable and will lead to severe barriers to achieving Ireland's 2050 Near-zero Carbon Energy by 2050

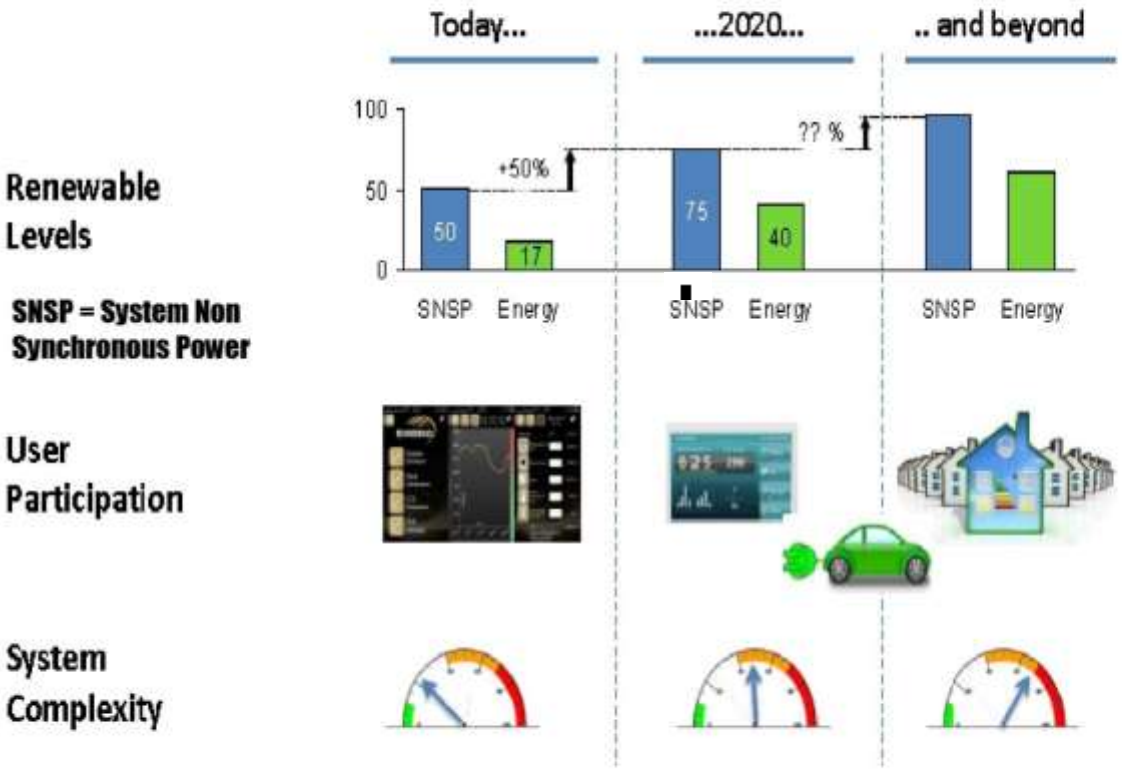
The National Challenge facing Grid & Community



The National Challenge facing Grid & Community

The System needs Smart Solutions

The drivers for Smart Grids



The System Needs Ever Increasing Levels of User Participation – How?

May 2014

EIRGRID

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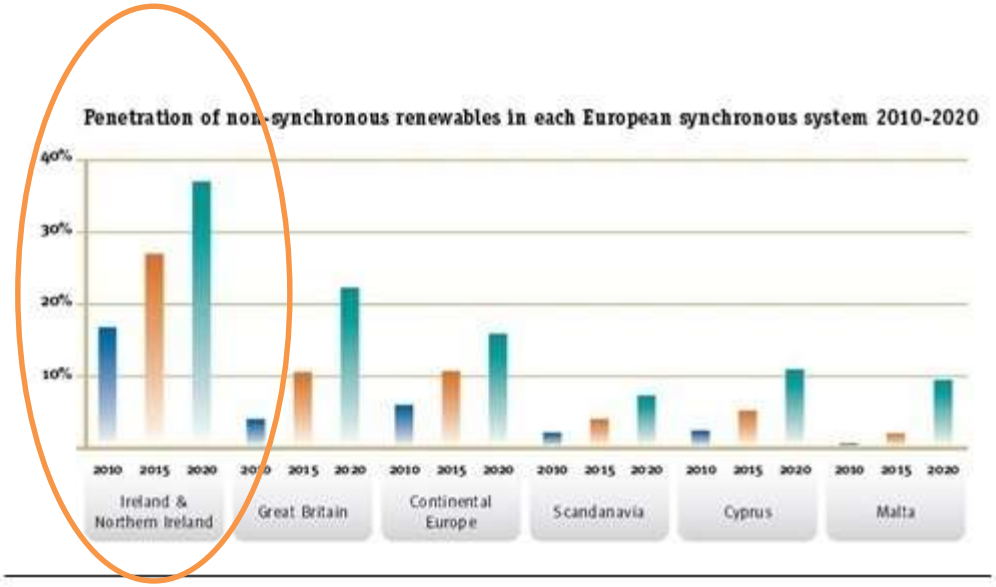

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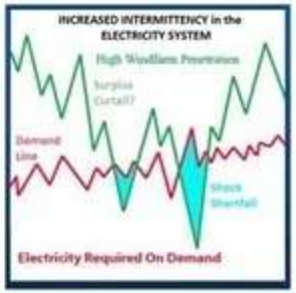

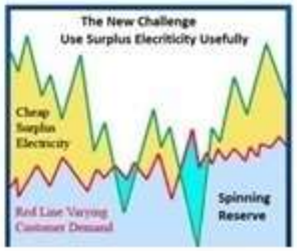

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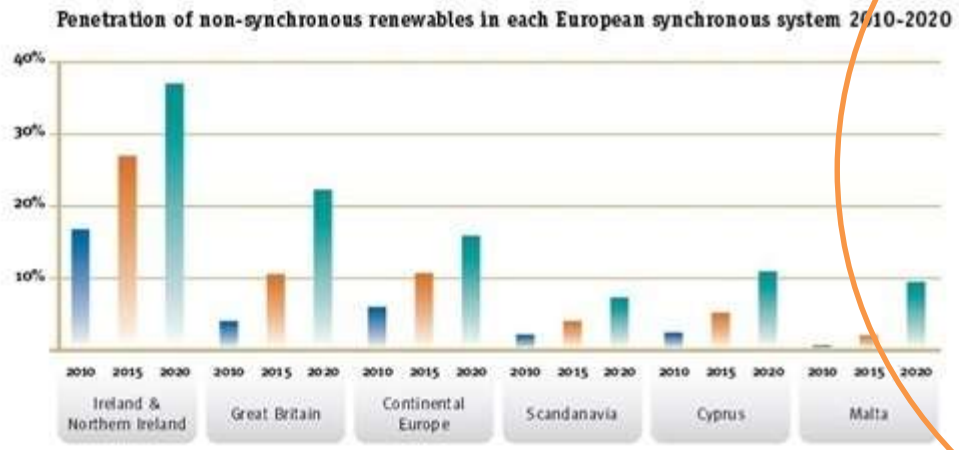

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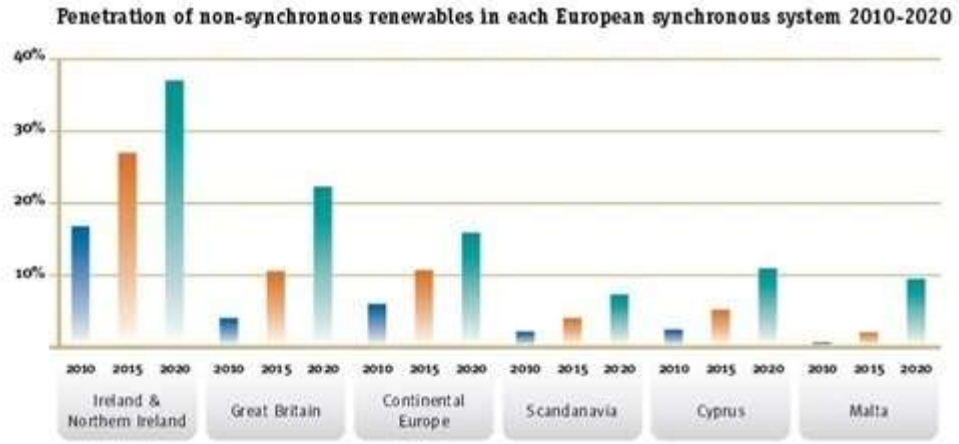
Grid-Edge - Solutions



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Is there a Community Solution?

