A comparative review of Australian technology demonstration and commercialisation initiatives in sustainable energy

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1. Introduction

Since the second world war, as large-scale technological innovations have become more and more expensive, complex and risky, western economies (recently followed by China's guided economy) have sought to bridge the chasm between laboratory-scale technology trial and commercial rollout, through the use of publicly funded demonstration projects and market measures which seek to limit the risk by commercial actors willing to invest in commercial deployment.

Thus, the path to commercialisation is often facilitated by public policy initiatives which, on the one hand, have the objectives of exposing technological and operational/commercial risks associated with deployment (through demonstration projects) and, and, on the other hand, remove commercial uncertainties through underwriting some proportion of the commercial returns that investors in project deployment seek (through the use procurement mechanisms and price guarantees).

Demonstration initiatives first received support in the USA and Europe in the defence equipment industry and are now widely applied in the energy and environmental field for projects such as utility-scale solar power (Department of Energy, 2010), water desalination, and CO2 sequestration (Natural Resources Canada, 2010), among others.

Proponents for demonstration argue that until technologies can be demonstrated at production scale at a relevant reference location and in a manner that portends to the project's operational effectiveness, technical efficiency, long term operating economics and ongoing reliability and maintainability, private investors will be unwilling to support promoters in deploying further such projects.

Proponents for deployment-based mechanisms argue that certainty in pricing and scale reduces investor risk, informs both producers and consumers and attracts large scale investment.

However, evidence supporting the need and effectiveness of both demonstration and procurement based funding is more ambiguous than generally believed. There is little rigorous analysis to prove that demonstration is necessary to encourage private funding and wide-scale deployment. Similarly, there is limited analysis of the cost-effectiveness of deployment-based mechanisms. These are complex research questions yet most evidence is anecdotal. In particular, the argument that private investors won't pay for demonstration but will drive deployment after successful demonstration requires further scrutiny, as does an exploration of potentially better options than demonstration funding to drive deployment.

The paper will discuss demonstration and procurement-based programmes in the context of technology commercialisation initiatives that commence with large scale investment in research and development, progress to demonstration and finally to commercial deployment. It will identify and compare notable renewable and sustainable energy commercialisation initiatives within Australia and overseas. Australia's $523m Low Emissions Technology Demonstration Fund program and the $1.5bn (as originally announced) Solar Flagships Program will be presented as case studies and compared with international initiatives such as South Africa's Independent Power Producers (IPP) Procurement Program and the U.S. Department of Energy Loan Guarantee Program.

With a range of other relevant Australian programs in various stages of implementation (including, for example, the $1.9bn CC&S Flagship program, the Australian Geothermal Drilling Program, the $10bn Clean Energy Finance Corporation) the implications of applying some of the key learnings discussed in this paper will be highlighted.

Clearly, conclusions about the effectiveness of demonstration and early-commercialisation programs and their relevance to investment and private sector deployment decisions may help inform public policy makers on how best to expend taxpayers' funds for greatest effect in addressing our sustainable energy challenges.

2. What are demonstration projects and programmes?

According to the UK Ministry of Defence (UK Ministry of Defence), technology demonstrator projects are "short term projects (or project activities) that help demonstrate the level of maturity of technologies in support of capability management decisions. They provide evidence for concept assumptions, foundation reviews, project and critical design reviews … " Technology demonstration projects have also been defined as "a finite initiative to test a technology according to project objectives" (Karlström and Sandén, 2004).

Demonstration projects typically embody some common characteristics including; the perceived or actual existence of technical, manufacturing, production, commercial or operational risks; substantial project/capital expenditure requirements; public benefits of successful outcomes; dependence on public or large corporate infrastructure; joint sharing of risk and investment between public and private sources.

Demonstration is an element of technological evolution. Research, development and demonstration take place at an early stage of technical development, preceding the commercial use of a nascent technology (Sagar and Van der Zwaan, 2006). Demonstration programs typically consist of a portfolio of projects focussed on a common technology arena or solution to a barrier to adoption. Such barriers might include price distortions, initial cost barriers, provision of information to consumers and infrastructural barriers (IBID) as well as political barriers to building coalitions among stakeholders and diffusing learning benefits (Harborne et al., 2007). Demonstration programs are often designed by governments to overcome these barriers. Programs may be competitively based (selecting alternative technical solutions, or stakeholders, or geographical sites) or collaborative (demanding diffusion of learning, sharing of intellectual property and stakeholder collaboration). This has in some circumstances supplanted the historical paradigm of innovation whereby governments assume a major role in basic science while industry undertakes the task of taking products into the market.

