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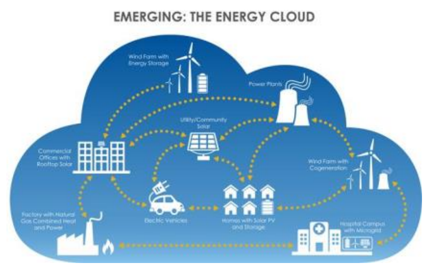
The Benefits and Costs of *Smart Grid Enabled* Demand Side Management

Interim Results from Pacific Northwest Smart Grid Regional Business Case (RBC)



IEPPEC, Berlin

9 September, 2014

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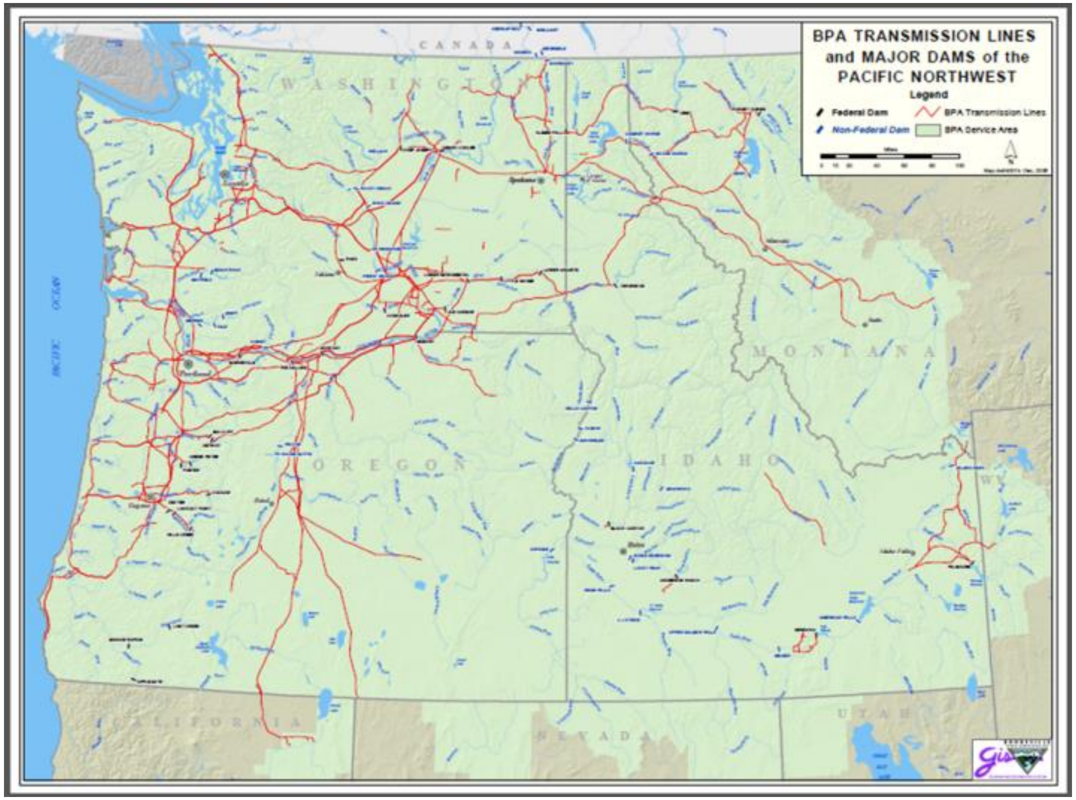
Scope of the Analysis

- **Region:** Pacific Northwest
- **Time horizon:** 30 years forward looking
- **Smart Grid Definition**
  - capabilities use two-way communications, and
  - some level of *automated intelligence*
- **Six investment categories are considered**
  - **EE and DR represent 2** of the 6 categories
  - 32 individual smart grid functional capabilities



- **Benefits and Costs are *Incremental*** to "traditional" approaches and investment (uncertainty analysis is integrated in the model)
- **The analysis work has been ongoing for the past 4 years**

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Location of Region within North America

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Motivation for the Study

Bonneville Power Administration (BPA) commissioned this work* to:

- Understand the ***potential*** for smart grid benefits
- Understand the ***risks*** for regional stakeholders
- Assist Regional stakeholders by providing information to help make ***appropriate investments*** in smart technologies.

