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King Abdullah Petroleum Studies and Research Center

Using Insurance to Manage Reliability in a Distributed Electricity sector: Insights from an ABM

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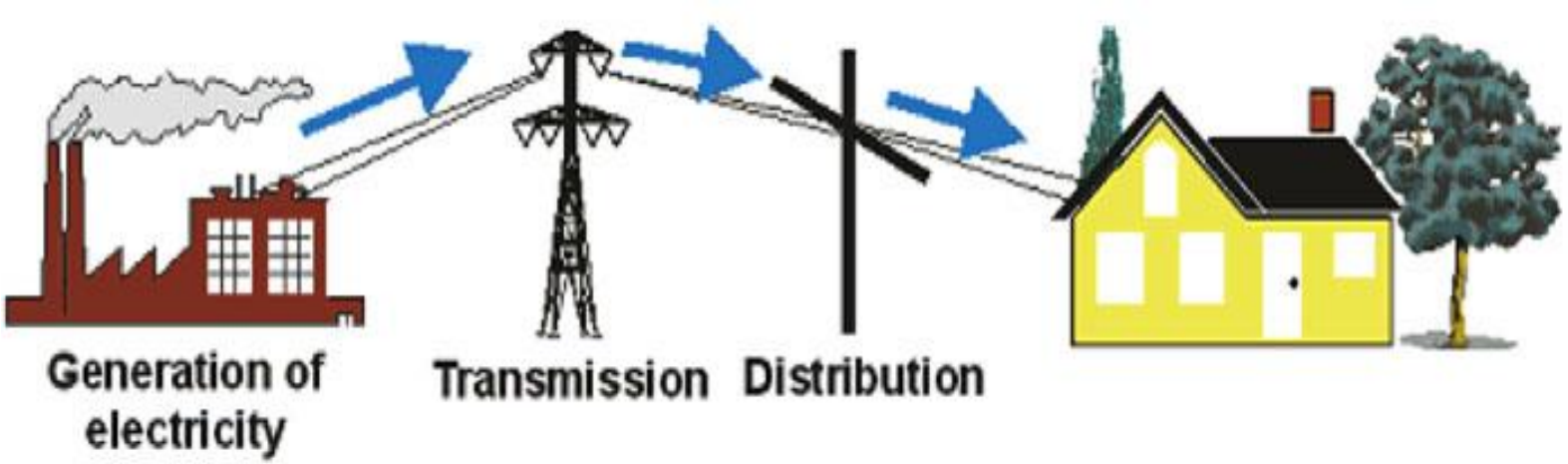
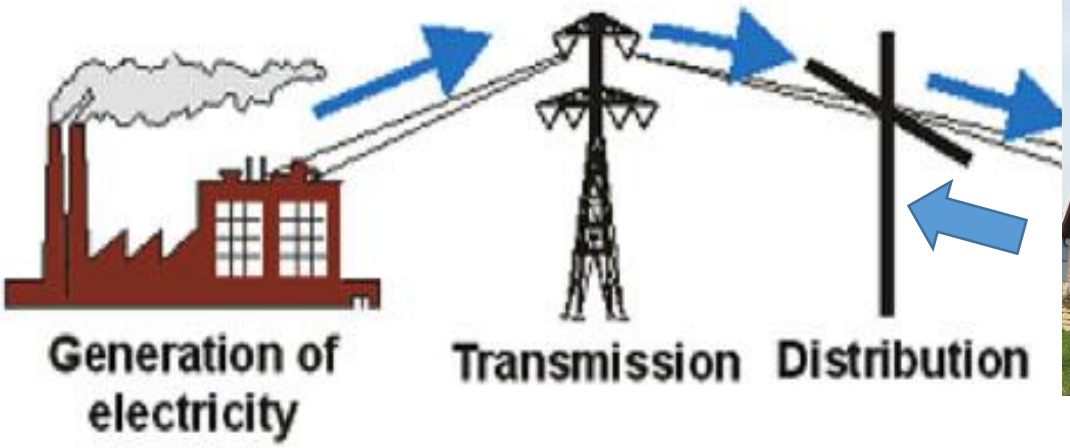
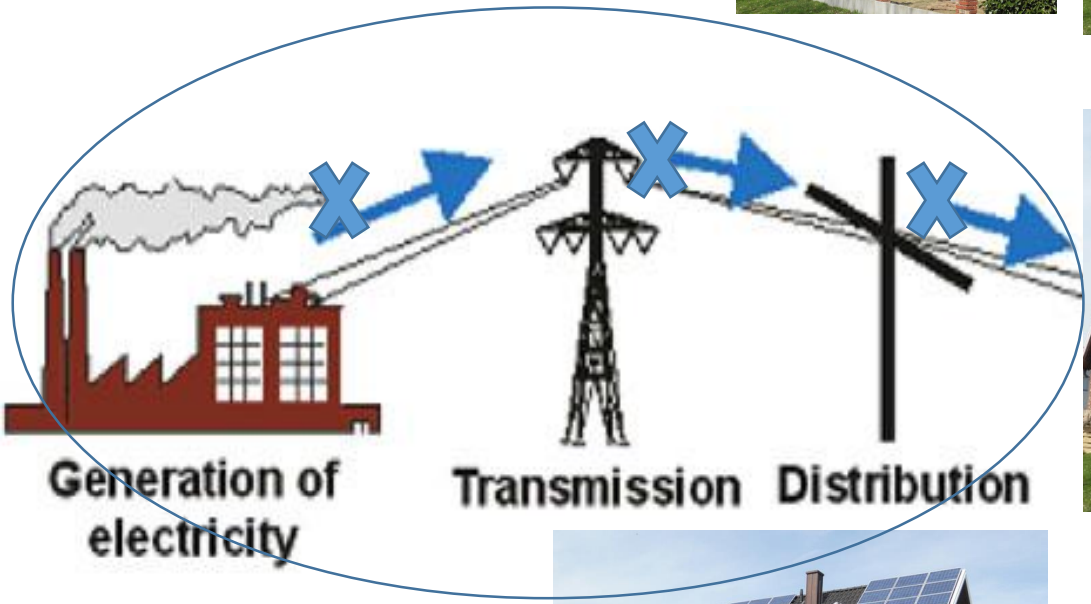
This is the power sector as we know it