3. What are market-based, procurement programmes?

Procurement based programmes encourage the commercial scale deployment of renewable and sustainable energy technologies through the provision of either fixed or competitively priced energy supply underpinned by a long-term power purchase agreement (PPA).

Traditional Feed in Tariff (FIT) programmes pay standard prices to all energy suppliers, typically limited by a maximum supply capacity or total programme cost. A FiT is a simple, comprehensible, transparent contracting mechanism for small renewable generators to sell power to a utility at predefined terms and conditions, without contract negotiations. FIT programmes use administrative processes to set a fixed price for the purchase of electricity. FiT programmes may benefit from lower transaction costs however it isn't clear that these programmes yield the lowest price for electricity consumers. Establishing the appropriate Feed-in-Tariff is difficult. If set too low then the returns to suppliers are too high at the expense of taxpayers and electricity consumers. If too low, new investment will not be viable. The standard-contract supply basis of most FIT programmes also cause complications for utilities who have little control over where power is generated, whether it's needed, or whether it fits in with its resource planning (ie. provides base load or intermittent supply).

Wholesale competitive procurement (or competitive tendering) on the other hand may benefit taxpayers and energy consumers as a result of lower cost electricity supply. Setting supply targets but enabling the utility (who is typically the counterparty to the PPA) to establish a competitive process and select supply based on lowest cost, best fit and technology choice uses competitive pressure to lower total costs while guaranteeing volume of supply across selected technologies and avoiding market distortions. The utilities obligation to procure the target energy supply over the programme period virtually guarantees programme execution subject to technical or developer non-performance.

However, as a mechanism to promote innovation and commercialisation of promising technology, it is important for policy makers to impose both supply and technology targets. Utilities will seek to limit development risk and may impose unreasonable demands on project developers which become barriers to relatively unproven technologies or developers without limited commercial experience. For example, in California's RAM Program, PG&E tendering conditions included a minimum level of developer experience (being at least one other project of similar technology and capacity) and technology risk (for example, in use at least two operating facilities of similar capacity worldwide) (Yura, 2011).

4. International Demonstration and Early Commercialisation Programmes

Demonstrations explore the commercial applicability of a relevant technology which has actual or perceived risk in the ability to scale, be produced in commercial quantity, or meet critical functional or operational criteria. Samuel Morse received $30,000 in 1834 to demonstration a telegraph systems between Washington DC and Baltimore MD. In the military, demonstration projects have been used since the first world war to demonstrate the capabilities of weaponry ranging from early piston engine fighters to naval vessels and more recently multi-role jet aircraft with the primary purpose of demonstrating operational performance of prototypes prior to investing at production scale.   Demonstration projects in the life sciences were introduced in Europe in 1994 (The European Commission, 2000) with the intention of accelerating the exploitation and dissemination of new technologies. Environmental demonstration projects have been directed at demonstrating the environmental and operational consequences of production-scale implementation of water treatment technologies. In energy, demonstration programs emerged after the Middle East oil embargo to extend research in nuclear technology, implement renewable large scale renewable energy initiatives and prove sustainable technologies, in particular integrated carbon sequestration.

The US Clean Coal Technology Demonstration Program (CCTDP) (National Energy Technology Laboratory, 2014) was founded in 1986 as the first of the major clean coal demonstration programs whose primary objective was to address acid rain. The primary goal of this multi-billion dollar program was to develop and demonstrate, at a commercial scale, a family of clean coal technologies. The program recently concluded with 33 reportedly successfully completed demonstration projects that meet or met existing environmental regulations, compete in the electric power marketplace, and provide a technical foundation for meeting future environmental demands. The Department of Energy claims the CCTDP as a model of government and industry cooperation which successfully met the DOE mission of fostering a secure and reliable energy system that is environmentally and economically sustainable. Recently, the US Department of Energy (U.S. Department of Energy, 2015) allocated $615 million for smart grid demonstration projects, for "new and more cost-effective smart grid equipment, tools, techniques, and system configurations that can significantly improve upon today's technologies." The largest grant it will give under that pool of grant funds is $100 million.