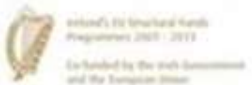
Can Communities Rally to Stabilize the Grid?

The Tallaght Smart Micro Energy Test Bed

Driven By:

1. South Dublin County Council
2. Tallaght Test Bed Technology Group
3. **Micro Electricity Generation Association (MEGA)**
4. Local Community Groups
5. Enterprise Ireland (EI)
6. Sustainable Energy Authority of Ireland SEAI)
7. Eirgrid (TSO) – Smart Grid innovation Hub

The key objective is to keep the **Test Bed** initially comparatively small and contained (MW's) but also **open for the trialling of Smart Grid Technology & Systems** with many other Local and International Companies and Research Institutes. On achieving stable critical mass, the operation will open 30 new similar Test Beds to create a basic smart cluster mesh throughout the Island of Ireland



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Enersol - Power Eng.
Smart M Power - CEUCo.
Endeco - Aggregator
Crowley Eng. - Biomass
Sunstream - Solar/Wind
Turmec Eng. - Waste

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ENTERPRISE IRELAND
where innovation means business

Comhairle Contae Átha Cliath Theas
South Dublin County Council

MEGA

energising smarter communities
Mpower

iERC
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SIEMENS - Microsoft

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EUROPEAN REGIONAL DEVELOPMENT FUND

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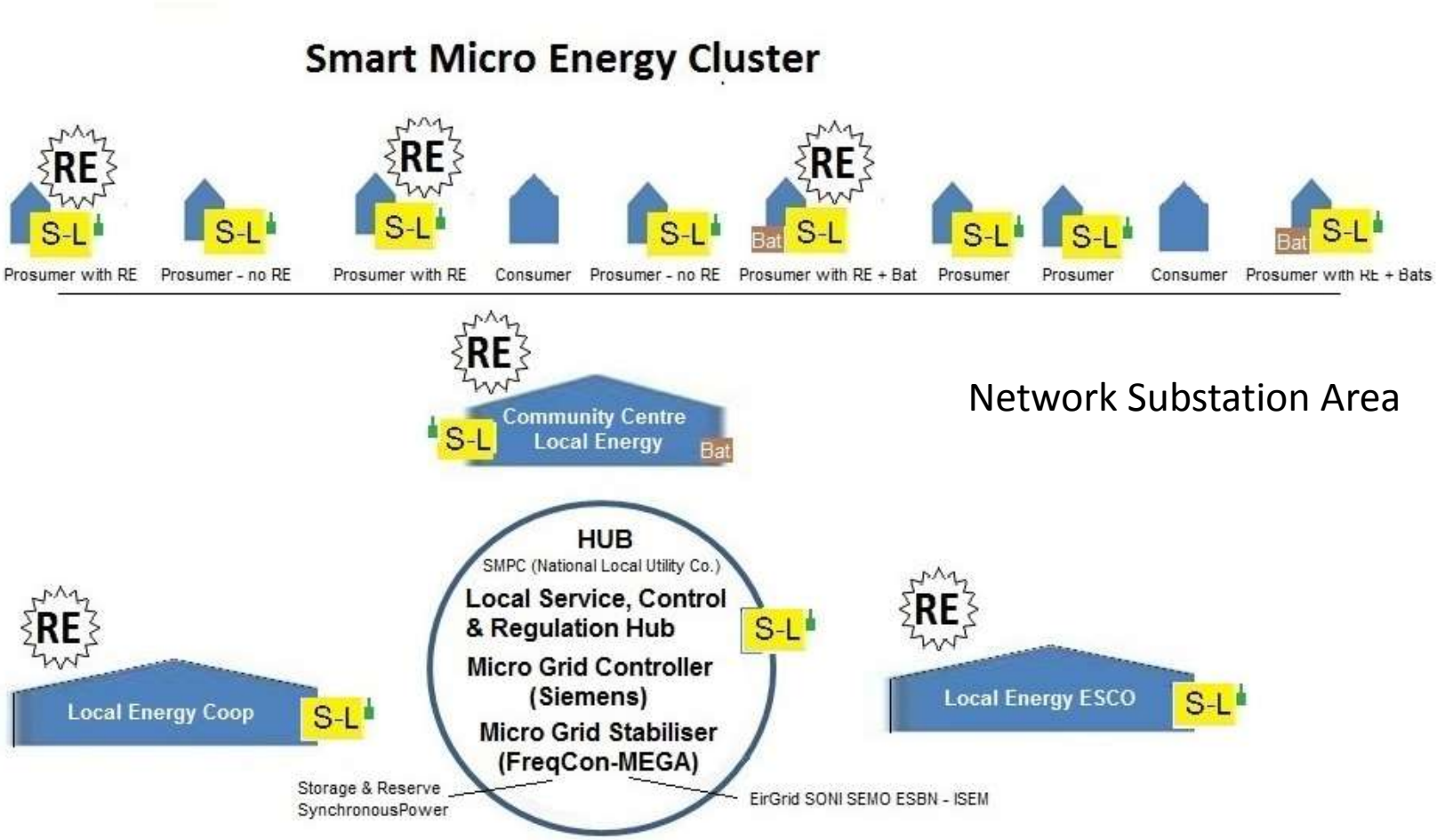
Tallaght Smart Grid Test Bed
Dublin 24 - Ireland

