Redesigning the Regulation of Electricity Distribution Under High Penetration of Distributed Energy Resources

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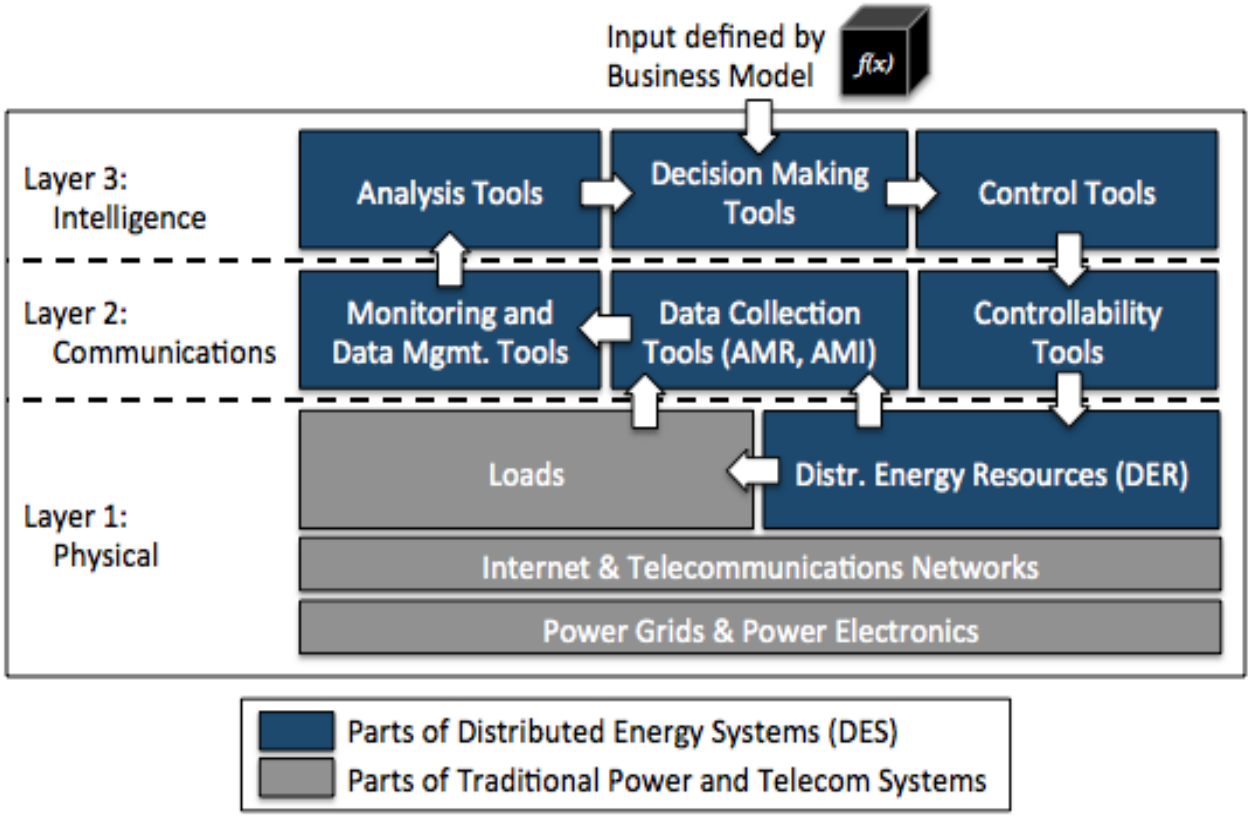
Distributed Energy Systems

- Distributed Energy Systems are a key component of the changes taking place in the electric power system
- Distributed Energy Systems have three key layers: intelligence, communications, and physical systems



DESs Versus DERs

- DESs are characterized by pairing DERs with ICTs, leveraging the synergies between DERs and integrating with or reacting to system signals