In 2007, the French Government launched, the “Grenelle de l’Environnement” demonstrator fund which focuses on new energy technology (e.g. second generation biofuels, low emission individual vehicles, capture and geological storage of $CO2$) and is funded with €400 million from 2008 – 2012. The program has publicly laid out its processes of invitation, selection, and evaluation and at the time of this report had selected eight demonstration projects for funding (Celine Najdawi, 2012). Notable early commercialisation and procurement-based programs in the clean energy sector include the U.S. Department of Energy Loan Guarantee Program, The California Solar Initiative and Renewable Auction Mechanism, South African Independent Power Producers (IPP) Procurement Program as well as Germany's long-standing Stromeinspeisungsgesetz (StrEG, 1991) and more recent Erneuerbare Energien Gesetz.

In Australia "Capability and Technology Demonstrator" projects which demonstrate whether higher risk technologies enhance military capability have been undertaken cooperatively with other governments. The past decade, has seen federal governments of both persuasions announce the $523m Low Emissions Demonstration Fund ("LETDF") and the $1.5bn Solar Flagships programs.

5. Defining programme objectives

Implementation of public policy interventions are complex and rarely fully achieve their desired objectives. Of course, an obvious pre-requisite is a clear and transparent set of policy objectives combined with robust and credible ex ante and ex post estimates of these objectives be they technological, commercial or industry transformational. Often, however, even this simple thesis appears to be overlooked in programme design in Australia.

As opposed to research projects aimed at generating basic knowledge, demonstration projects are typically aimed at addressing the uncertainties and risks associated with innovation which prevented potential users from adopting new technologies. Demonstration project objectives are to prove the viability of a new technology together with its possible economic advantages under realistic conditions. Some criteria against which projects could be characterised include novelty (technology or application); pre-existence of necessary knowledge; execution on a realistic scale of operations; participation of both technology producers and users; pre-competitive; demonstrate technical superiority or ability to comply with regulations or standards; or prove its economic advantages.
By increasing the opportunities for joint fact finding and, particularly, by revealing more about the impact and operation of various new technologies, demonstration projects promote public learning and enable the rework of design characteristics based on performance, environmental or visual impacts.

Demonstration projects can enable scale up from the laboratory to commercial scale and help with learning about, and changing institutional and wider societal barriers to adoption. Demonstration projects test technology, products, processes and systems and they promote market diffusion and commercialisation. The wide-ranging technical, economic and commercial/ market objectives attributed to demonstration projects explain the complexity in assessing their success.

As if determining the success of projects is not problematic enough, assessing the efficiency and effectiveness of programmes seems almost insurmountable.

Demonstration programs are typically designed to support projects which are designed to “shorten the time within which a specific technology makes its way from development and prototype to widespread availability and adoption by industrial and commercial users”(Lefevre, 1984). Early commercialisation programmes are designed typically to provide certainty to commercial actors by underpinning demand and thereby reducing investors’ commercial deployment risks.

Accepted reasons for public funding of demonstration projects is the ability to access capital which may otherwise not be forthcoming from private sources due to the perceived risk of the project. A further reason is the need to access shared industry infrastructure or publicly owned infrastructure. Often the outcomes of demonstration projects are expected to be shared among a range of industry actors and access to infrastructure by just one competitor may not be well regarded by others in the sector. The balance between corporate intellectual property creation and the public good is often difficult to achieve. Publicly funded demonstration projects provide some rationale for sharing operational learning’s resulting from demonstration projects since the risks of failure are shared between the public and private purse.

Opponents of publicly funded demonstration programs argue that in the absence of a clearly identified strategic need, government sponsorship should be confined to exploratory and diversified research to resolve technical uncertainties. The Center for Science and Technology Policy at NYU has concluded that “the record is bleak when the federal government attempts to develop particular technologies when it has no direct procurement interest in the innovation itself” (Lefevre, 1984). Similarly, Michaelis (Michaelis, 1968) argues that technological innovation is pulled into the marketplace not pushed by government.

Another complexity in designing demonstration programs is that, typically, technical unknowns are overshadowed by a variety of economic and environmental considerations. Program objectives are important since technical goals play a major role in program definition while a host of non-technical factors inhibit commercialisation. These technical and non-technical program goals compete with each other for priority.

