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# Technical and governance considerations for advanced metering infrastructure/smart meters: Technology, security, uncertainty, costs, benefits, and risks

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## HIGHLIGHTS

- AMI presents an almost unprecedented technical and governance policy challenge.
- AMI enables vertical integration of electricity, gas, water, IT, and telco entities
- AMI investments involve major technical, implementation, and strategic decisions.
- Adequacy of consumer education, safety, privacy, and protection is paramount.
- Policy must maximise AMI benefits and minimise uncertainties, costs, and risks.

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## ABSTRACT

The fundamental role of policymakers when considering Advanced Metering Infrastructure (AMI), or 'smart meters for energy and water infrastructure is to investigate a broad range of complex interrelated issues. These include alternative technical and non-technical options and deployment needs, the cost and benefits of the infrastructure (risks and mitigation measures), and the impact of a number of stakeholders: consumers, distributors, retailers, competitive market operators, competing technology companies, etc. The scale and number of potential variables in the AMI space is an almost unprecedented challenge to policymakers, with the anticipation of new ancillary products and services, associated market contestability, related regulatory and policy amendments, and the adequacy of consumer protection, education, and safety considerations requiring utmost due-diligence. Embarking on AMI investment entails significant technical, implementation, and strategic risk for governments and administering bodies, and an active effort is required to ensure AMI governance and planning maximises the potential benefits, and minimise uncertainties, costs, and risks to stakeholders. This work seeks to clarify AMI fundamentals and discusses the technical and related governance considerations from a dispassionate perspective, yet acknowledges many stakeholders tend to dichotomise debate, and obfuscate both advantages and benefits, and the converse.

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## 1. Introduction

In 2009, after the politically disastrous implementation of electricity 'smart meters' in the Australian state of Victoria, the Victorian Auditor General recommended several approaches to minimise risk and independently assess the potentially large costs and benefits of AMI. These included the necessity for engaged government agencies dedicating sufficient governance resources, particularly to understand potential perverse outcomes, risks, and unintended consequences for consumers for the distribution of costs and benefits. The Victorian Auditor General (2009) report criticised accelerated mandatory deployments of AMI technology in advance of state, national, and international standards and frameworks, and represented an unacceptably high implementation risk. Due to the complexity of AMI investments, regular and detailed stakeholder education and consultation forums were recommended, inviting a spectrum of consumer advocacy groups in addition to electricity industry stakeholders to discuss elements beyond initial AMI technical and functionality considerations.

The investment in AMI or smart meters are more than just a new electricity or water meter. AMI can be described as three elements: systems that measure; systems that collect/communicate the measured data, and; systems that analyse the data. AMI 'systems' themselves can be generally categorised as hardware,

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software, and communication systems (Sood et al., 2009). AMI is not restricted to the electricity sector and are also directly applicable in gas, heat, and water supply sectors. AMI investments are technically ambitious. Selecting some technology types increases technical risks, and numerous trials now underway in Australian states are a fundamental risk mitigation strategy. However, there is much attention on how consumers may or may not capture the net benefits of AMI investments, and will require significant investigation by energy regulators and government administrators, as the known large consumer pushback on 'smart meter roll-outs' (the 'Bakersfield effect'), must be understood carefully (Gogn and Wheelock, 2010). Apart from basic AMI technology functionality issues, it is fundamental for AMI administrators to understand the aims, business cases, competitive positions, and regulatory environment to anticipate future developments, particularly between major energy players. Nonetheless, technology and regulatory regime risks of AMI implementation are primarily related to the technical design capacity of equipment, and the cost structures they operate within. Comprehensive and relevant information relating to benefits, costs, and risks of potential AMI technology options are necessary when assessing whether projects (or components of projects) are desirable, viable, and achievable. The rigorousness of the analyses must be commensurate to the unique complexity, scale, and potential consumer impact of AMI projects (Victorian Auditor General, 2009). This research uses the example of Australia, and in particular AMI considerations for the Western Australian (WA) South West Interconnected System (SWIS). The WA SWIS is an electricity network spanning a very large geographical area, with an associated high demand variability susceptible to large climatic variables. The SWIS, like many networks around the world is in need of large investments to accommodate growth in peak demand, enable larger penetrations of distributed large and small scale renewable energy technologies, and to cater for an expansive growth from increasing residential electricity demand, and new large energy intensive processes (McHenry, 2009, 2012, 2013; McHenry et al., 2011).

