Accelerate energy transition with smarter regulation for faster grid digitalization

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[1] The results and comments presented in this paper are entirely the authors' responsibility and should not be in anyway associated to the official opinions of ERSE or other institution.

Accelerate energy transition with smarter regulation for faster grid digitalization

- ❑ Context: looking for innovative companies
- ❑ Innovation on Grids, a regulatory perspective
- ❑ Effective Regulatory Scheme
- ❑ Conclusions

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❑Context: looking for innovative companies

- Energy transition required innovation in the electricity networks

✓Energy transition required innovation in the electricity networks (IEA, 2021).

✓Historical slow rates of change of energy systems have been widely reported (e.g. Grubler, 2003; Jamasb, 2005; Mac Kinsey, 2017; IEA, 2020).

✓Therefore, we address the following question:

- **What is the most suitable regulatory model to foster investment in the new technologies that are needed to modernize the electricity networks?**

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❑Innovation on grids, regulatory perspective

- New technologies and new concepts

✓Over the past few years, various technologies have been developed to enhance the performance of the electrical sector, as well as to integrate new or already established concepts (Dileep G., 2020; Reuver M. et al, 2016; Spiliotis K. et al, 2016; Kuiken D. and Más H., 2016; Bayindir R. et al, 2016).

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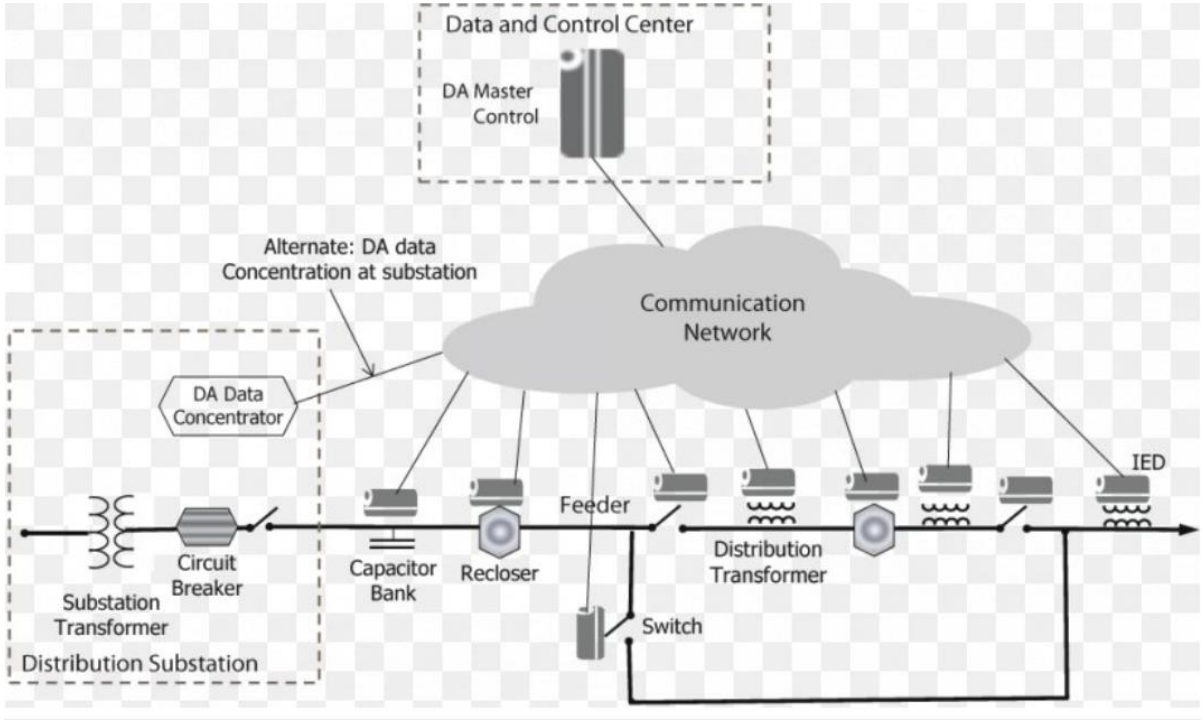
❑Innovation on grids, regulatory perspective

- Substation and Feeder Automation (SFA)



Source: https://favpng.com/png_view/distributed-generation-scada-advanced-distribution-automation-electrical-substation-schematic-dnp3-png/kcVFvBEi

✓SFA uses specific hardware and software resources to endow electrical networks with intelligence that allows a continuous monitoring, control, protection, data acquisition about network assets, and the execution of various automated actions.