A further complexity is the appropriate division of administrative responsibility between private and government stakeholders. Government policy often revolves around accountability of public funds while commercial objectives include market positioning, prestige and profits. Government oversight may hinder commercialisation yet address good governance requirements. Project failure (such as the recent Solara debt guarantee loss) may provide an inducement for a more hands-off approach once the funding decisions are committed.

6. What are the key indicators of success for demonstration programmes?

Harbourne (Harborne et al., 2009) argues that an effective technology demonstration program must “(a) foster diversity for technology innovation, (b) create legitimacy for the technology; and (c) create powerful, persistent and predictable incentives that generate a self-reinforcing process of market creation and adoption.” Baer (Baer, 1976) sought to identify the major factors associated with successful project outcomes and formulate guidelines for Government to improve the execution of demonstration programs. Karlstrom (Karlström and Sandén, 2004) explored criteria for ex ante selection of projects and ex post determination of success.

Despite the public data describing demonstration projects in specific areas, there is a paucity of information on the economic efficiency of demonstration projects as a tool of public policy or as an aid to technology commercialisation. This is especially so when considered alongside other policy tools such as business subsidies (which are often applied in countries within Europe for example in the German PV sector), investment tax allowances, or direct publicly funded development.

“It is surprising that demonstration programs have not received more explicit and systematic attention, especially as they involve substantial commitments of public funds” according to Harborne (Harborne et al., 2009), a sentiment confirmed by Lefevre (Lefevre, 1984)who commented that “surprisingly little is known about energy demonstrations and whether the sceptics of technology forcing are correct”. Hendry (Hendry et al., 2010) states “the role of public demonstration projects …remains imperfectly conceptualised and researched. Notable in this is the absence of substantial evidence on what companies actually gain as distinct from what advocates suggest they should and what policy makers believe sponsored (demonstration) can achieve”. Meanwhile, demonstration projects have been criticised as being wasteful and ineffective (Bañales-López and Norberg-Bohm, 2002).

Indicators of success of publicly funded demonstration programs include institutional learning that can be shared among industry participants to yield on-going cost improvements and enhanced technological choices; dissemination of information to market participants thus opening up markets and eliminating institutional barriers; creation of coalitions of participants and stakeholders who will underpin market development, and; transference of market benefits and risk from the government sector to the private sector.

Learning results in lower cost, enhanced operational proficiency, improved safety and skills development which enables introduction and diffusion of technology. Learning rates are highest at the initial phases of technology development and plateau as technology matures. The incentive to share learning-by-doing among industry participants in order to build commercial success is often at odds with industrial stakeholders’ desires to retain proprietary knowledge.

Technical and market information generation and dissemination to potential adopters is vital to building commercial momentum and, yet, again, industrial often see the data developed during demonstration as proprietary and important to profitable growth. Demonstration program design may encourage or impede collaboration among stakeholders. Program design may induce competition amongst participants for funds (thereby eliminating the potential for broad collaboration of stakeholders) or may induce competition across technologies (and may ultimately result in the failure of complementary technological solutions). Thus, program design is a key determinant of program success in creating appropriate stakeholder coalitions.

Almost by definition, commercial success demands that the private sector assumes most of the risk and benefits of the products or technology. During program inception the proportion of public sector versus private sector risk assumption is a key indicator of the prospects of successful commercialisation. The greater the prospect of success and the greater the reward for success, the larger proportion of risk the private sector will assume. The willingness of a private sector participant to assume a larger share of risk is regarded as the most useful gauge of the likely success of a demonstration project and value creation potential. However, demands within a program for substantial private sector commitments may only permit well capitalised industrial partners to participate and may result in actually exclude smaller firms to penetrate markets (which may ultimately have been addressable without government support in any case).

Strengthening demonstration demands supplementation with other diffusion-oriented programs such as accelerated depreciation schedules, exemption from corporate or sales taxes, government purchase guarantees and grants. In the energy sector, in particular, government regulation regarding carbon emissions and energy efficiency can be imposed to provide economic incentives for industry participants to explore emerging technological solutions.