This is a more accurate picture of the power sector today



Now, imagine the event in which there is a rapid deployment of DERs



Research design

- DERs penetration raise questions about the very nature of the electric power industry What ultimately are its products? How should it price them? What business models should the industry be developing? (OEF, 104).

Problem

- In the most extreme case, consumers would produce all the power their home need and store it until the time of consumption, effectively by-passing the utility.
- The issue of reliability for self-sufficient households would still remain. A pay as you go system would not reflect opportunity costs of new idle capacity.
- Traditional tariffs are inadequate in case of mass grid defection and in the presence of technologies where customers can best reflect their preferences

Our solution

- We test the creation of an energy insurance market that enables household's preferences for risks (from self-sufficiency) to be internalized and yet allow utilities to continue operating in the market using an alternative business model.

What we propose

In a nutshell

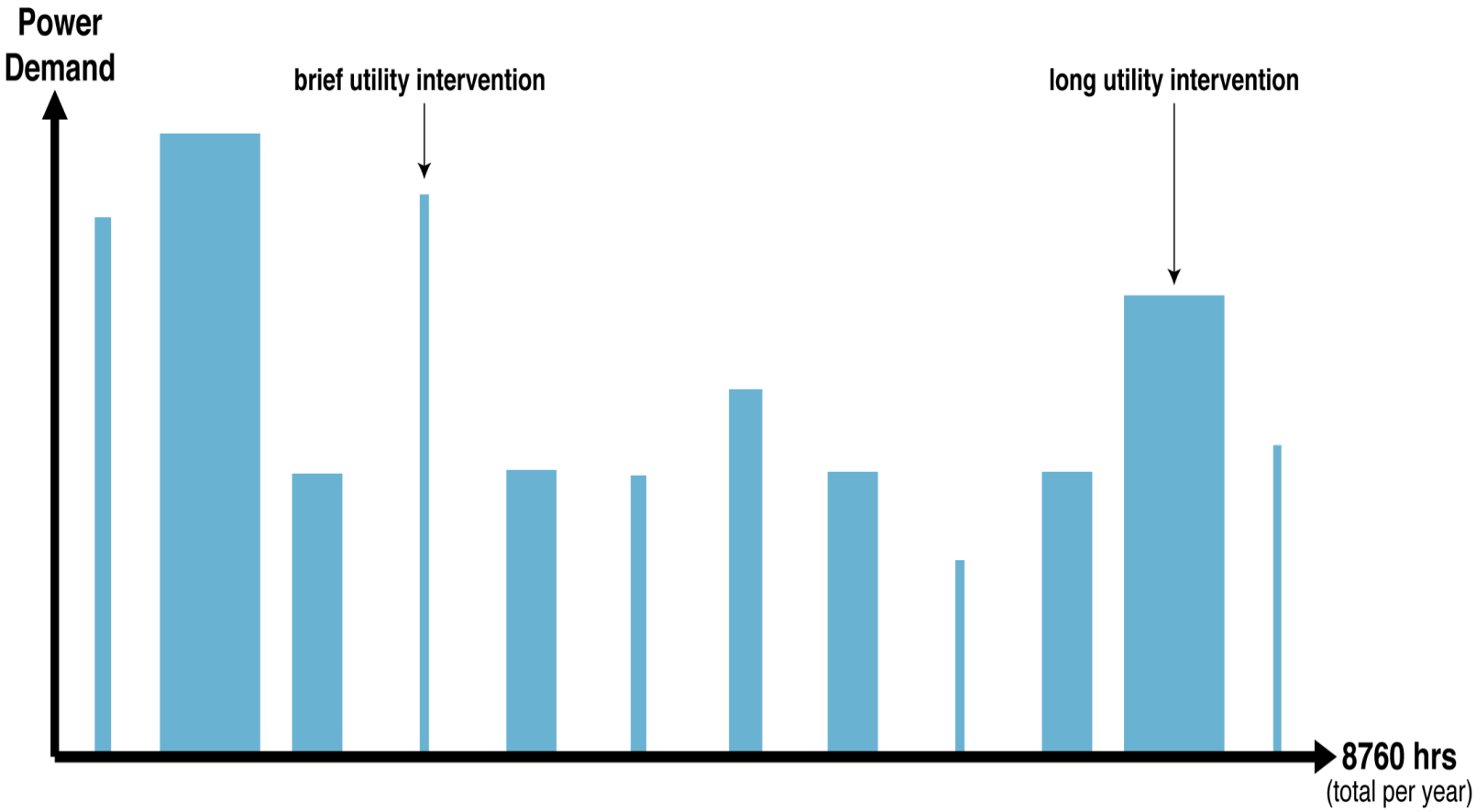
Utility offers an insurance to energy self-sufficient households