BPA is a Federal (U.S. Government) Power Agency

- Operates ¾ of the transmission (100kV+) in the Region, and
- 2/3 of the generation (including hydro system and nuclear)
- Is chartered as "a steward" of the Region's resources

Regionally

- Approximately 6M electric power customers in the region
- Approx. 60,000 MW peak regional capacity, winter peaking

* A white paper with extensive detail is available on the Bonneville Power Administration website at: http://www.bpa.gov/Projects/Initiatives/SmartGrid/Pages/default.aspx

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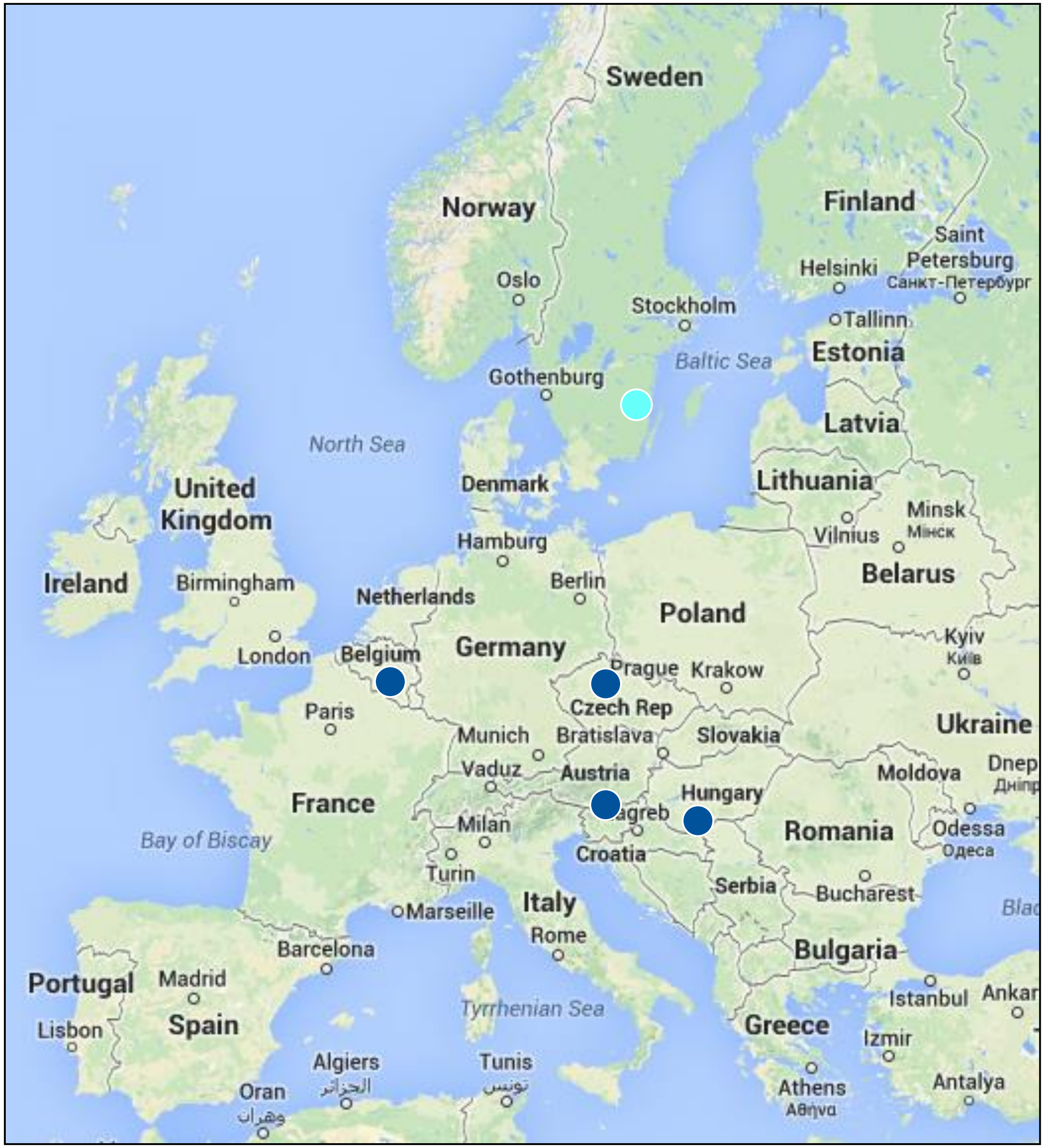
Region Comparison to Selected European Countries

- Similar number of connected customers (near 6M)
- Generally lower consumption and peak demand (1/2 to 1/3)
- Sweden with similar consumption, but only about half peak demand
- End-use consumption profiles, technologies, and approaches are different