Strategic Location
Silicone Valley Model

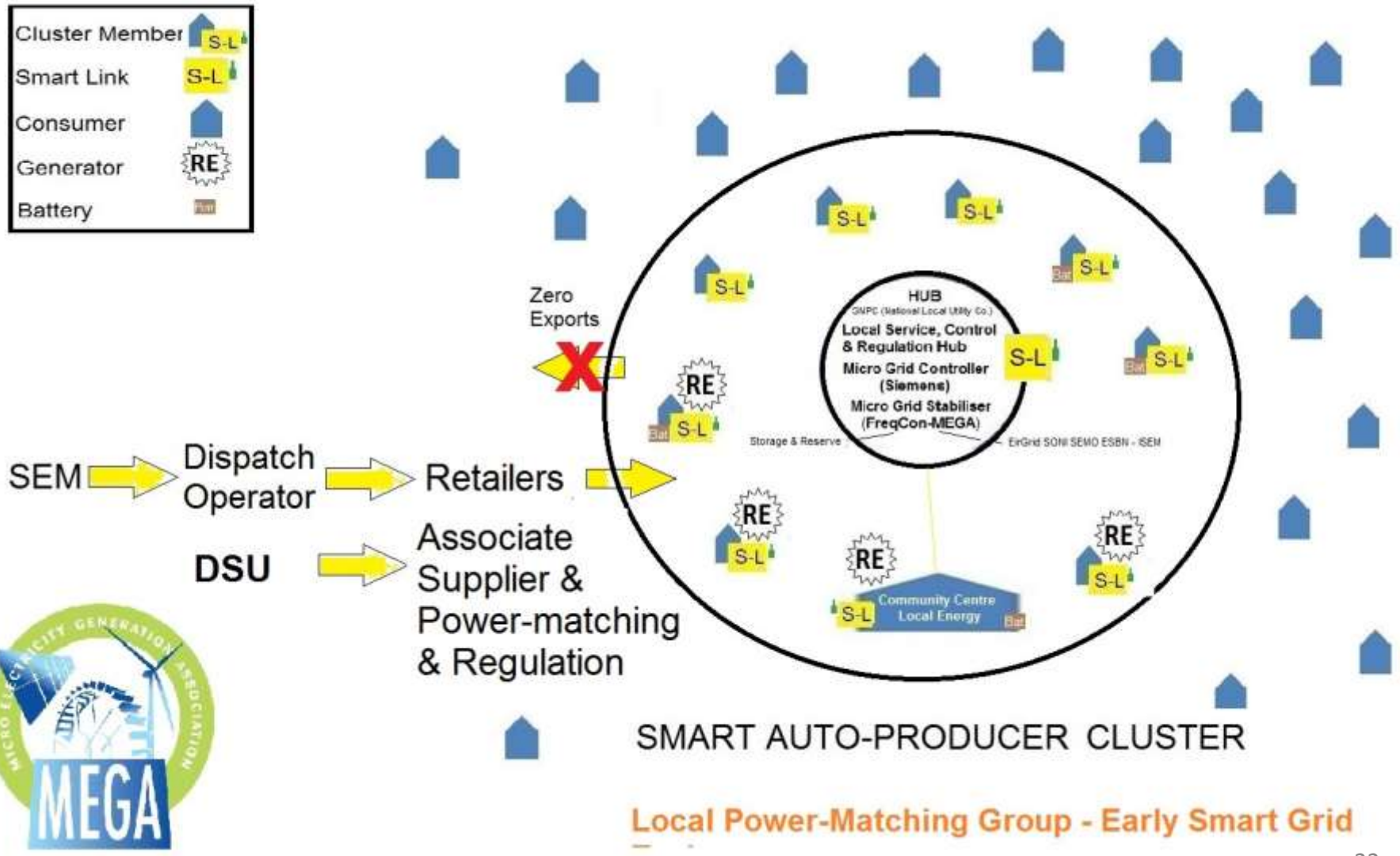
Vision for Common Community Action

1. Develop Test & Certify the Tallaght Smart Grid Framework, through openess to all viable Collaborations, & the growth in Number and Size of intermeshing Smart Micro Energy Clusters embedded in LV System with one Super Cluster as the Hub.
2. Spread to 30 new Test Beds across Ireland:
- Future Local Community-Owned Smart Grid Framework Systems
-Canditate Smart Grid Hardened Nodes



Grid-Edge -Behind-the-Meter – **Communities of Willing Prosumers** – Interconnected by Internet protocol Prosumer Smart Meter I/O Power Matching Controller Units enabling Smart Real-Time Local Electricity Power Matching – Local Consumption/Recycling of Local Clean Electricity in Real-time – Forming Intelligent Smart Micro Energy Cells intermeshed nationally – providing valuable Grid Support & Rapid Response.

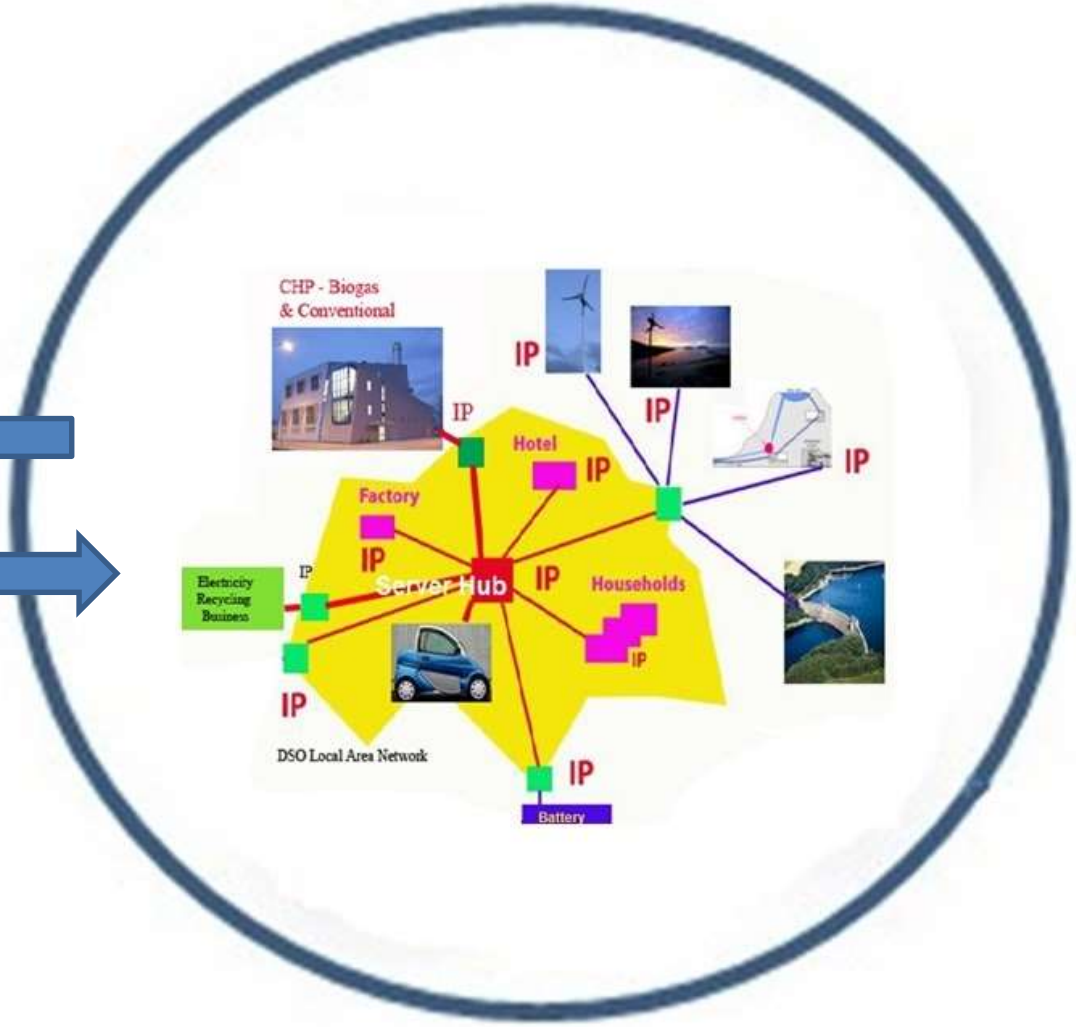
Micro-Energy Working with the Market



Smart Micro Energy Clusters

Power
Matched
Balancing
No
Exports

SEM



Local Community Auto-Producer (own-needs) Groups – Regulated by Contract

Community Energy Solution Types	Issues or Advantages
A: Community/Co-op invests in generation, exports to market divides profits. No change to Retailer.	**Grid Capacity Limits** – Long-term Balancing , Stability & Market issues.
B: Community/Co-op invest in generation and supply license exports to market sells lower cost energy to members and divides profits. Retailers churned.	**Grid Capacity Limits** – Costs of Supply System. Balancing , Stability & Market issues.
C: Smart Community contracts **Community Energy Utility Co.** to invest in locally Power-matched DER Earnings from market on shared-benefits basis for capacity, balancing & Power Quality Services – no change to Retailer. **Own use Microgeneration**	**Grid –Supportive** -All power generated by members locally is consumed in real time locally - no exports to Grid + Power-Balancing & System Services. Regulated Early Smart Grid Technology Deployment.
D: Smart Community contracts Community Utility Co. to invest in DER and Power-match Locally, Earnings from market on shared-benefits basis for capacity, balancing & Power Quality Services – Power Deficit purchased from market and supplied under contract to members. Retailer churned. **Own-use Microgeneration**	**Grid-Supportive** -All power generated by members locally is consumed in real time locally -no exports to Grid + Power-Balancing & System Services. Early Smart Grid Technology Deployment. Need for special auto-producer license. Facilitates Demand Side Bidding.