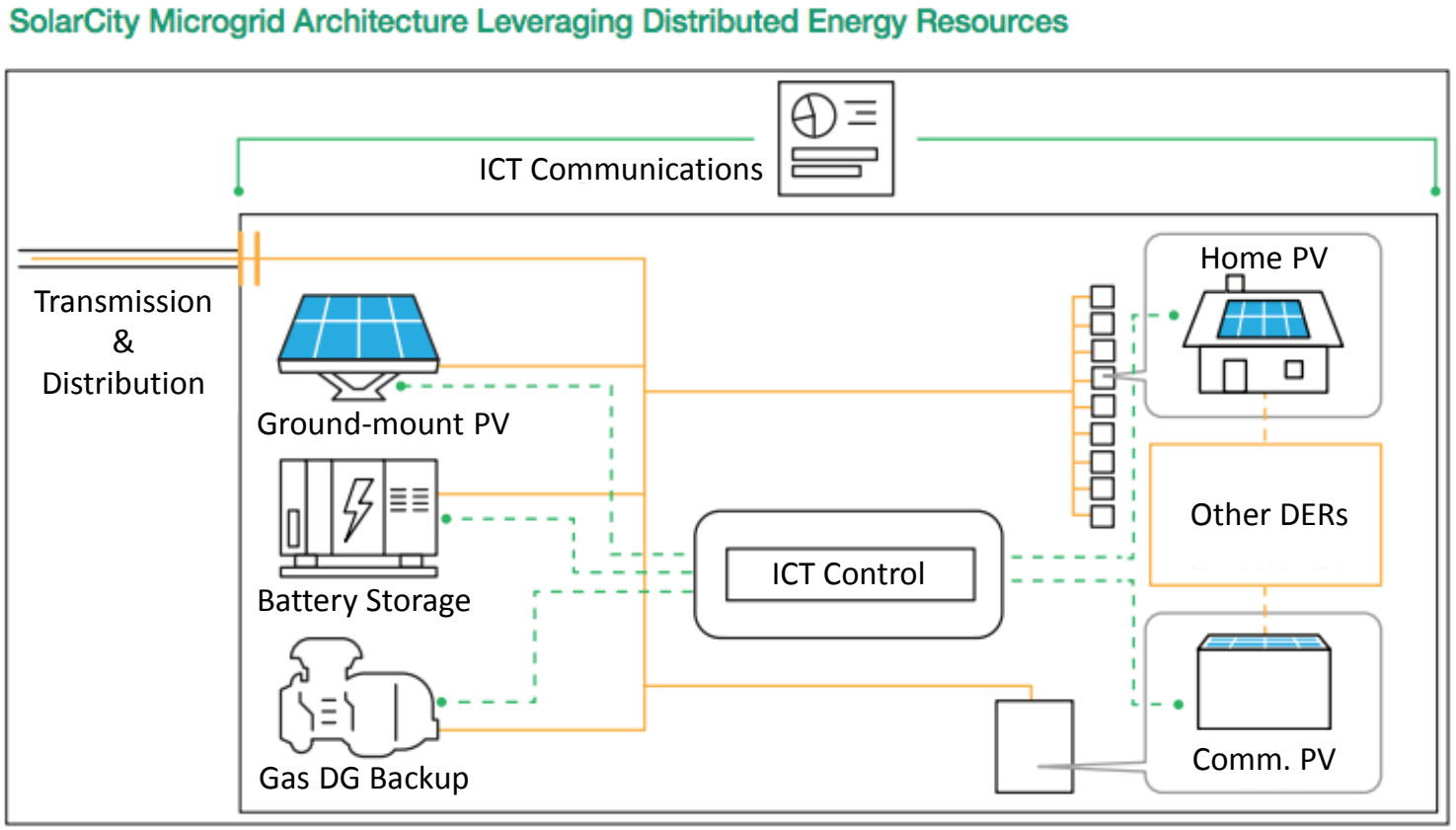


Image Source: SolarCity

Regulatory Challenges

- Increasing integration of DERs and DESs presents regulatory challenges and opportunities*:

3) a framework for characterizing the circumstances under which different energy technologies can successfully compete to provide different electricity services

1) a novel process for establishing the allowed revenues of an electricity distribution utility

2) a new approach to designing distribution network use-of-system charges (as part of a comprehensive system of prices and regulated charges for all electricity services)

**From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European Electricity DSOs*

Image Source: SolarCity

Moving Towards a Level Playing Field

- The objective is to create a level playing field on which electricity services can be provided with the most efficient combination of decentralized and centralized resources

Image Source: bostonglobe.com

Remunerating the distribution utility

A novel combination of four established "state of the art" practices:

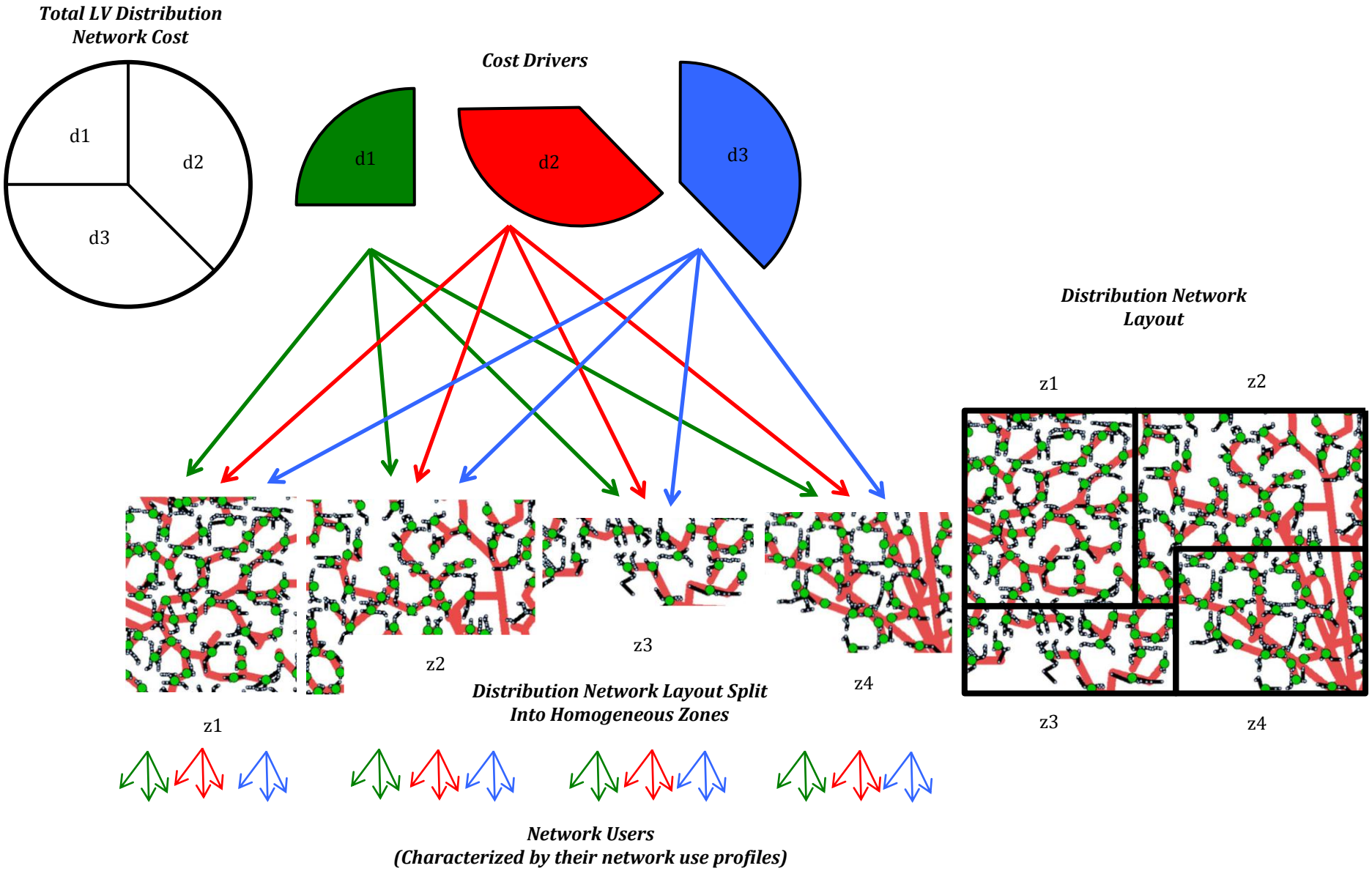
- An engineering-based **reference network model** (RNM) for forward-looking benchmarking of efficient network expenditures
- An incentive compatible **menu of contracts** to elicit accurate forecasts from the utility and create incentives for cost saving efficiency efforts
- A "fast-money/slow money" **TOTEX-based approach** to equalize incentives for OPEX and CAPEX savings
- *Ex post* automatic adjustment mechanisms, or "**delta factors**," to accommodate uncertainty in the evolution of network use and minimize forecast error

Allocating distribution costs

A four-step process:

- Identify the **cost drivers**
- Determine the **contribution of each cost driver to the total** distribution network cost
- Allocate **costs to network users** – i.e. compute each network user's DNUoS charge – using **profiles**
- Choose an adequate **format** for presenting the final DNUoS charge to network users

The Process


Total LV Distribution Network Cost
d1
d2
d3
Cost Drivers
d1
d2
d3
Distribution Network Layout
z1
z2
z3
z4
Distribution Network Layout Split Into Homogeneous Zones
z1
z2
z3
z4
Network Users
(Characterized by their network use profiles)

DESs and Electricity Services

- Like centralized generators and storage units, DESs can provide a set of **commodity services**