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Comparison of Regional Electricity System Characteristics

Country/Geography	Number of DSOs 2011	Number of DSOs with > 100,000 customers	Total Number of Connected Customers	TWh/yr (2010)	MW Peak (2010)
Pacific Northwest (U.S.)*	141	10	6,365,036	161,000,000	60,657
Austria	138	13	5,870,000	65,000,000	21,400
Belgium	24	15	5,243,796	90,000,000	18,322
Czech Republic	3	3	5,837,119	64,000,000	20,073
Denmark	72	6	3,277,000	35,000,000	13,420
France	160**	5	33,999,393	513,000,000	123,783
Germany	880	75	49,294,962	565,000,000	166,329
Greece	2	1	8,195,725	59,000,000	16,729
Hungary	6	6	5,527,463	40,000,000	8,753
Ireland	1	1	2,237,232	25,000,000	8,495
Italy	144	2	31,423,623	331,000,000	106,489
Netherlands	11	8	8,110,000	117,000,000	26,636
Poland	184	5	16,478,000	142,000,000	32,832
Portugal	13	3	6,137,611	55,000,000	18,797
Spain	350**	5	27,786,798	278,000,000	98,837
Sweden	173	6	5,309,000	147,000,000	35,701
United Kingdom	7	7	30,828,266	366,000,000	93,146
Total EU	1839	195	263,370,337	3,276,000,000	907,406

* Source for numbers for Pacific Northwest is U.S. EIA, and all numbers are from 2011

**Source: Eclareon and Oko-Institut (2012), Integration of electricity from renewables to the electricity grid and to the electricity market

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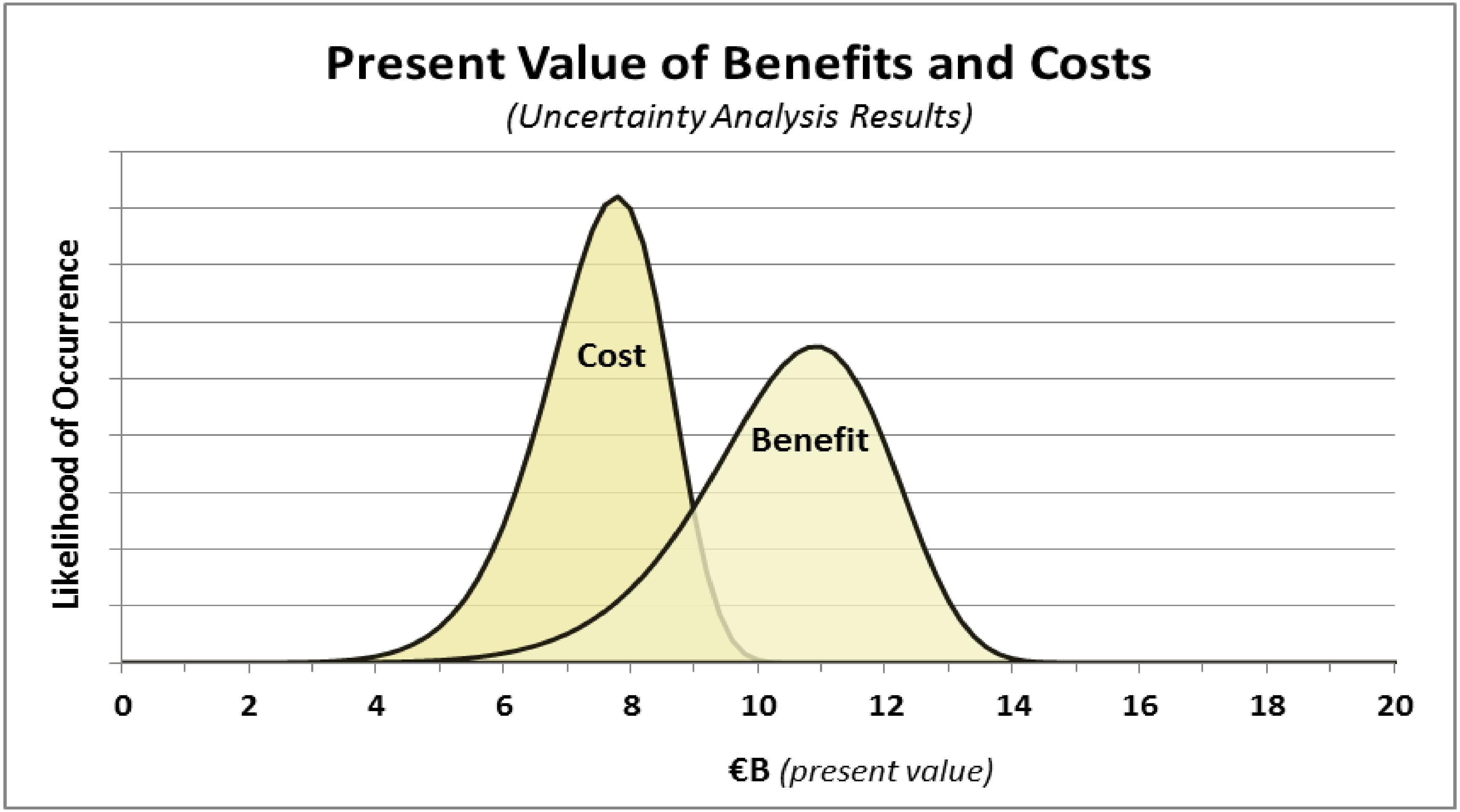
Smart Grid investment looks attractive overall (including all 6 major investment categories)