Community Energy Utility Company

The **CEU Co.** Can Rally Community of Prosumers to Stabilize the Grid?

Smart Micro Energy Clusters

Power
Matched
Balancing
No
Exports

SEM

Local Community Auto-Producer (own-needs) Groups – Regulated by Contract

Smart Micro Energy Clusters

Local Community Auto-Producer (own-needs) Groups – Regulated by Contract

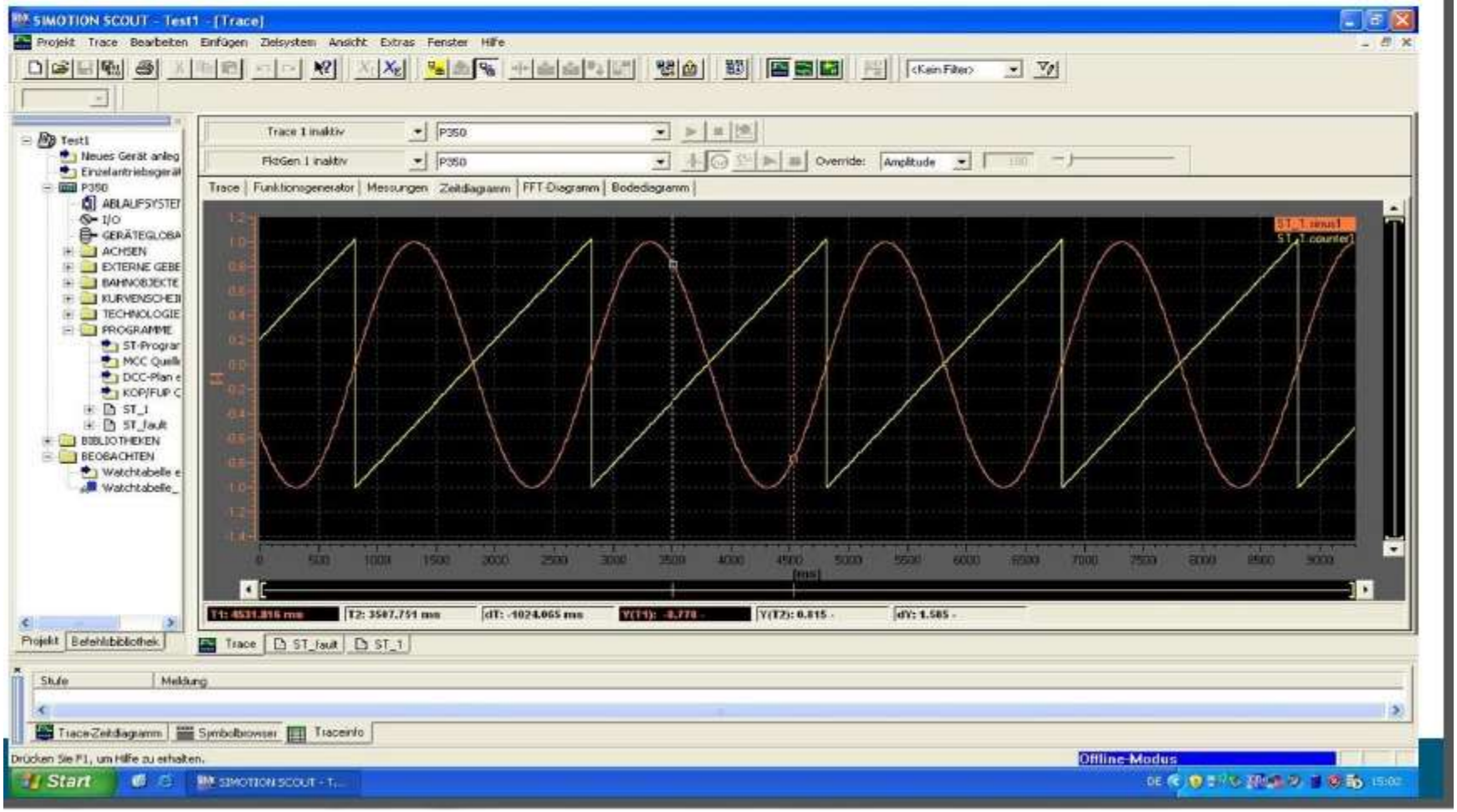
Micro Grid Stabiliser

300 kW - High Speed Response – Ultra Cap Driven – Statcom – Lit-Ion + Lead Carbon Bats - Phase Balancing – Harmonic Suppression – PQ Rectifier – 2 DC/AC + 2 DC/DC Converters – PMU Equipped

SMART MICRO ENERGY CELL AUTO-REGULATOR

Precise Phase and Frequency Measurement

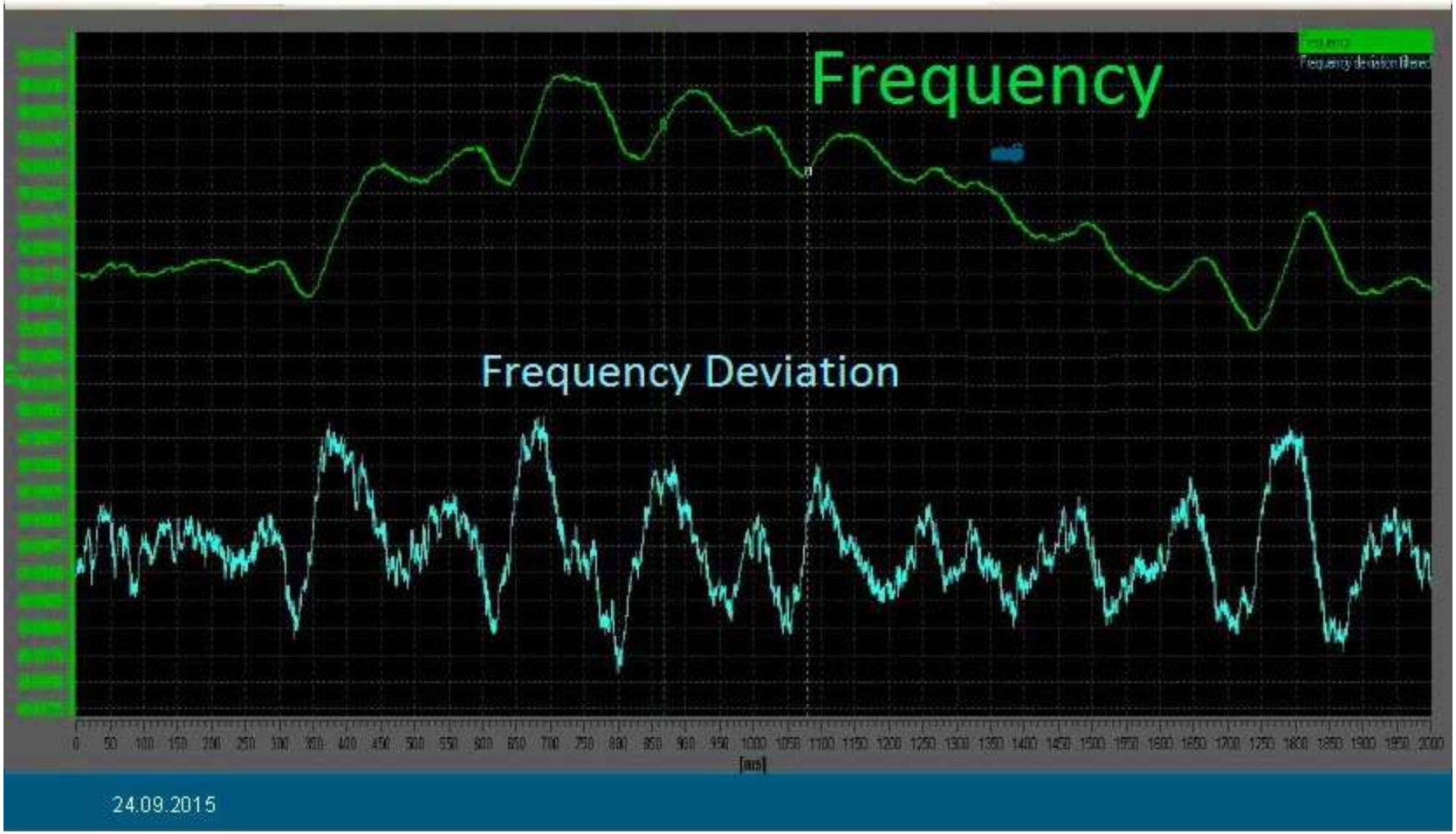
FREQCON
sustainable solutions



ROCOF Rate of Change of Frequency

Measurement Resolution: **1mHz/sec , 10 msec**
(normal grid situation)