7. A Framework for Assessment of Demonstration Programs

A framework against which one could assess the success of a demonstration program (as distinct from the successful completion of a demonstration project) is presented below:

	Program Objectives	Indicators of Success
1	Sharing of institutional learning, intellectual property & fact-finding	- Published technical information - Published market information - Published case studies - Patent filings - Declining costs of production and implementation
2	Shortens time to widespread availability and adoption	- Adoption and availability targets are disclosed at program initiation and continually assessed during program implementation and at conclusion
3.	Enables access to private	- Growth of private capital applied to the

	capital	target sector and underlying projects
4.	Assists in overcoming barriers to market development such as access to infrastructure, permits or regulatory impediments	- Barriers to market development are identified and disclosed - Program design incorporates elements that assist in overcoming identified barriers
5.	Provides appropriate administrative responsibility and accountability	- Results from appropriate industry consultation - Clear guidelines for project delivery and accountability
6.	Results in diversity of technology innovation	- Emergence of multiple technological approaches
7.	Provides parallel implementation of reinforcing incentives for market creation	- Integrates well with other government research, development and deployment policies and initiatives
8.	Is economically efficient (compared to alternative programs)	- Economic analysis framework is developed and assessed prior to program launch
9.	Details explicit project selection criteria	- Criteria are relevant, objective and transparent
10.	Is subject to post-implementation determination of success	- Review and audit are thorough, independent and transparent
11.	Creates stakeholder coalitions for industry development	- Strong collaboration between industry participants - Competition for funds does not crowd out smaller competitors
12.	Results in the transfer of risk from the government sector to the private sector	- High proportion of private vs public funding - Low proportion of contractual, investment and market risk adopted by the government

8. Case Study - LETDF

Technology demonstration projects are not well known in Australia, so much so that they may be considered almost an ad-hoc creation of recent Australian public policy. The records show few initiatives which would qualify as demonstration programs within a complex Australian public innovation system environment over the past 20-30 years. The Low Emissions Technology Demonstration Fund satisfies the common characteristics of demonstration projects outlined earlier. It was followed by the Victorian Large Scale Demonstrator Project (LSDP) program.

The LETDF was launched by the Minister for Industry, Tourism and Resources on 11th October, 2005 having been announced in June 2004 (DITR, 2006). The context for this policy initiative was a social/political environment of some disillusionment with the then Government's environmental policies. Some viewed the Government as an environmental recalcitrant – being one of only two developed countries failing to sign the Kyoto protocols, and it faced overt condemnation from environmental interest groups as an indicator of more general public disaffection on this issue. With this in mind, the LETDF may have been viewed as an initiative which was as much designed to enhance the Government's environmental credentials as to make a meaningful impact on the adoption of low emissions technologies. The Howard government announced the LETDF to operate from 2005–2020 with the proclaimed objective of supporting the demonstration of new low emission technologies with significant long-term greenhouse abatement potential as part of a more general set of initiatives in relation to the environment. The Government would provide funding to "help Australian firms commercialise world-leading low emissions technologies" (IBID). The LETDF program itself would provide $522.9 million over 16 years to projects that accelerate the demonstration of new low emission technologies to achieve significant greenhouse abatement over the long-term. The fund was designed to be technology neutral and include low emission fossil fuel electricity generation, geo-sequestration, hot dry rocks, energy efficiency and intelligent transport systems and there was no specified funding limit on each project. The LETDF would provide joint private sector and public funding of qualified projects and would be jointly managed by the Department of Environment, Water, Heritage and the Arts and the Department of Industry, Tourism and Resources.

The stated objective (IBID) of the LETDF was to "demonstrate the commercial potential of new energy technologies or processes or the application of overseas technologies or processes to Australian circumstances to deliver long-term large-scale greenhouse gas emission reductions."

Victoria's Large Scale Demonstration Project (LSDP) was announced in May 2005 as one of the initiatives under the State Government's $187m Energy and Technology Innovation Strategy (ETIS). The LSDP would leverage the Commonwealth's LETDF but in contrast to the LETDF, the Victorian Government's objective was to ensure that the State maintains a reliable, efficient and economic generation system. In its 2004 report (Department of Infrastructure and Department of Sustainability and Environment, 2004) into the environmental challenges of energy management policy in the State, the Victorian Government identified that additional base load brown coal fired power generation will be required from 2015. However, in order to have economically and environmentally-competitive brown coal power generation technologies in commercial operation by 2015 the demonstration of those technologies in pre-commercial scale (approximately 100 MW) by 2014 would be required. The underlying rationale for this was that private investors and operators needed "bankable" projects around 2012 on which they can build investment cases to deliver commercial-scale generation plant around 2020. The Victorian Government subsequently announced a further $110 million fund to establish new large-scale, pre-commercial Carbon Capture Storage (CCS) demonstration projects.