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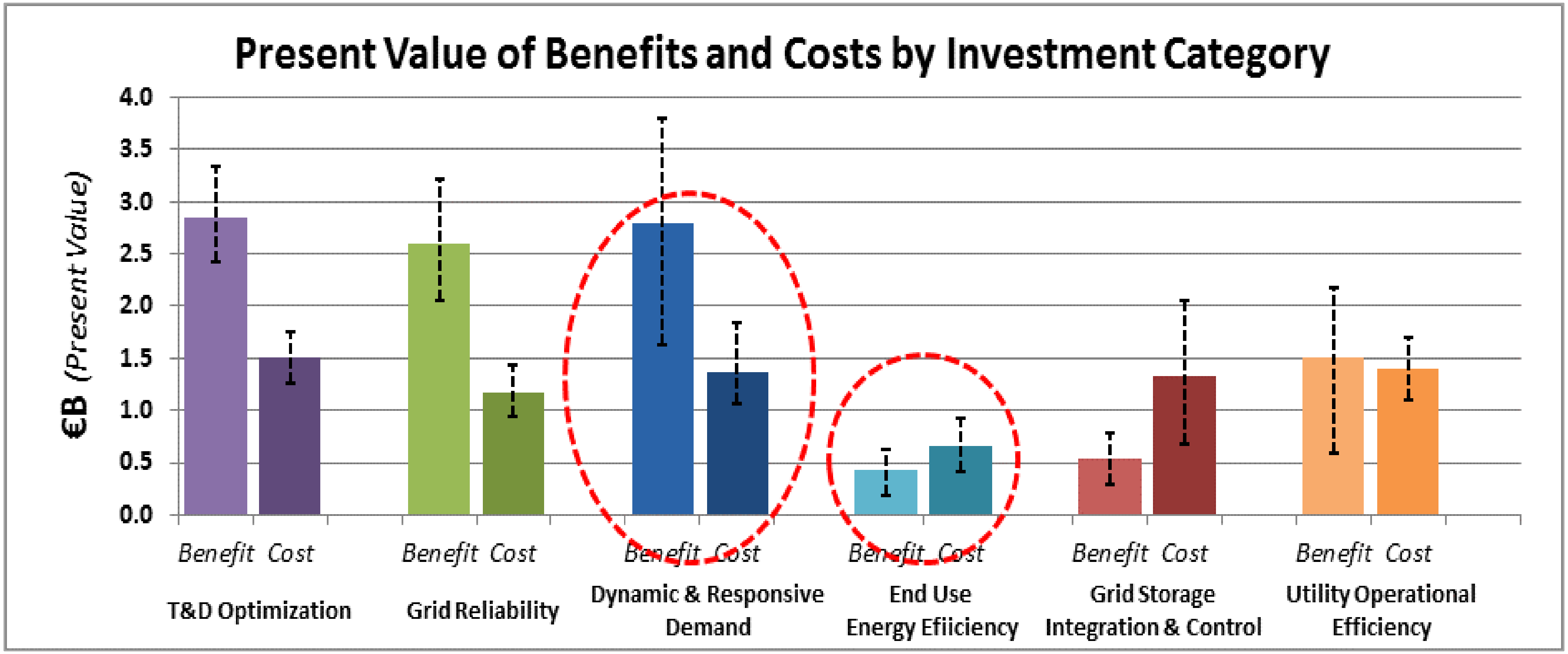
Six Investment Categories Show Different Returns and Risks



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Smart Grid Capabilities for End-Use Energy Efficiency

- ***Smart*** **end-use** Energy Efficiency (EE) encompasses enhancements beyond traditional EE measures that require smart grid functionality
- Capabilities that might reduce energy consumed by customers include:
  - Enhanced information feedback, and techniques to facilitate consumer behavior change
  - Capabilities for automated energy management
  - Identification of poorly performing equipment as candidates for replacement or maintenance
    - Equipment upgrades and improved maintenance for efficiency purposes
- Note that this analysis does not address the cost effectiveness of *traditional* end-use energy efficiency measures, and only addresses end-use efficiency to the degree it is impacted by smart grid functionality.