## 2. The sensitivity of benefits and threats of AMI pertinent to administrators

Electricity networks themselves are becoming a major limiting factor in the provision of efficient and cost-effective electricity services for the growing number of consumers, particularly with the increasing availability of new high-consumptive electric appliances exacerbating daily and seasonal peak demand. The potential applications and benefits of AMI integration into electricity networks are potentially numerous and substantial: interval measurement of electricity consumption; remote reading and switching capabilities; automatic meter data processing and transfer; increased electricity retail competition; a diversity of new energy service providers; increased generation, transmission, and distribution efficiency; two-way communication for increased customer information and enablement; real-time decision-making and control for both consumers and utilities (fault management, network reconfiguration, forecasting, modelling and planning); enabling of third-party assessment of network operator cost statements; etc. (Cavoukian et al., 2010; Deconinck, 2010). Yet, the potential hazards of AMI are also abundant and significant: privacy and security concerns; digital-averse consumer backlash; information and communication technologies (ICT) dependent systems, unknown technology implementation needs; high capital costs, unknown operating costs, unknown utility and advanced capability uptake; unknown technical reliability; communication technology uncertainty; potentially major competitive market changes; etc. (Deconinck, 2010). The AMI administering entity is fundamentally responsible for establishing, and reviewing the ongoing AMI project viability, engagement with stakeholders, the identification and management of risks and unintended consequences (Victorian Auditor General, 2009). The advantage of exploring AMI investments at the present time is that much of the initial Australian national and international experiences with AMI have provided administrators with a level of insight, some standards and frameworks, and much needed advice for the unique responsibilities of administrators. For example, in contrast to independent regulators, AMI administering departments have a broader and enduring societal responsibility, particularly within a disaggregated corporatised or privatised electricity market. While WA AMI projects will be couched within a national regulatory context that will determine to some extent the relationship between the electricity network operator and electricity retailers, there is likely to be significant consumer concerns (and lack of information and comprehension) regarding the aggregated influence of AMI and non-AMI market changes and future impacts (Electric Power Research Institute, 2010). For example, WA residential electricity consumers may benefit from AMI investments on average and in the long term, however, there is likely to be increased costs (both related and unrelated to AMI) for consumers (and/or taxpayers) over the short-to-medium term. It will be a challenge politically to communicate to communities that further increases in the short-term total electricity costs are necessary when electricity prices have already increased markedly in recent years in WA.

### 2.1. AMI information application considerations for policymakers

More efficient and reliable electricity networks are a fundamental driver of AMI investments (Corbett, 2013; Gjukaj and Bualoti, 2011). AMI can introduce several efficiencies in network distribution operations, including determining investments based on real (rather than inferred) transformer and power line data (Valigi and Di Marino, 2009). Thus, AMI can be perceived as obtaining the knowledge required to re-engineer the electricity network (particularly the distribution infrastructure) for greater functionality and efficiency. The traditional electricity network in WA (and most industrialised jurisdictions) were designed for radial, centralised generation, dependent on manual restoration (Sood et al., 2009). Re-engineering this historical legacy will likely be more expensive than initial AMI deployments, and will likely take at least 20 years for the majority of large networks with large sunken investment costs.

A significant component of new network re-engineering will likely be an expansion in distribution automation (DA)[1] technologies and demand-side management (DSM) options. The communication of data from a wide geographical network of meteorological stations in WA, coupled with a dynamic rating of network equipment will enable DA technologies to harness benefits of dynamic powerline ratings. Dynamic ratings increase efficiency of the electricity sector as many network electrical components are 'derated' with increasing temperatures (such as gas turbines, transmission and distribution lines). This is significant in WA as high electricity demand is positively correlated with increased temperatures (Independent Market Operator Western Australia, 2007, 2008, 2009, 2010, 2011). The government owned natural monopoly SWIS network operator, Western Power, have sought to explore the use of dynamic ratings on both the distribution and transmission network. This allows

[1] Distribution automation will require communication technologies that permit Supervisory Control System and Data Acquisition (SCADA) functions and decisions to be undertaken without human intervention (Sood et al., 2009).

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