Features

- Insurance exists in order to reduce or eliminate the cost to an individual who faces an adverse event (like the loss of power) for a price.
- Utilities' idle generation capacity, increased as a result of DER adoption, is repackaged and repriced as insurance. Asset transformation (Helms, 2016).
- Utilities would charge a fixed fee that would guarantee utilities a more stable revenue stream instead of relying on dynamic pricing, levying high prices during abrupt demand surges.
- Instead of selling commoditized kilowatt-hours (kWh), utilities would sell guaranteed services.

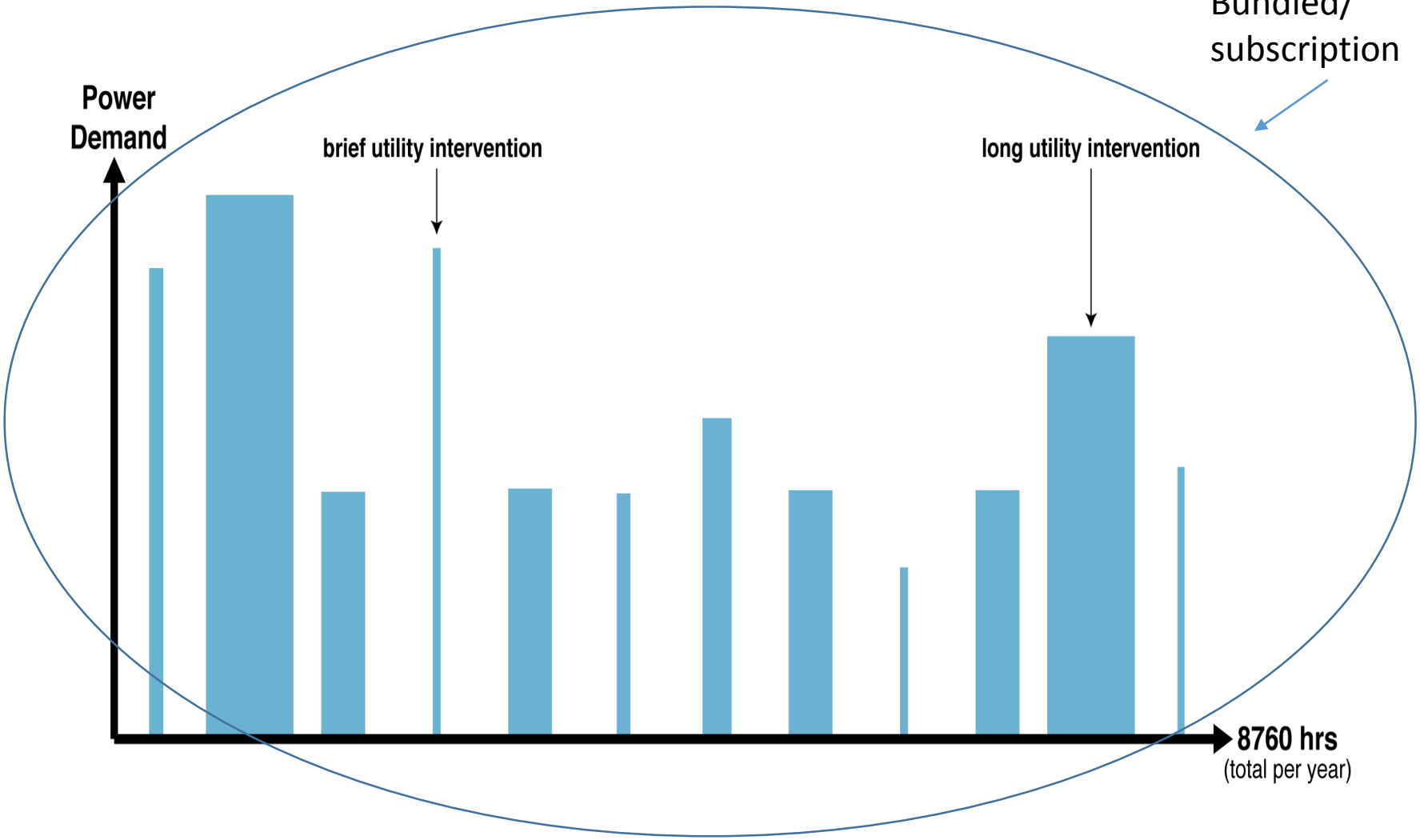
Revenue model for the electricity firm (1)