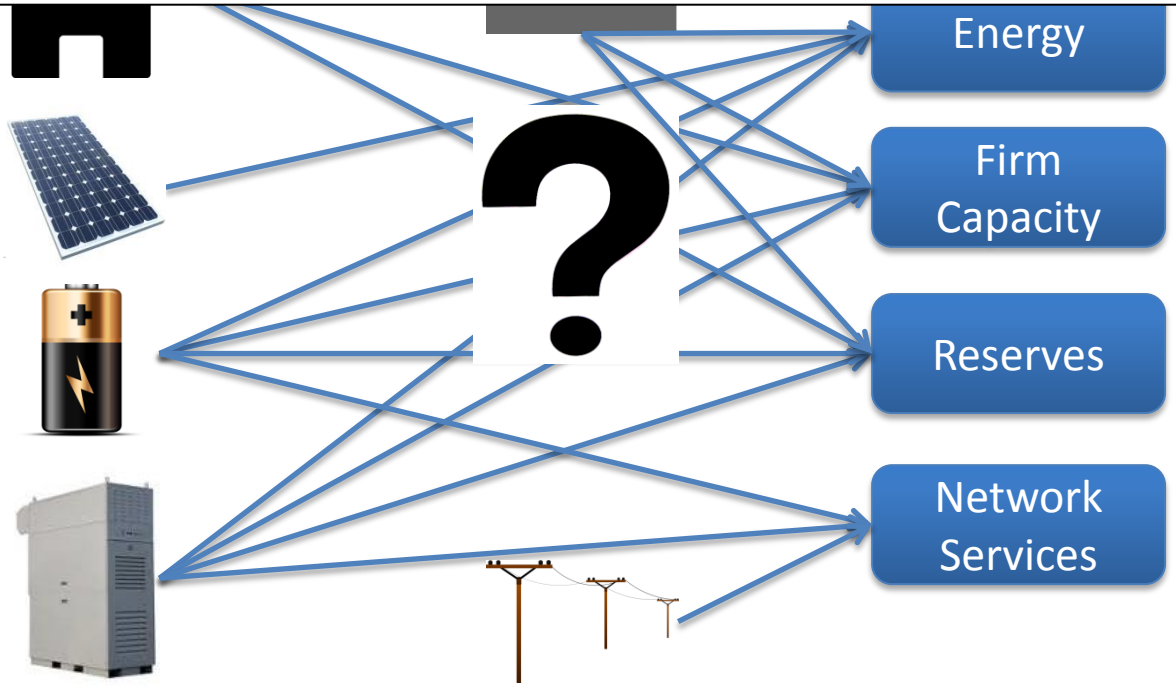
Electricity Services

- Energy
- Reserves
- Firm generation capacity
- Voltage regulation
- Frequency regulation
- Network capacity
- Network loss reduction
- Network congestion reduction
- Network reliability

Understanding DESs

- Services from centralized resources are largely understood

What services will DESs provide?
At what cost?



Thank you

For more on remuneration, see:

- Jenkins, J.D. & Perez-Arriaga, I. (2014), The Remuneration Challenge: New Solutions for the Regulation of Electricity Distribution Utilities Under High Penetrations of Distributed Energy Resources and Smart Grid Technologies. MIT CEEPR Working Paper No. 2014-005.
- Jenkins, J.D. (2014), Economic Regulation of Electricity Distribution Utilities Under High Penetration of Distributed Energy Resources: Applying an Incentive Compatible Menu of Contracts, Reference Network Model and Uncertainty Mechanisms. SM Thesis, MIT Technology & Policy Program.
- Cossent, R. (2013). Economic Regulation of Distribution System Operators and its Adaptation to the Penetration of Distributed Energy Resources and Smart Grid Technologies. PhD Thesis, Comillas Universidad Pontificia.
- Cossent, R., & Gómez, T. (2013). Implementing incentive compatible menus of contracts to regulate electricity distribution investments. *Utilities Policy*, 27, 28–38.

For more on network charges, see:

- Perez-Arriaga, I. & Bharatkumar, A. (2014). A Framework for Redesigning Distribution Network Use of System Charges Under High Penetration of Distributed Energy Resources: New Principles for New Problems. MIT CEEPR Working Paper No. 2014-006.
- Bharatkumar, A. (2015), Distribution Network Use-of-System Charges Under High Penetration of Distributed Energy Resources. SM Thesis.
- Perez-Arriaga, I., Ruester, S., Schwenen, S., Batlle, C., and Glachant, J.M. (2013). From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European Electricity DSOs. Technical report, European University Institute, Florence.
- Reneses, J., Rodriguez, M.P., and Perez-Arriaga, I. Electricity Tariffs. In Regulation of the Power Sector, pages 397-441. Springer, London; New York, 2013.