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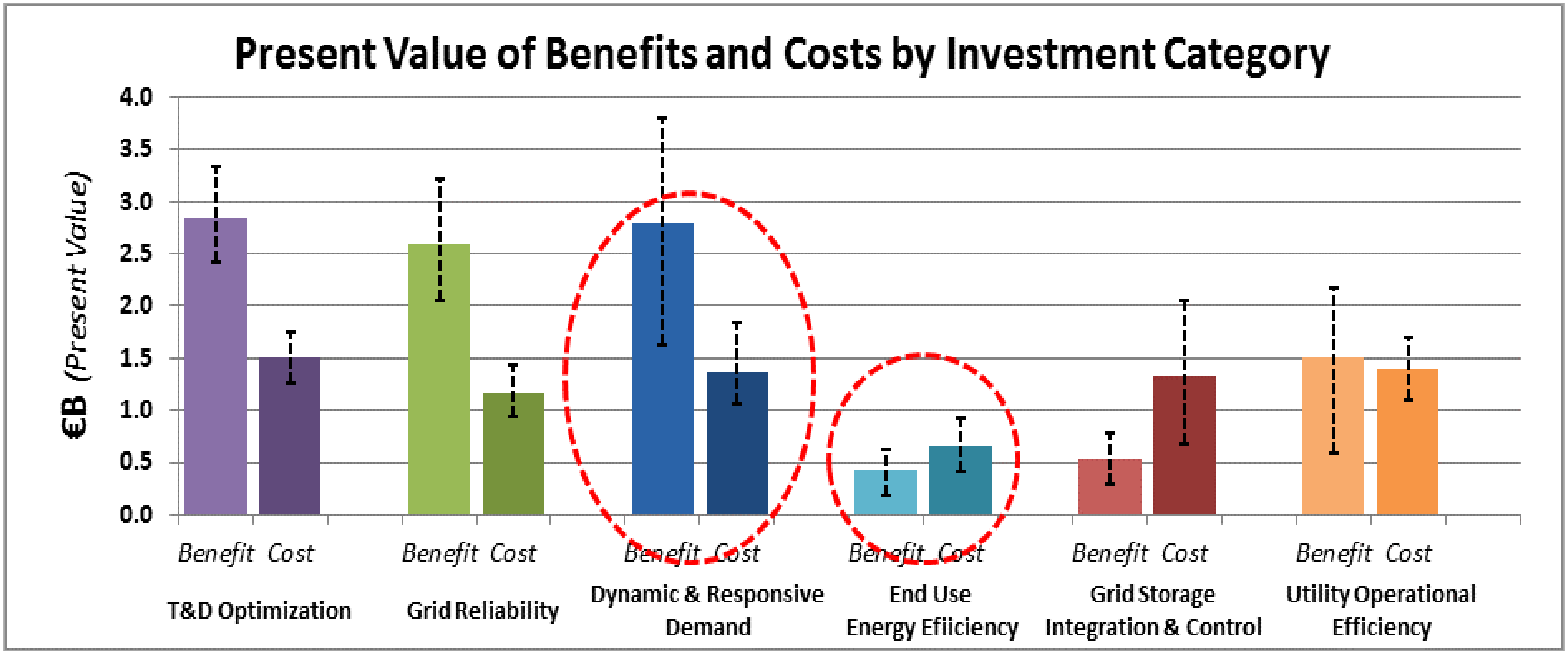
Initial Findings for End-Use Energy Efficiency Investment Area