Stylized demand for power from the Utility for a self sufficient household



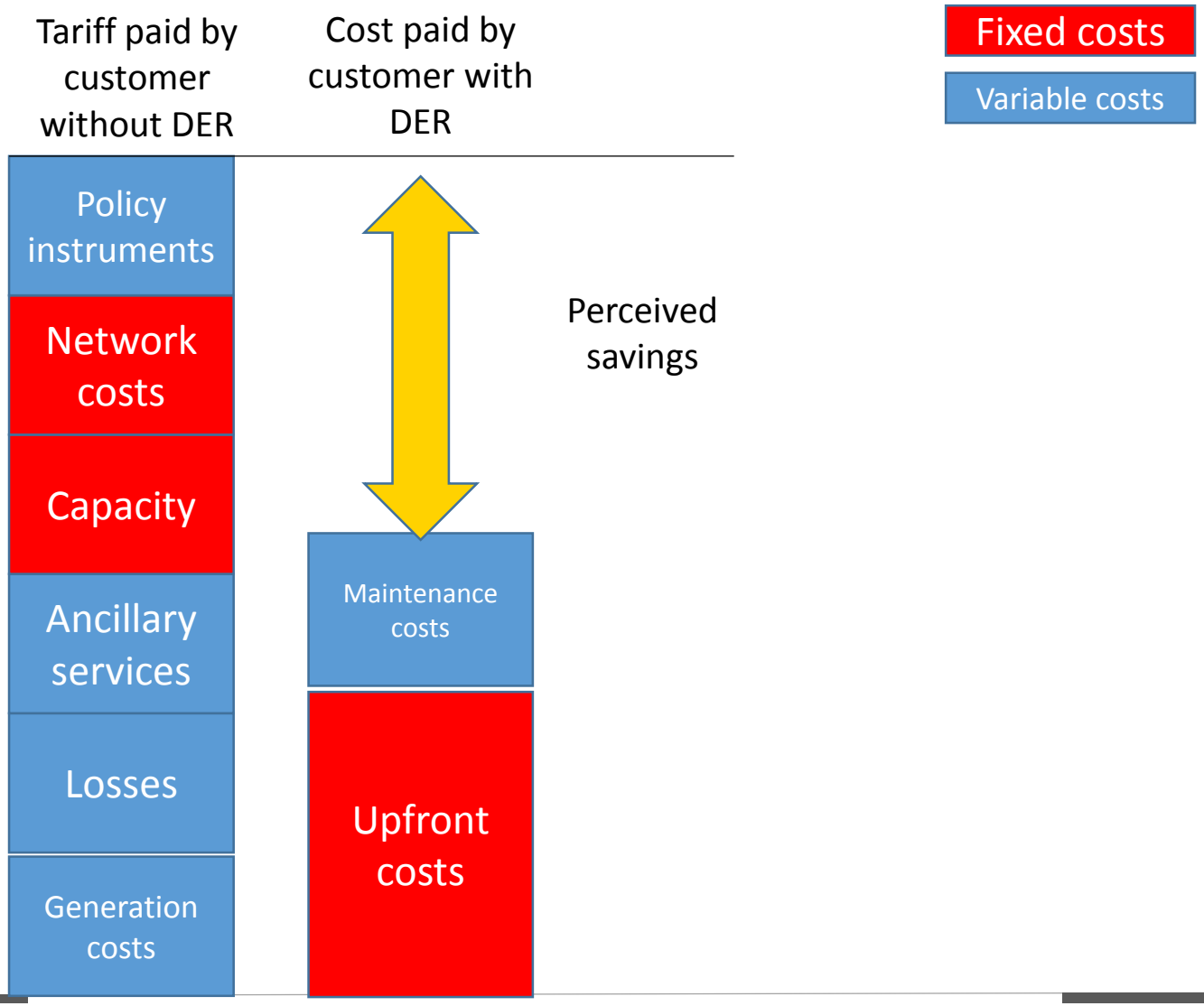
Revenue model for the utility (2)

Stylized demand for power from the Utility for a self sufficient household



Changes from a tariff perspective (1)