FREQCON
sustainable solutions



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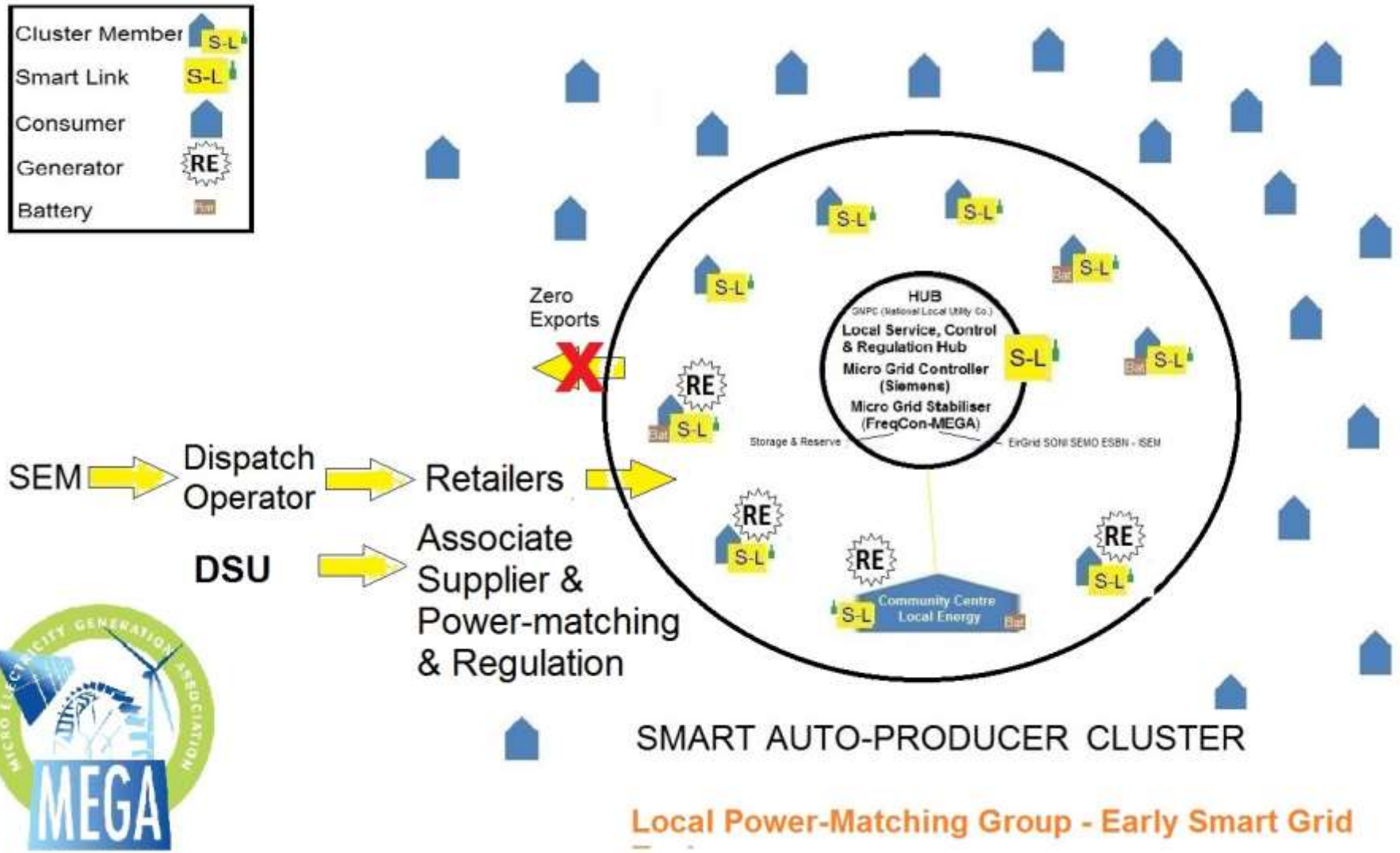
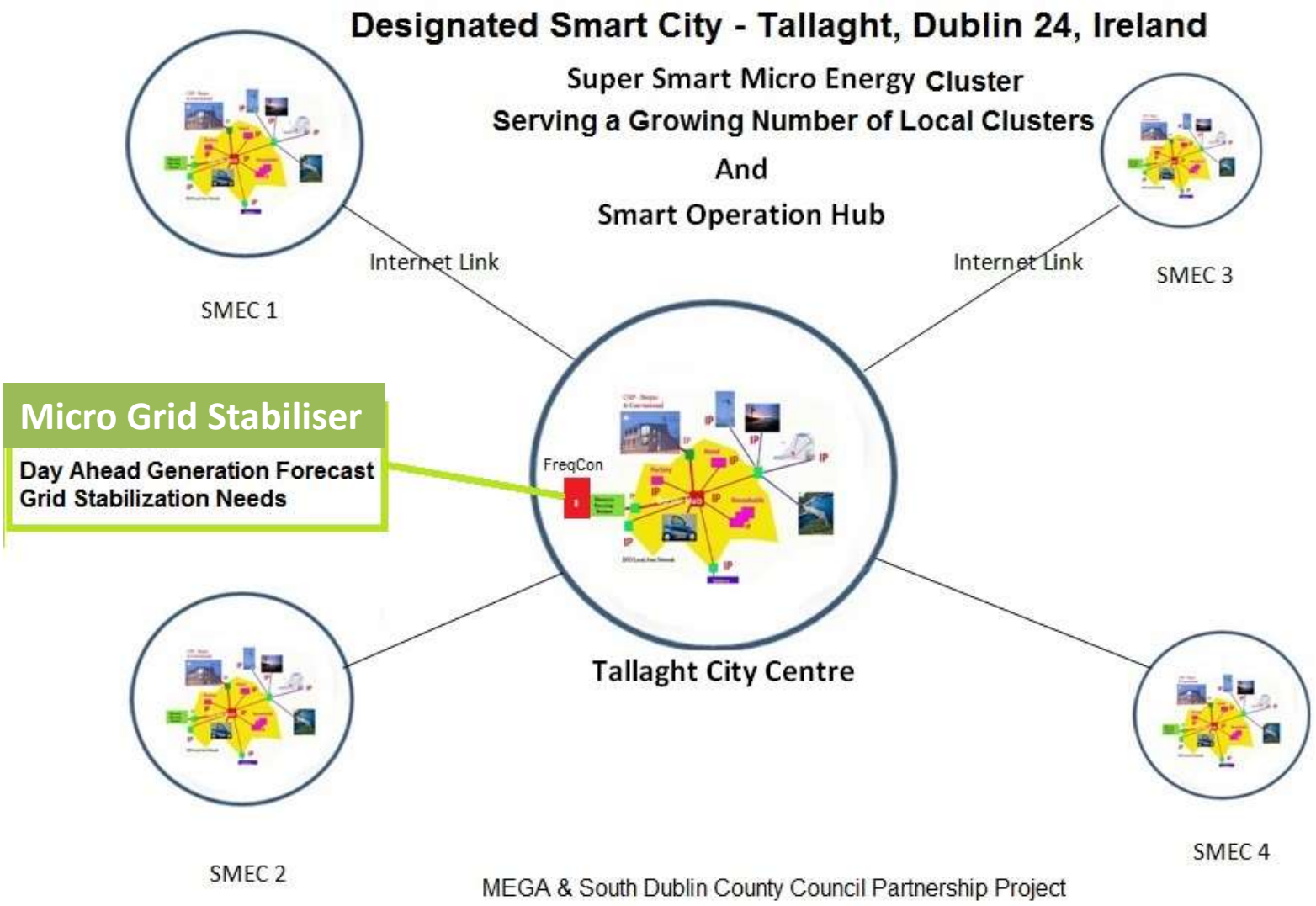
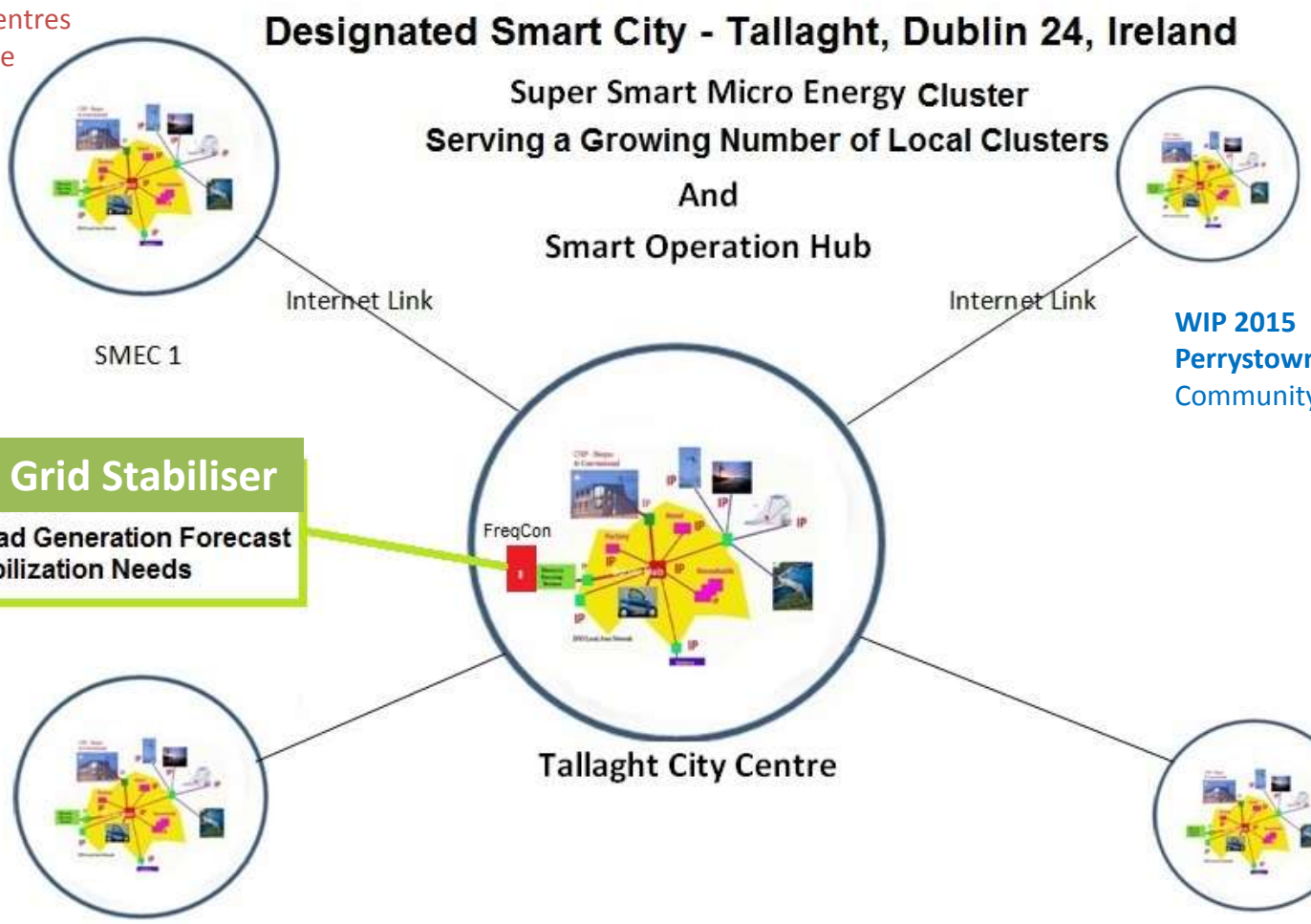