- **Lighting**—smart grid does not add much benefit for the cost
  - "traditional" lighting efficiency measures don't leave much room for smart grid--examples:
    - Changing out lights for FCLs or LEDs is not a smart grid activity
    - day-lighting and occupancy sensors and controls can achieve additional savings, but also don't require smart grid
- **Information feedback** and behavior change can be implemented without SG
  - Again, non smart-grid measures create challenging *baseline* for SG—example:
    - Home Energy Reports (HERs) have been fairly successful without smart grid capabilities
- **Equipment replacement and maintenance** is farther in the future
  - Holds promise, but affects are estimated to be many years in future, greatly reducing NPV in analysis
  - May eventually be able to leverage smart grid infrastructure "for free" if installed for other reasons
- **Non-end use efficiency** (e.g., conservation voltage reduction)
  - Analysis indicates that by far the largest potential EE application for smart grid is Conservation Voltage Reduction (CVR) and related voltage optimisation approaches
  - However, it has it's own challenges from a structural perspective

End-Use Energy Efficiency Looks Quite Limited



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Smart Grid Capabilities for Demand Response

- Many forms of DR are possible without smart grid, and have been feasible for decades.
  - However, smart grid can bring important benefits to DR programs that traditional DR mechanisms cannot provide
  - These require more advanced communication and control capabilities.
- To capture the incremental benefits of smart DR, the study applied a breakout:
  - by seven end-use categories,
  - four customer sectors, and
  - three degrees of intelligence (curtailment events, real-time pricing, and fast-acting ancillary services). Generally
- The Analysis considered the administrative overhead, operations, engineering, contracting, and other labor costs associated with establishing and maintaining the different types of DR asset systems.
- In general, DR is more attractive from a cost-benefit perspective when the load per control point is high.

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Regional Smart DR Deployment Assumptions

Smart DR End Use	Final Market Penetration (% of end use load)	Years to Reach Assumed Final Penetration (yrs)
Space Heating	10%	12
Space Cooling	8%	12
Lighting	3%	12
Appliances & Plug Loads	5%	12
Water Heating	10%	12
Industrial Process & Refrigeration	10%	12
Agricultural Irrigation	20%	12

- Deployment assumptions leveraged many information sources about DR that has been deployed in the region already
- The assumptions about future deployment were vetted by Regional subject matter experts (SMEs)

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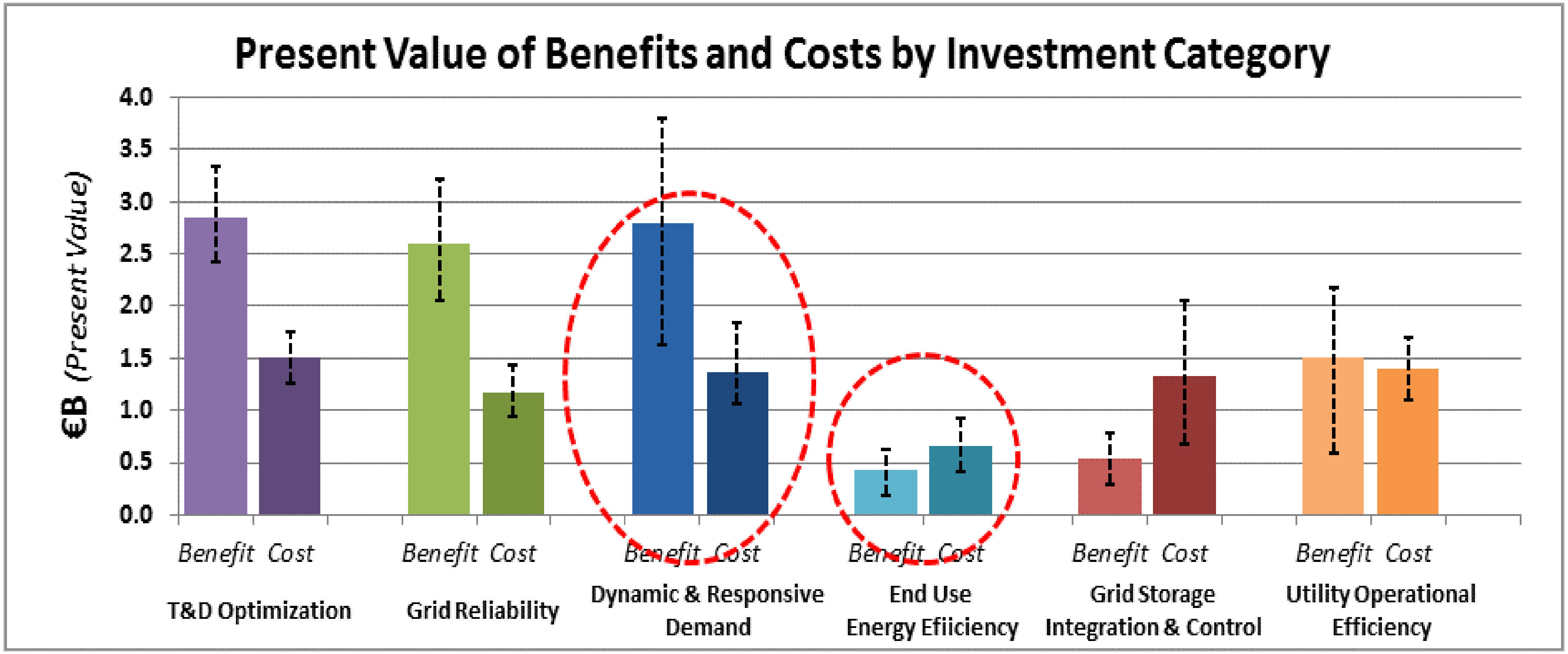
Dynamic and Responsive Demand Looks Quite Good