The LETDF and LSDP objectives do not clearly address any of the identified criteria of demonstration projects outlined earlier in this paper, such as shared learning, dissemination of knowledge, creation of stakeholder coalitions or the ultimate transfer of risk from the public to the private sector. Further, no details of selection processes were announced.

Applications for funding in round one of the LETDF closed on 31 March 2006. Thirty applications were received from electricity generators, oil and gas producers, iron and steel producers, the oil and gas services sector, and the transport sector for low emissions technologies covering brown and black coal, natural gas, transport and renewable energy. The department established a panel of experts to assess the merits of each application. This process was managed by AusIndustry.

Responsibility for the LETDF was transferred to the Department of Resources, Energy and Tourism in 2007. No further funding rounds were held and DRET's annual report 2007/8 noted that grants totalling $410 million were offered to six companies. In June 2008 five projects were announced as final qualifiers for LETDF funding totalling $345m. $96m was budgeted for investment in 2008/9 and $137m in 2009/10. It's not clear how much of this was acquitted, however, it is estimated that less than 25% would have been spent in these periods. The revised 2010/11 budget indicates a planned expenditure of just $38m (versus $137m) in 2009/10 and a total expenditure of $281m - just over half of the original program headline budget of $522m.

In May, 2011, DRET announced that three out of the original six projects were being supported under the LETDF with one project having its funding offer withdrawn, a second having its funding support transferred to an alternative program (NLECI) and a third having its funding agreement terminated.

The approved projects were (1) HRL - an Integrated Drying & Gasification Combined Cycle Clean Coal 400 MW power station to be built in the La Trobe Valley in Victoria; (2) International Power - a brown coal drying and carbon capture and sequestration project to be implemented at the Hazelwood power station in the La Trobe Valley in Victoria; and (3) Solar Systems - a Large Scale Solar Concentrator Power Project to be implemented in north west Victoria; (4) Gorgon - a carbon dioxide Injection Project at the Gorgon gas fields in Western Australia; (5) CS Energy - an oxy-firing and carbon sequestration project at the Callide A power station in Queensland; (6) Fairview Power - selected to obtain a $75 million grant extract and burn methane from coal and inject and store the carbon dioxide emissions underground in Queensland.

Three of six approved projects were to be co-funded by the Victorian Government under the LSDP initiative. Funding was committed to three proposed projects. In April 2008 the government announced an extra $72 million towards large scale sustainable energy demonstration projects and said it "would be seeking proposals for large-scale, pre-commercial demonstrations of sustainable energy technologies such as solar, energy storage, biofuels, biomass conversion, geothermal energy efficiency and clean distributed energy". It solicited requests for proposals in December 2008 and these are currently being assessed with the outcomes to be announced in late 2009 / early 2010. The selection process for LSDP funding included an initial assessment by two independent assessment panels - one commercial and one technical - over a period of weeks, with the shortlisted projects assessed by an international independent assessment panel.

The first jointly funded LETDF/LSDP project was to be an Integrated Drying & Gasification Combined Cycle (IDGCC) power station proposed by HRL Limited, an unlisted, Australian owned, energy, technology and project development company. HRL proposed to build a 400 MW demonstration plant in the La Trobe Valley in Victoria implementing a new technology for integrated drying and gasification of moist reactive coals (by heating the coal to ~700 degrees and forming a synthetic gas) to produce power at a higher efficiency than conventional power plants, with an estimated 30% lower cost of electricity production, 30% less CO2 emissions, and 50% less water consumption. Already demonstrated at the 10 MW scale, this project was aimed at demonstrating the technology at full scale. The Australian Government would contribute $100 million and the Victorian Government an additional $50 million. The project was due to commence in 2007/8.