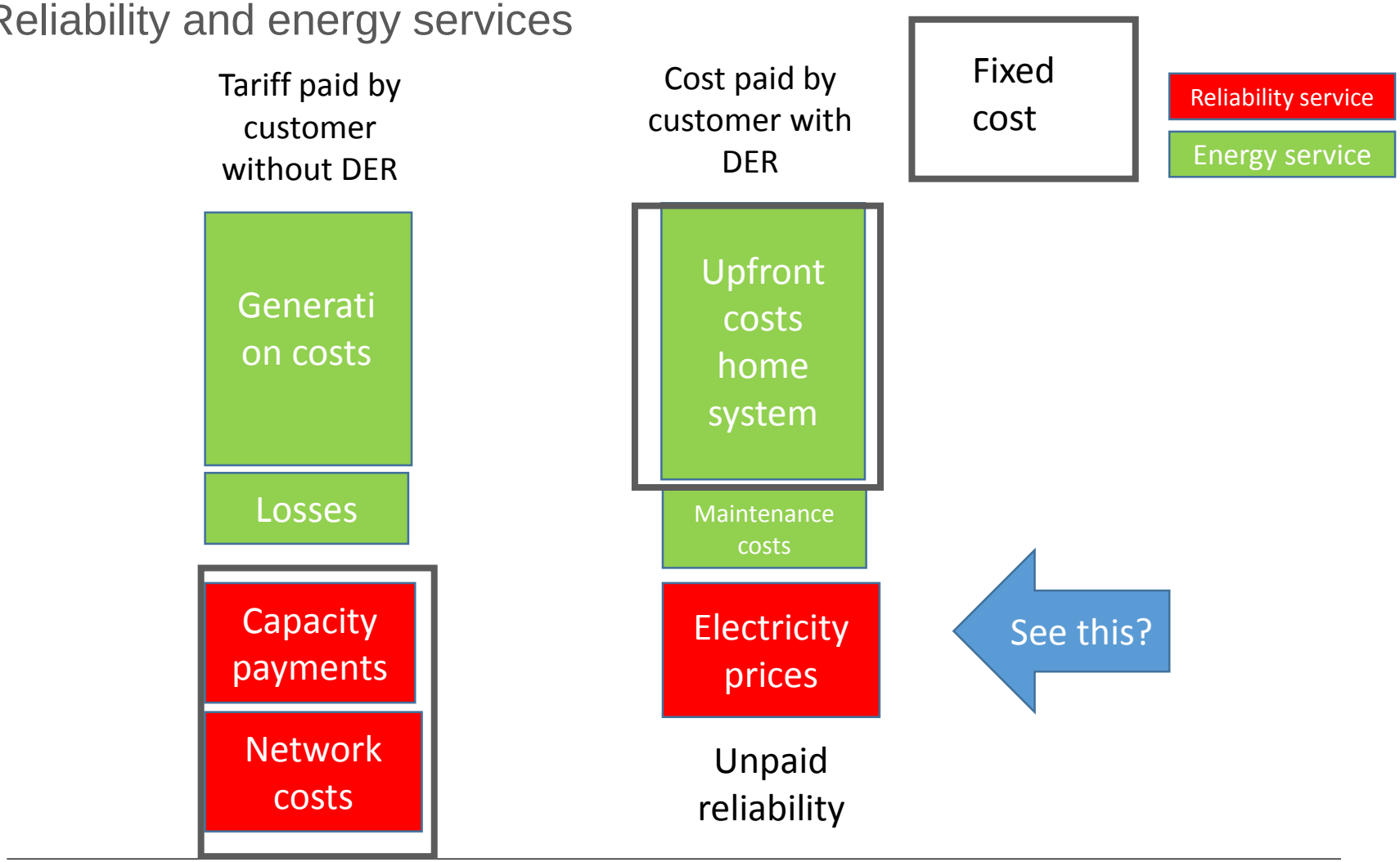
Tariff structure/ value chain based on costs