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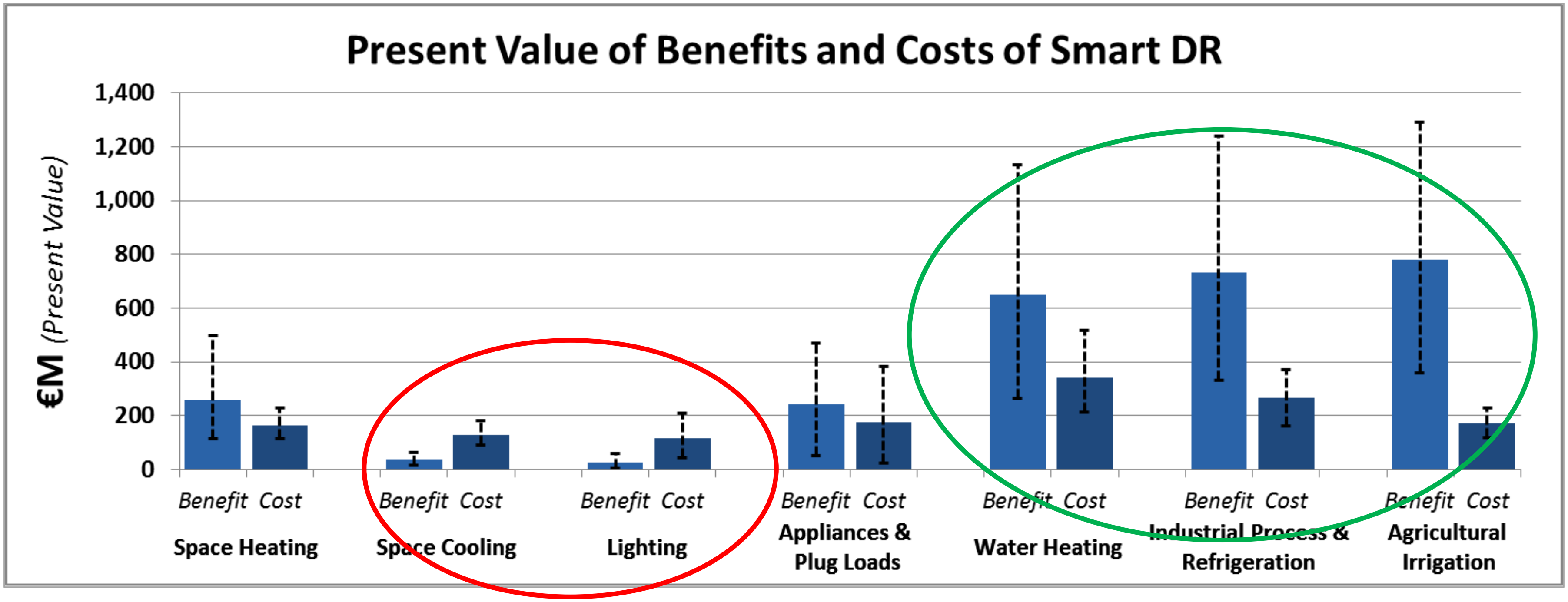
Smart DR Investment Returns Vary Widely by Target End-Use



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The RBC Process: Takeaways and Looking Forward

- **Plans for continuing this analysis**
  - White paper analysis to be updated in 2015
  - Regional inputs and assumptions will be updated prior to analysis
  - Inputs will be finalized from the Pacific Northwest Regional Smart Grid Demonstration Project – the largest federally funded Demonstration Project in the U.S.
- **This analysis methodology and model is being used in other jurisdictions**
  - Smart Grid Great Britain is sponsoring a smart grid benefit cost analysis of U.K. Plc.
  - Ministry of Energy in Ontario Canada has commissioned an analysis for that Province.
- **Navigant is re-engineering the Regional Resource Planning Model (RPM) focused on integrated Regional planning for DSM and generation.**
  - Working with another Regional Planning entity, the Northwest Power and Conservation Council
  - Leveraging the same modeling platform (Analytica)
  - Navigant is working on developing a Demand Response supply curve for the region, that will eventually be used in the RPM.