The second was a coal drying demonstration project proposed by the UK headquartered International Power, the owner of the Hazelwood power station in the La Trobe Valley in Victoria. The project would demonstrate technology to dry the brown coal which would be used as feedstock for one of the boilers at the Hazelwood power station. Subsequently capture and sequestration technologies would be applied to the resulting reduced CO2 emissions. The project would use internationally available technology in these applications and adapt them to local conditions with an expectation that, if successful, these technologies would be applied to the remaining seven generating units at Hazelwood and may be retrofitted to other brown coal plants in the LaTrobe Valley. The total project cost was originally estimated to be $369 million. The Australian Government would contribute $50 million and the Victorian Government an additional $30 million. Construction was intended to commence in 2007 and be completed by the end of 2009 according to the Victorian Government.

The third project was proposed by Solar Systems Generation, a privately owned Melbourne-based company. The proposed project was the construction of a zero-emission 154MW solar concentrator power station in north-western Victoria. Claimed to be the biggest and most efficient solar photovoltaic power station in the world it would utilise a technology called ‘Heliostat Concentrator Photovoltaic’ (HCPV) technology which was claimed to enable 1500 times more electricity generation from photovoltaic cells than the same area of conventional flat plate solar panels. The project would result in a significant scale-up of manufacturing of high-tech plant components in Australia with a new manufacturing facility built for construction of this project and subsequent power stations expected to be ordered from Australia and overseas. The total project cost was originally estimated to be $420 million. The Australian Government would contribute up to $75 million, and the Victorian State Government another $50 million. The project was to commence in 2008 and reach full capacity by 2013.

Three other projects were to be funded by the LETDF alone. The first was the Gorgon carbon dioxide injection project proposed by Chevron and its joint venture partners Shell and Mobil. The project is part of the Gorgon gas development off the north-west coast of Western Australia and involves the injection of carbon dioxide into a nearby saline aquifer underneath Barrow Island. The project is at commercial scale and involves capturing carbon dioxide from reservoir gas, compressing and dehydrating the CO_2, transporting the CO_2 by pipeline to a saline aquifer under Barrow Island and injecting it into the aquifer while monitoring the injected CO_2 to ensure health, safety and environment security. Carbon sequestration is emerging as a credible technology in the oil and gas sector where capture of CO_2 is relatively straightforward and sequestration is being applied in several oil and gas fields such as in the North Sea where liquid CO_2 is sequestered in depleted oil reservoirs. Injection of CO_2 into a low permeability saline aquifer is relatively unproven and this is expected to be the world's largest geological sequestration project of its type, removing about 3 million tonnes per annum of reservoir CO_2. The total estimated project cost was expected to exceed $841.3 million with the Australian Government contributing $60 million.

The second LETDF-alone project was an oxy-firing and carbon sequestration project proposed by CS Energy (which owns the Callide A power station at Biloela in central Queensland) along with a consortium of partners including Japanese companies JCoal, JPower and IHI, the Australian Coal Association, Xstrata Coal, Schlumberger, the CO2CRC and the CRC for Coal in Sustainable Development. The project involves the retrofit the existing Callide A coal-fired power station with a set of new technologies which produce oxygen that is used to oxy-fire pulverised black coal whose combustion gasses are captured with the resulting CO_2 separated, liquefied and transported to a suitable geological storage site. The demonstration project would store up to 30,000 tonnes of carbon dioxide over three years. The total cost of the project was expected to be $188 million with the Australian Government contributing $50 million. This project was transferred to the National Low Emissions Coal Initiative (NLECI) also administered by the Department of Resources, Energy and Tourism.

The final project, which appears to have had its funding offer withdrawn, was Fairview Power which was to have demonstrated coal bed methane extraction and CO_2 storage. The project was expected to have a total cost of $445m with $75m provided by the Australian Government.