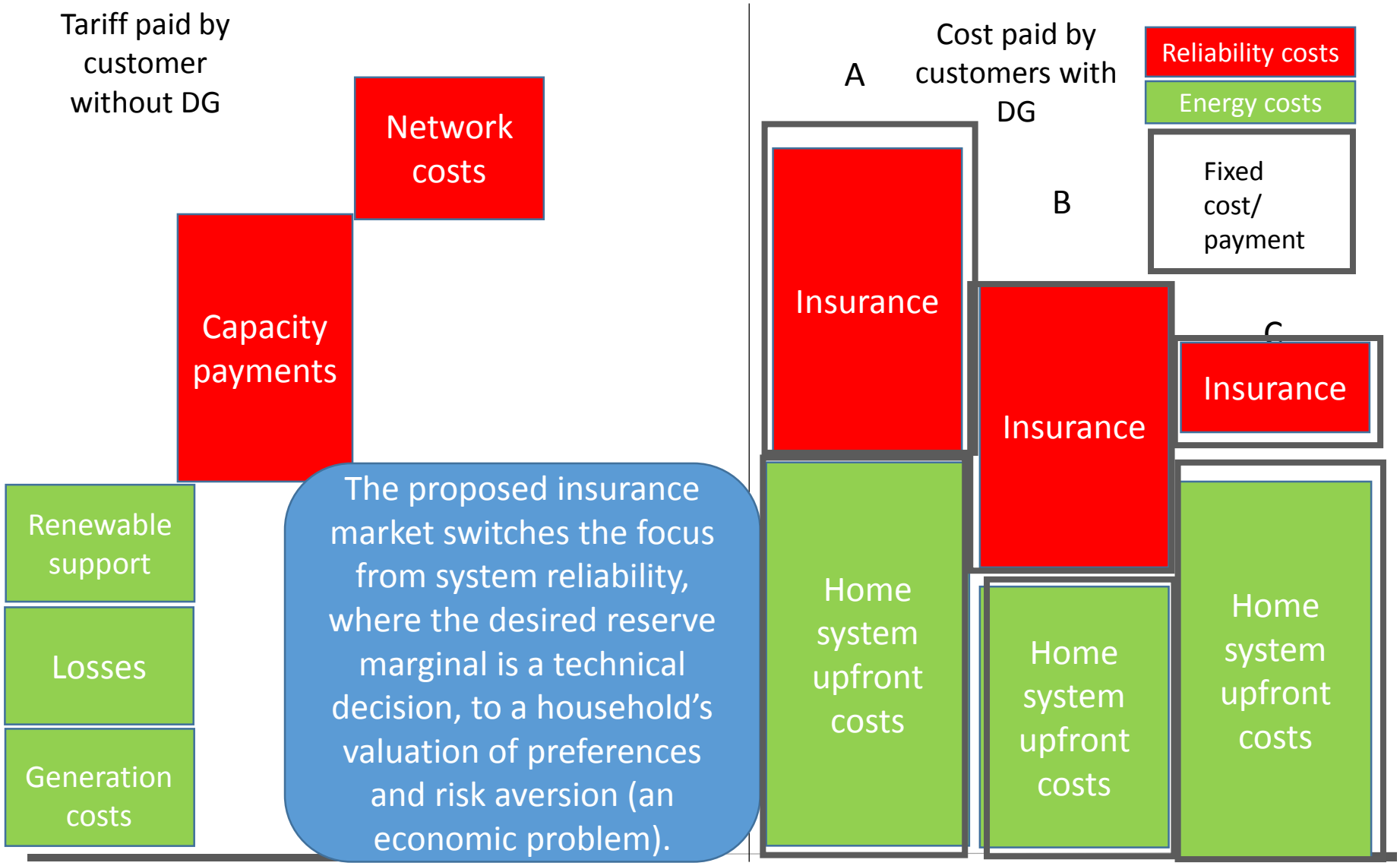
**Adapted from NERA

Changes from a tariff perspective (2)