✓SFA allows gathering data from different sensors and sends these data to a central computer which manages the data and controls devices in the field remotely.

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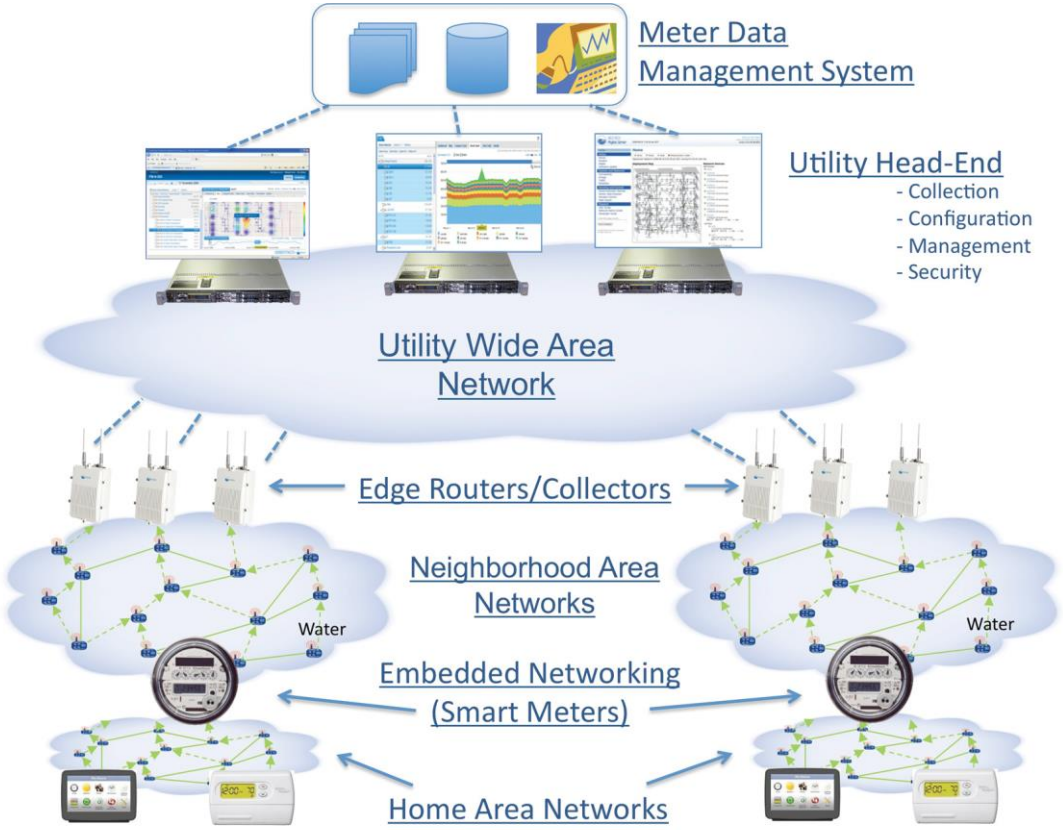
❑Innovation on grids, regulatory perspective

- Advanced metering infrastructure (AMI)



Source: https://electricenergyonline.com/energy/magazine/525/article/InternetStandards-Come-to-the-Advanced-Metering-Infrastructure.htm

✓AMI incorporates a set of features that provide an intelligent two-way connection between utilities and consumers, including the loads and the generation and storage systems installed on the consumers' side.

✓The main resources used in the AMI are the smart meters and the two-way communication platform.