Designated Smart City - Tallaght, Dublin 24, Ireland
Super Smart Micro Energy Cluster
Serving a Growing Number of Local Clusters
And
Smart Operation Hub
Internet Link
Internet Link
SMEC 1
SMEC 3
Micro Grid Stabiliser
Day Ahead Generation Forecast
Grid Stabilization Needs
FreqCon
Tallaght City Centre
SMEC 2
SMEC 4
MEGA & South Dublin County Council Partnership Project

Phase 1 WIP
Jobstown-Bawnlea D24
2 Community Centres
Education Centre
Leisure Centre
31 Prosumers

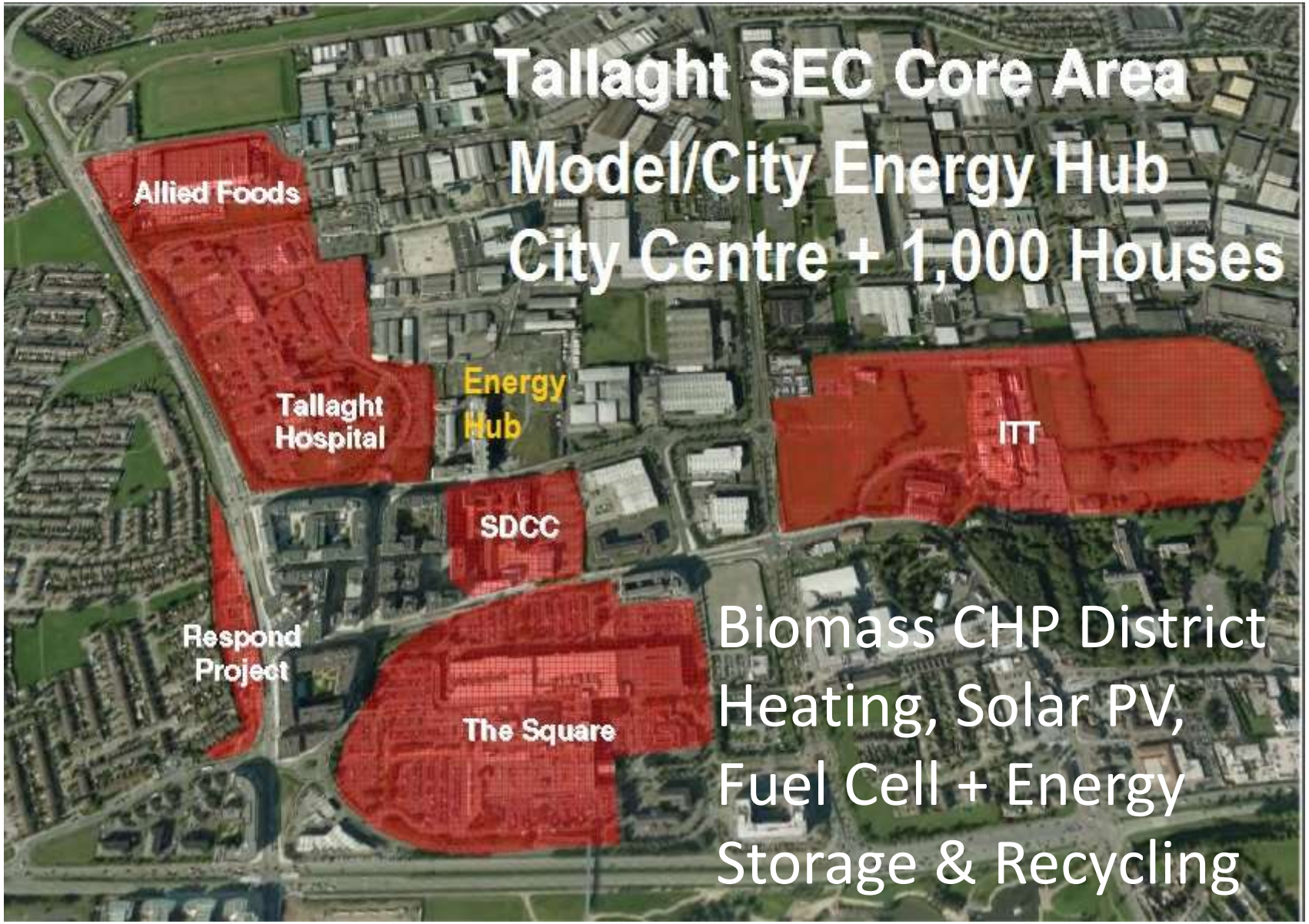


WIP 2015
Perrystown D24
Community Centre

Phase 2 WIP
Oldbawn D24
Community Centre
GAA Club
NS School
19 Prosumers

MEGA & South Dublin County Council Partnership Project

WIP 2015
Whitechurch D24
Community Centre
Library
57 Prosumers


Tallaght SEC Core Area
Model/City Energy Hub
City Centre + 1,000 Houses
Allied Foods
Tallaght Hospital
Energy Hub
ITT
SDCC
Respond Project
The Square
Biomass CHP District Heating, Solar PV, Fuel Cell + Energy Storage & Recycling

Early Cellular Smart Grid

•Replication of Smart Grid Test Bed into 30 additional locations across Ireland.

•Automation by one Transactive Energy Trading Platform

•Aggregating Power Balancing & Flexibility Services on a National Level

•Directly connected to the System Operators providing intelligent distributed data and forecasting information in advance in in real-time – Data Analytics.

In a Nutshell

Community Energy Grid Support Services - the Key to Grid Resiliency - future Near-Zero Carbon Energy system:

1. Grow Inter-meshed Smart Energy Cells in Size and Number to enable increased RE Penetration while making the Grid easier to Manage – Pillar 1 Cellular Smart Grid.
2. Smart Energy Cells enhance Demand Response, Ultra-high Frequency Response and can switch to VPP mode for short periods to buy time for Central Grid Response – Pillar 2 Cellular Smart Grid
3. This is the fair way forward for Communities

The Smart Grid solution

- High number of distributed renewable electricity producers as explicit price-makers.
- Increased participation of flexible consumers in the market, preferably as explicit price-makers (prosumers)

Through:

- Price-maker aggregators in the wholesale market (like AGU and DSU)
- Eventually: µGrids (Distribution Network) to compensate for increased local disturbances in real-time

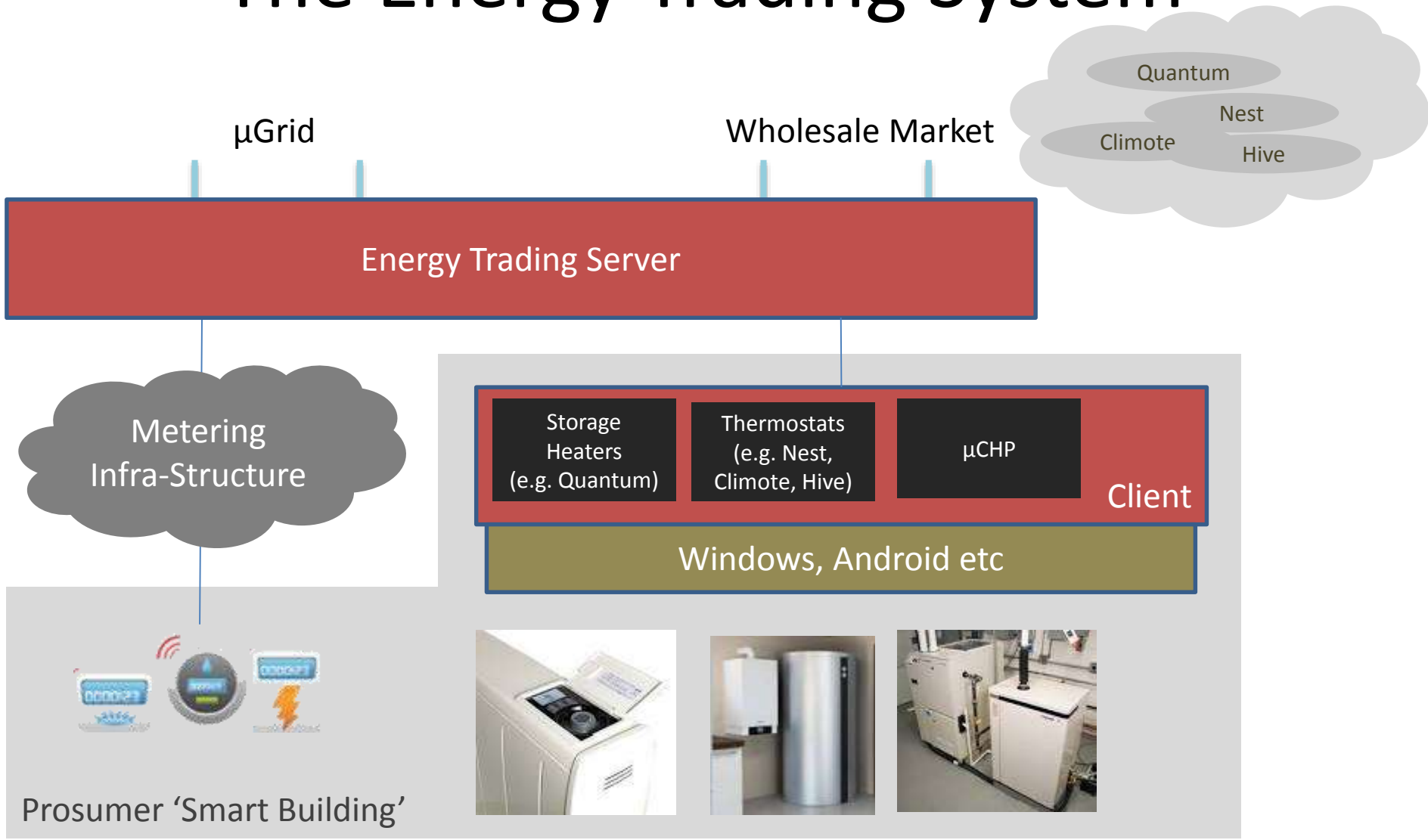
Will they talk to each other?