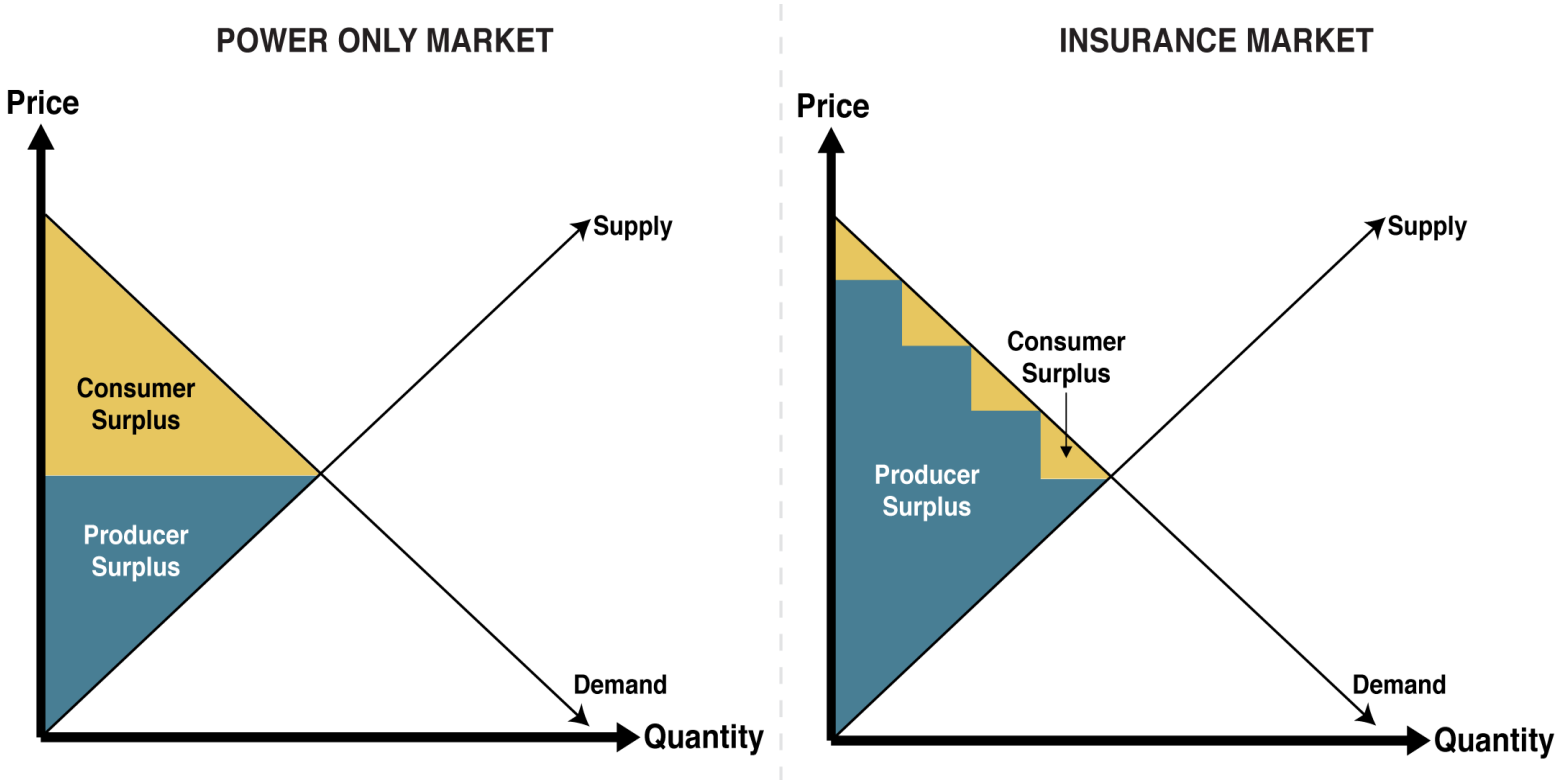
Reliability and energy services



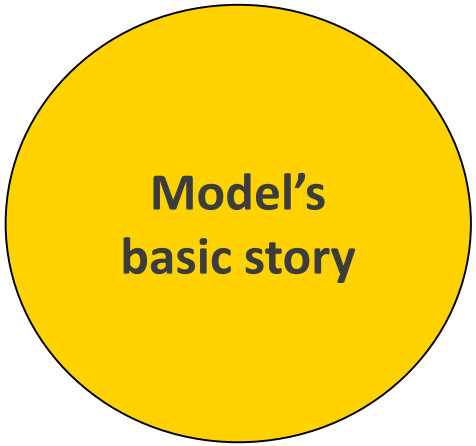
System vs individual, energy vs reliability, fixed vs variable



Changes from a market perspective



Formalizing some assumptions in an conceptual Agent Based Model



Set up

A. Each household agent is characterized for its risk aversion, expected losses, budget and a probability of distribution.

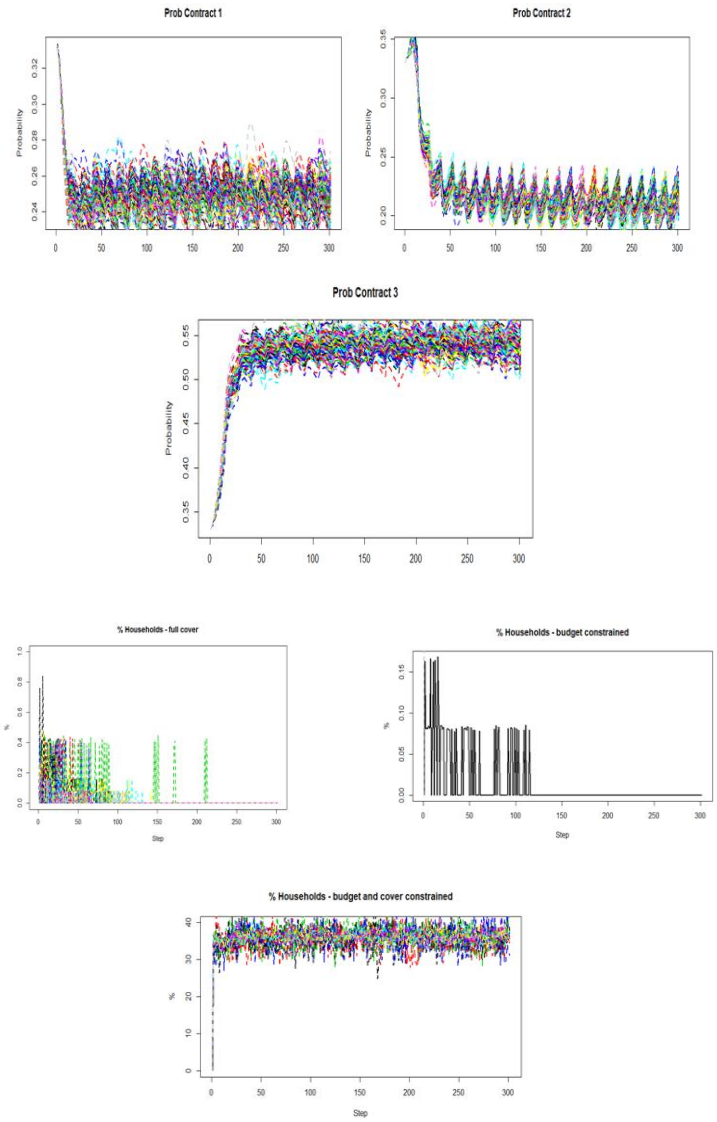
B. The supplier provides a menu of three alternative contracts for households to select from. Each contract bundles combinations of prices and loss coverage.