Key
CONTACTS

Erik Gilbert
Director
Boulder, CO, U.S.A.
(303) 728-2536
erik.gilbert@navigant.com

Ian Smyth
Managing Director
London, England
(207) 469-1129
ian.smyth@navigant.com

Dimitris Vantzis
Senior Consultant
London, England
(207) 015-2362
dimitris.vantzis@navigant.com

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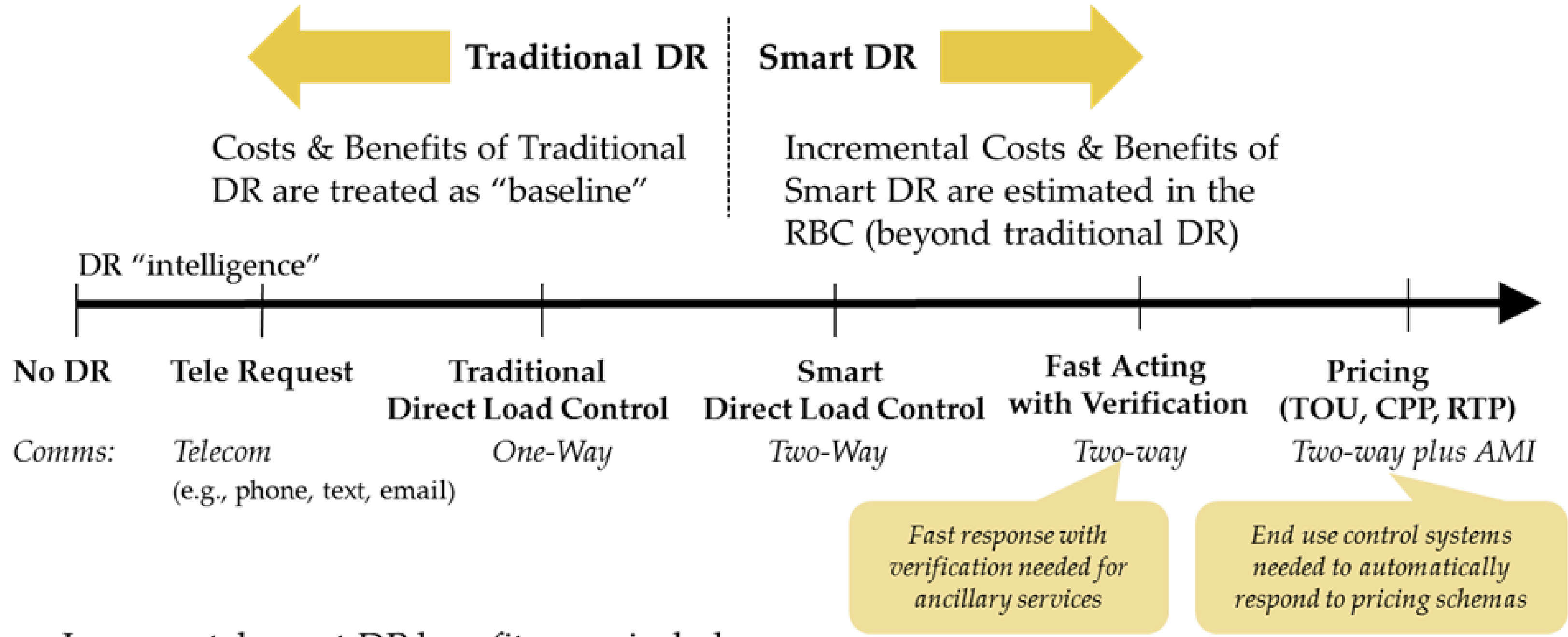
Illustration of the *Smart* DR Definition



- Incremental smart DR benefits may include:
  - Improved response rate
  - Deeper curtailment *(zero, currently)*
  - Increased participation
  - Avoided ancillary services
  - Avoided oversupply mitigation expenses

- Incremental smart DR costs may include:
  - Additional communications infrastructure needed for two-way communications
  - New control systems to respond to increasingly complex signals for pricing or ancillary services