MEGA Solution: The Community Energy Market

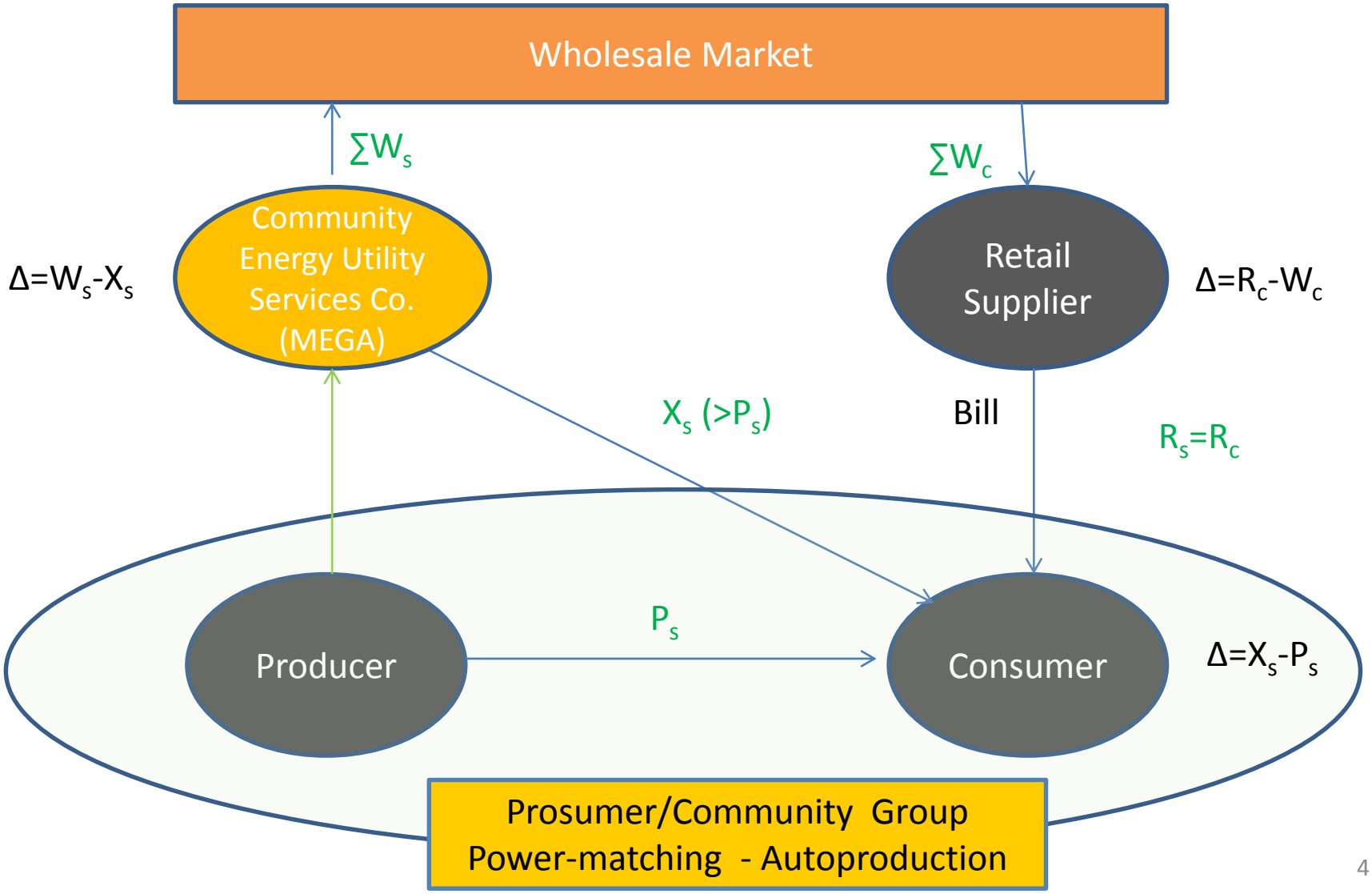
Trading of energy between **prosumers** in the same community eco-system: prosumers operate in a market physically restricted to the local distribution network (µGrid)

- Power Matching: matching local Production with local Consumption through trading (i.e. planning)
- Capacity µPool for real-time compensation:
  - Sell ancillary services capacity (DS3) to wholesale market
  - Sell compensation capacity to µGrid

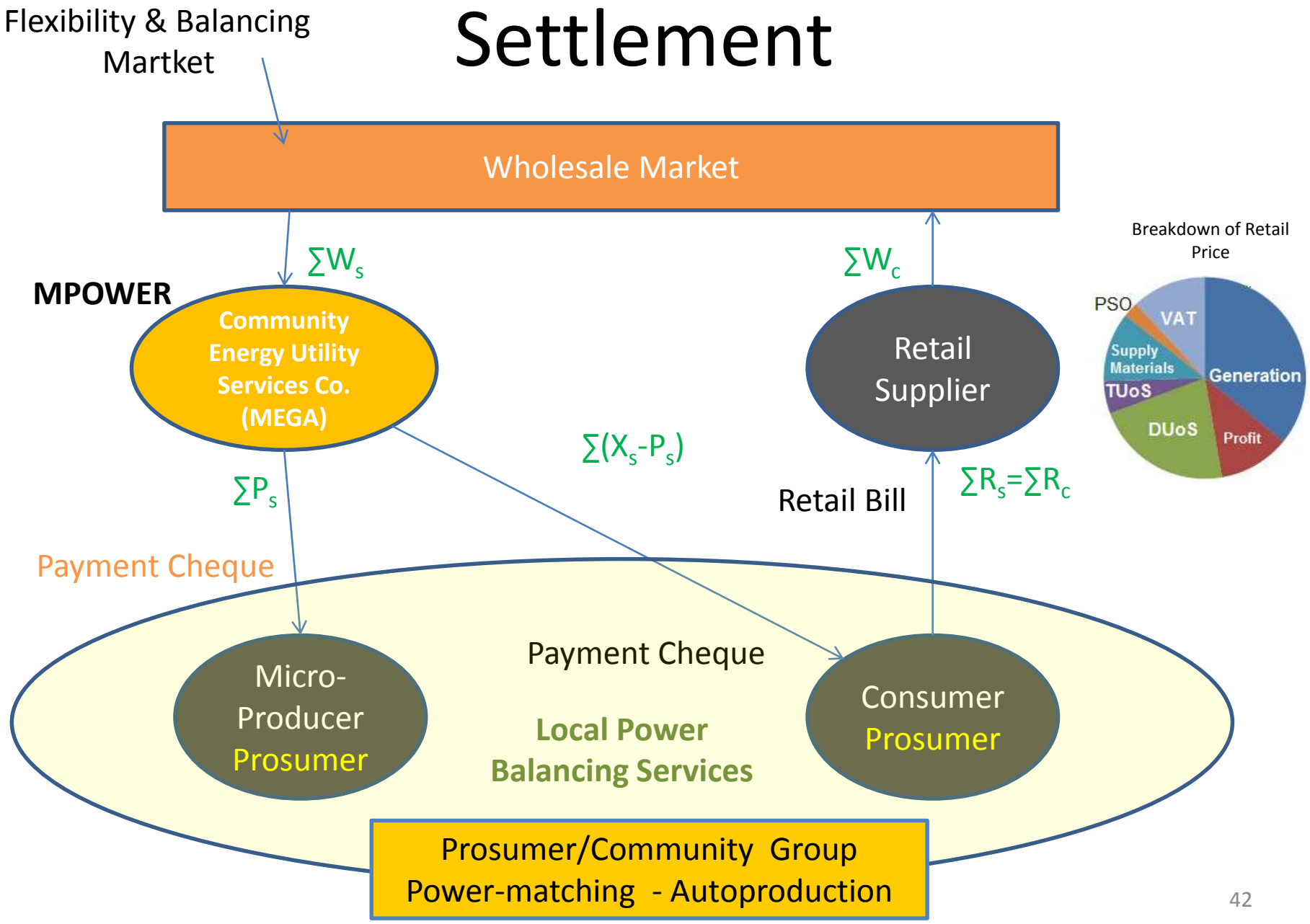
The Energy Trading System



Power Matching Trade



Settlement


Flexibility & Balancing Martket
Wholesale Market
∑W_s
∑W_c
MPOWER
Community Energy Utility Services Co. (MEGA)
Retail Supplier
∑(X_s-P_s)
∑P_s
∑R_s=∑R_c
Retail Bill
Payment Cheque
Payment Cheque
Micro-Producer Prosumer
Local Power Balancing Services
Consumer Prosumer
Prosumer/Community Group
Power-matching - Autoproduction
Breakdown of Retail Price
PSO
VAT
Supply Materials
Generation
TUoS
DUoS
Profit

Rapid Development Project of National Interest

Microgrid Franchise for Intelligent Community

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Thank You

Micro Electricity Generation Association (MEGA)

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MICRO ELECTRICITY GENERATION ASSOCIATION
MEGA