C. A household at t=0, starts with an even probability distribution (0.33, 0.33, 0.33)

Dynamics

1. At t=0 Household selects one contract and they are contractually bound to it for τ periods
2. During τ periods a household may face a random loss of energy, which may or may not be covered in full.
3. "Mistakes" are recorded: not the "right" contract for me.
4. After every τ periods, the supplier has the option of modifying the offerings and households of updating their choice. Updates in probability of distribution, unit prices (increase or decrease)
5. These set of contracts and choices, once again remain fixed for the next 300 periods.

Formalizing some assumptions in a conceptual Agent Based Model



Results

- We find that a stable market can exist, where prices converge to a long run equilibrium, and the distribution of choices made by households become stationary.
- Our results suggest that the creation of this market improves welfare as consumers transfer some of the inherent risk to the utility.

If you are interested

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From vertical to horizontal unbundling: A downstream electricity reliability insurance business model

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ABSTRACT

Distributed energy resource technologies (DERs) allow consumers to generate, trade, reduce, and shift their electricity consumption, largely bypassing traditional utilities. DERs can reduce consumer reliance on the grid, and in the most extreme scenario self-sufficient consumers could disconnect from the grid and avoid all external charges. However, since most DERs delivers energy, but not reliable capacity, it would be in the interests of most of these consumers to stay connected to the networks, in the event their system fails. Such a 'pay as you go' price scheme would not reflect the opportunity cost of electricity firms' sudden idle infrastructure though.

This paper proposes a market mechanism that can ameliorate these distortions. We flesh out a solution based on the creation of a market of risk, enabled by a reassignment of property rights, where utilities trade reliability insurance services to households to protect them against the failure of their own DER system. Creating such an insurance market would allow customers to reflect their preference for reliability and pay accordingly.

1. Introduction

The fundamental structure of energy electricity firms and their relationship with consumers have remained unchanged for a long time, even with the introduction of reforms to liberalize markets and the transfer from public to private ownership. However, the emergence of new distributed energy technologies (DERs) (a combination of solar panels, batteries and information technologies) can, in all probability, reduce the use of and reliance on centralized generators and the grid, the bedrock of vertically integrated and competitive markets alike.

DERs enable consumers to generate and trade their electricity, and to reduce and shift their electricity consumption, giving them the potential to become, to a large extent, electricity independent. This shift would reduce incumbent electricity firms' output, revenue and profits. DERs consequently raise questions about the very nature of the electric power industry: What ultimately are its products? How should it price them? What business models should the industry be developing? (OEF, 2016).

This paper therefore examines the current organization of the electric power industry and the concern that it could be impacted by the rapid and substantial deployment of DERs. This scenario could significantly increase the number of electricity independent households. In the most extreme scenario, self-sufficient consumers could potentially disconnect from the grid altogether and avoid all external charges. However, since most DERs delivers energy, but not reliable capacity, it would be in the interests of most of these consumers to stay connected to the networks, in the event their system fails. Such a 'pay as you go' price scheme would not reflect the opportunity cost of electricity firms' sudden idle infrastructure though. Also, a massive and fast deployment of DERs in the domestic sector would also imply, for instance, an immediate redundancy of generation and network capacity as customers in the domestic sector would informally take over the 'formal' sector (a concept developed by Cohen and Sundararajan (2015) with implications like the emergence of sharing economy firms). Such shifts would result in redundancy of capacity -in one extreme a duplication- and by definition, a "de-optimization" of the electricity system.

The paper propose a market solution to ameliorate these distortions. We propose that the incumbent electricity can repackage and reprice as a reliability insurance their idle assets that result from sudden DERs installations; instead of selling commoditized kilowatt-hours (kWh), electricity firms would sell guaranteed services. This insurance would offer a last resort service to energy self-sufficient households to protect them against the prospect of a blackout. This product would reduce both price and volume risks firms face in exchange of charging fixed fees that guarantees them a stable revenue stream, instead of relying on dynamic pricing in which they levy high prices during abrupt demand surges.

Creating an insurance market could limit the potential 'revenue

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