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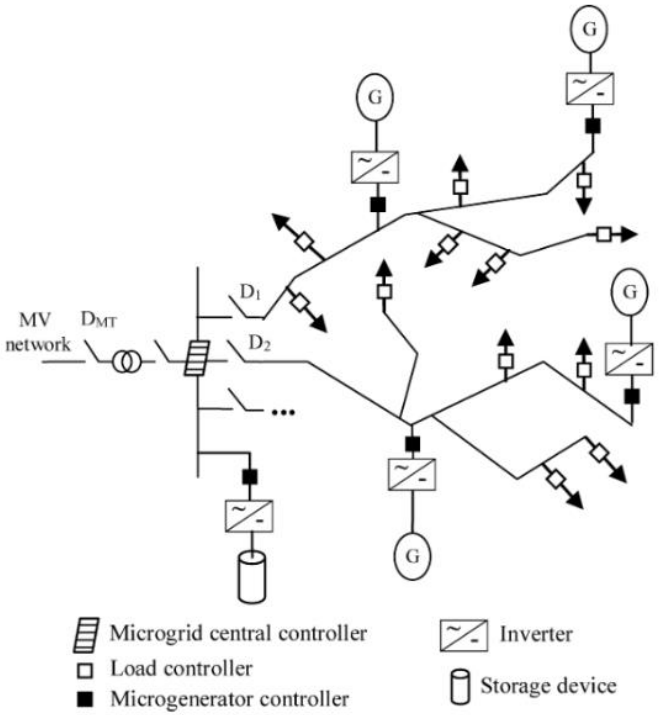
❑Innovation on grids, regulatory perspective

- µG



✓A µG is an association of a LV distribution network, microgenerators, loads and storage devices, having some local coordinated functions.
✓The concept of µG has been developed to ease the integration of microgeneration in low voltage networks.

Source: Paulo Moisés Costa, Manuel A. Matos, “Assessing the contribution of microgrids to the reliability of distribution networks”, Electric Power Systems Research, Volume 79, Issue 2,2009,Pages 382-389,
ISSN 0378-7796,

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❑Innovation on grids, regulatory perspective

- Innovative technologies and cost control

✓Two important dimensions have to be considered before defining the regulatory scheme:

- What are the impact of new technologies on network costs?
  - Assessing if cost efficiency will promote innovation.

- Will benefits go beyond the sector, ie., is there positive externalities?
  - Evaluating whether regulated network tariffs shall recover all investments costs.

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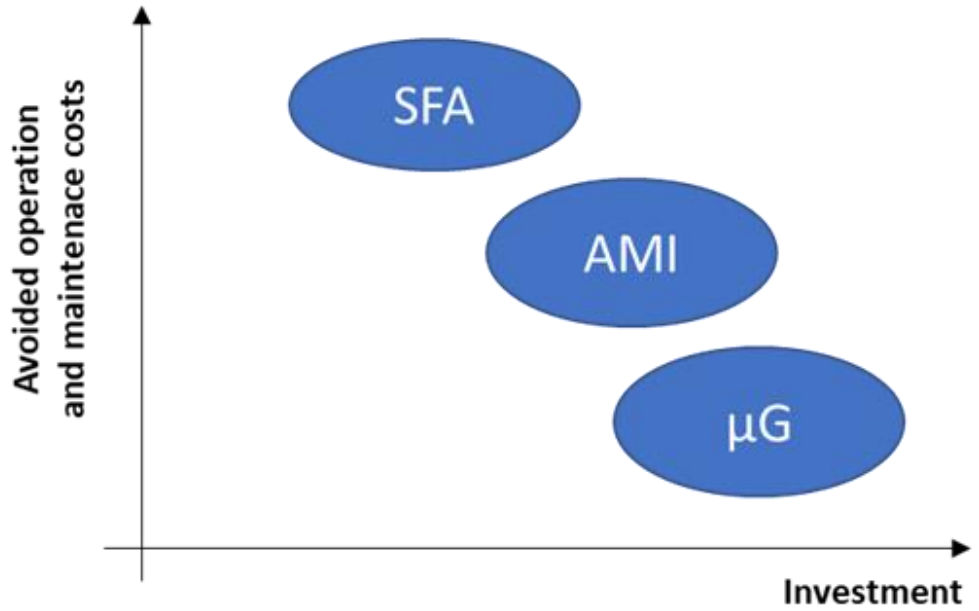
❑Innovation on grids, regulatory perspective

- Innovative technologies and cost control
  - ✓ SFA technologies allow significant operating costs decrease, while imposing a relative low investment cost when compared to the AMI and µG (microgrids) technologies:



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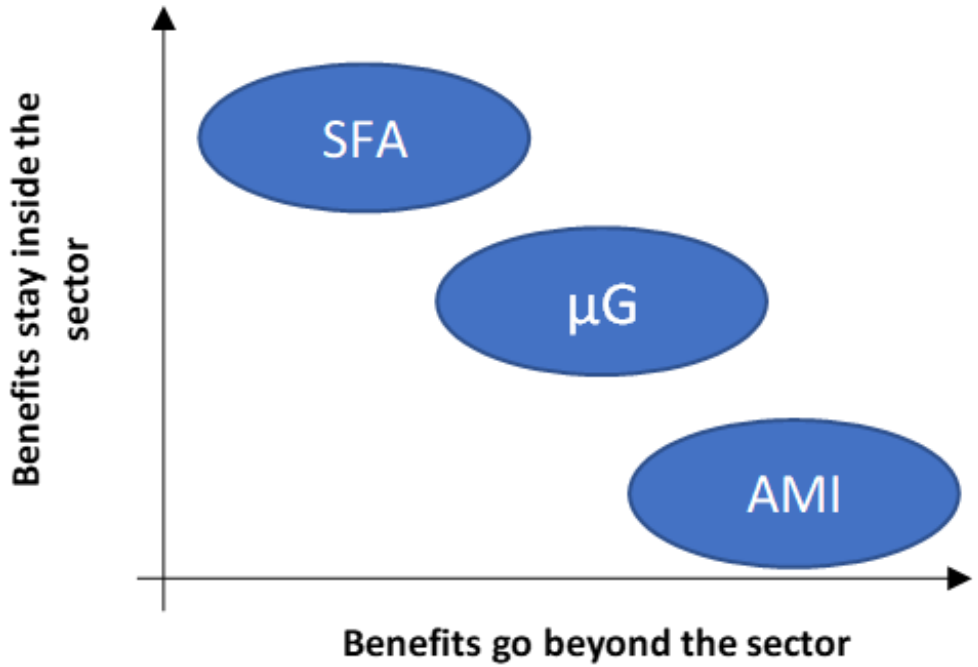
❑Innovation on grids, regulatory perspective

- Innovative technologies and externalities
  - ✓ AMI type technologies benefits spill over from the sector, in a more significant way than the SFA and µG technologies:



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❑Effective regulatory schemes

- Modelling

✓We developed a decision model that assesses the changes in the firms' incentives to invest in new technologies under different regulatory schemes.

✓The model assumes that companies maximize their expected gains by allocating their resources to OPEX, CAPEX or Innovation, under different regulatory contexts. We compare two representative regulatory settings: TOTEX and hybrid regulatory schemes.

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❑Effective regulatory schemes

- Modelling

✓The expected revenues of the regulated company that considers an incentive based approach for TOTEX are:

$$-I_{TotexSG} + \sum_{t=1}^{T} \frac{DTOTEX}{(1+r)^t} + \sum_{t=T+1}^{\infty} \frac{(1-\delta)DTOTEX}{(1+r)^t} + \sum_{t=1}^{\infty} \frac{\xi G_{Totex}}{(1+r)^t} \geq 0$$

Where:

- *T* is the next time allowed revenues review period;
- *r* is the firm's cost of capital;
- $I_{TotexSG}$ is the amount invested in innovative technology in a TOTEX regulatory scheme;
- δ is the proportion of TOTEX savings that is transferred to consumers after *T*
- $DTOTEX$ is the costs decrease in a TOTEX regulatory scheme;
- ξG_{Totex} is the proportion of external benefits due to Innovation that is retained by the company in a TOTEX regulatory scheme.

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❑Effective regulatory schemes

- Modelling

✓The expected revenues of the regulated company that considers a hybrid approach are:

$$-\mathrm{I_{SG}} + \sum_{t=1}^{T} \frac{\mathrm{DC}}{(1+\mathrm{r})^{t}} + \sum_{t=1}^{T} \frac{\mathrm{DI_C}}{(1+\mathrm{r})^{t}} + \sum_{t=T+1}^{\infty} \frac{\mathrm{r}\gamma(\mathrm{I_{SG}} - \mathrm{DI_C}) + (1-\alpha)\mathrm{DC}}{(1+\mathrm{r})^{t}} + \sum_{t=T+1}^{\infty} \frac{\xi G}{(1+\mathrm{r})^{t}} \geq 0$$

Where:

- I_{SG} is the amount invested in innovative technology;
- *DC* is the operational cost decrease (that includes depreciation);
- *DIC* is the reduction of conventional investment due to the innovative investment;
- α is the proportion of the operational costs savings that is transferred to consumers after *T*;
- γ is the proportion of the investment expenditure that is accrued on the firm's regulatory asset base after *T*.
- ξG is the proportion of external benefits due to innovation that is retained by the company.

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❑Effective regulatory schemes

- Modelling

✓Totex methodology is compared with the traditional hybrid methodology, for two situations:

- The regulator defines goals that are achieved by the company which retains parts of the benefits that goes beyond the goals:
  i. Static evaluation, the cost structure does not change
  ii. Dynamic assessment, the cost structure changes

f(C_{SG}) increases with I_{SG}, therefore $D_{f(I_{SG})} = \frac{D_{C_{SG}}}{D_{I_{SG}}} > 0$

g(C_c) decreases with I_{SG}, therefore $D_{f(I_{SG})} = \frac{D_{C_{Ic}}}{D_{I_{SG}}} < 0$

h(I_{ic}) decreases with I_{SG}, therefore $D_{h(I_{SG})} = \frac{D_{I_c}}{D_{I_{SG}}} < 0$ and h(I_{ic}) increases with I_{SG}, therefore $D_{h(I_{SG})} = \frac{D_{I_c}}{D_{I_{SG}}} > 0$

- Case study, for a situation of profit sharing between regulated company and consumers.

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❑Effective regulatory schemes

- Results

✓The regulator defines goals that are achieved by the company which retains the benefits that goes beyond the goals (Static and dynamic evaluation):

- If an investment in SG decreases network investment costs, then the best option is to apply a TOTEX methodology.
- If an investment in SG does not decrease network investment costs, but brings benefits that are higher than the costs they produce in the network, then a hybrid regulatory scheme is more appropriate.
  - However, if the benefits go beyond the network activity, it has to be weighed if only part of the cost (in proportion to the benefit that stay in this activity) should be recovered through tariffs.

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❑Effective regulatory schemes

- Results

✓Case study, for a situation of profit sharing between regulated companies and consumers

- We assume a typical case that is quite representative of the cost structure of network activities, where CAPEX has typically a biggest relative weighting than OPEX and regulator is more demanding (in terms of cost control) for OPEX than for CAPEX:

  - Totex is also more beneficial, as long as investment in SG globally decreases the need to invest.

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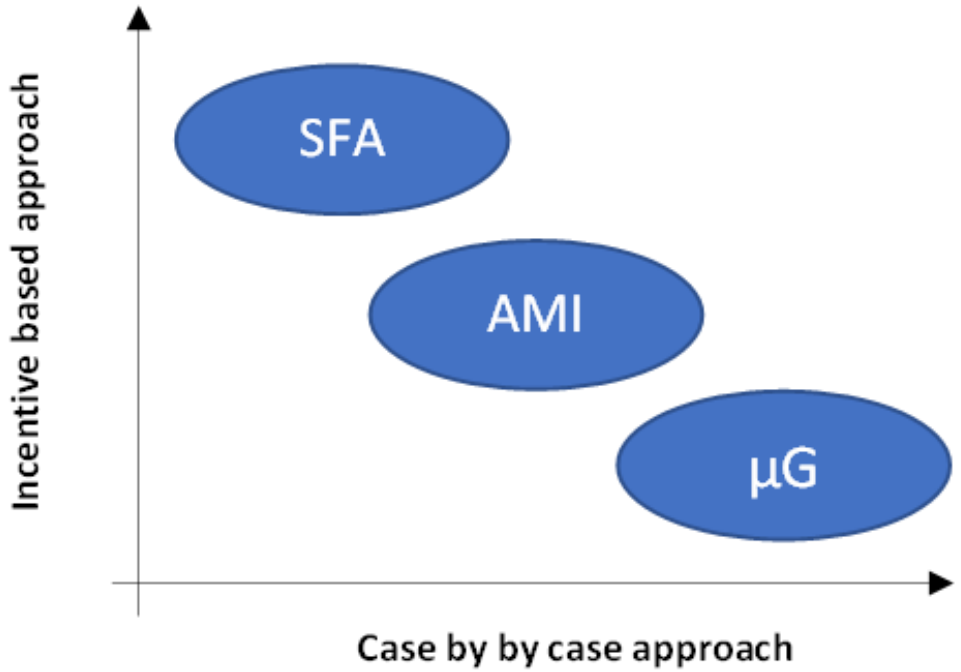
❑Conclusions

- Effective regulatory approach
  - ✓ Incentive based regulation, in particular TOTEX, will be more effective in promoting SFA-type technologies, while a case-by-case analysis will be more appropriate for µG's technologies. AMI technologies lie on the middle:



Thank you!

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