Determining the status of projects funded under the LETDF is challenging. The Department of Resources, Energy and Tourism doesn't publish operational updates of the approved projects on its website or in its annual reports. Similarly, the most recent program updates on the Victorian LSDP are from mid-2008. The Victorian Department of Primary Industries advised (Jan O'Dwyer, 2009) that "there was only one large scale sustainable energy demonstration project funded from ETIS1 - Solar Systems" with $50 million "allocated to the project by the Victorian Government with funding also provided by the Commonwealth." The DPI was unable or unwilling to provide details of the funding payments made to date, however, it is believed that only $500,000 had been provided to Solar Systems by either the Federal or State Government.
The author requested information from the DRET however nothing was forthcoming. The lack of public disclosure has been reported by others too – "Neither Martin Ferguson's office nor the Department of Energy were prepared to comment on the Fund. Indeed, the Department of Energy's spokesman, Tom Firth, either could not or

would not disclose whether the other four projects had met their milestones or received their promised funding." (Eltham, 2009) DRET has reportedly performed a process review of the program but not dealt with the projects themselves.

According to the Australian National Audit Office (McVay, 2009), DRET has not completed any reviews of the LETDF. However, the ANAO released a report into the Administration of Climate Change Programs in April 2010 which included an assessment of five climate change programs, which nominally allocated $1.679billion including the $500m LETDF program. The report's findings were "designed to assist in the implementation of these and future programs as well as convey lessons that may have application to other grant programs in the departments concerned." Relevant to the LETDF was the audit's inquiry pertaining to the "development of program objectives and assessment of program risks; assessment and approval of competitive grant applications;.... and measurement and reporting of program outcomes."

ANAO officers believed that the program was "moving very slowly and that no outcomes have yet been achieved" but that this was understandable given it was still "early days" with the LETDF and with most of the agreements only recently signed. The report concluded that the LETDF was "not sufficiently advanced for any meaningful comments on overall program results to be made to date."Surprisingly, it also concluded that "The assessment and selection of climate change projects... was transparent, with criteria used to assess all proposals. Generally, there was a high degree of rigour and technical expertise applied to the assessment process." This conclusion was not obvious from the various published material available on the LETDF or discussions with those involved in the project application process. The report also concluded that "performance reporting could have been substantially better in terms of accuracy and consistency".

The Wilkins Strategic Review of Australian Government Climate Change Programs which concluded that "many programs appear to have been introduced to address short-term announcement imperatives rather than in response to evidence of a need to act. As a result, the growth in the number of programs has been 'lumpy' over time. The 2004 Energy White Paper initiatives are an example of this – the speed with which the package of programs was formulated resulted in much of the program design work being undertaken following the announcement of the package. This has led to delays in the implementation of some programs – most notably the Low Emissions Technology Demonstration Fund (LETDF). Despite having been announced in 2004, at this point the Review cannot conclude that the program has achieved clear results." Wilkins concludes that "support for technology demonstration and commercialisation, such as LETDF, which involves one-off funding decisions, does not fit well with the model used for financing and delivering large technology demonstration projects in the commercial sector."

Existing programs supporting the development and demonstration of low emissions technologies appear unlikely to deliver a sufficient portfolio of technologies that will facilitate Australia's transition to a low-carbon economy. This can potentially be attributed to the lack of flexibility in approach and scope inherent in most existing programs – a majority of which are grant programs and directed toward specific energy technologies.

Interviews with relevant contacts within the five successful project proponents were requested, however the author was only able to interview representatives from two companies – Solar Systems and Gorgon. These discussions and a review of company annual reports and press releases suggest that the LETDF has not yet delivered. Firstly, LETDF has been slow to finalise its commitments to projects which the Government apparently, at the time of assessment, found to be promising and few projects were ultimately consummated. The ANAO report found that "... there were substantial delays in negotiating the agreements, subsequent to funding approval. Delays of two years were not uncommon. " While it is not clear to the public, it appears that contracts for LETDF funding have only been finalised in relation to three projects (HRL, Gorgon and International Power). Solar Systems had executed definitive agreements for LETDF funding, however, in August 2009, the company entered voluntary administration after an unsuccessful search for equity investment over a period of about 18 months. It is unlikely that any significant funding from LETDF (or the Victorian LSDP) was ever received by the company. It is unclear whether a more timely commitment of LETDF funding would have avoided this outcome, however this question has been asked ….."Did Australia's largest solar power project collapse because of government inaction?" (Eltham, 2009). Following the withdrawal of funding for Solar Systems, the next ranked project was approved for funding. In September 2009, the proponent of a second project entered voluntary administration and the status of that project is unclear. It appears that Fairview Power's funding approval was terminated early in the selection process. Finally, it appears that CS Energy's Callide A Oxy-fire retrofit was transferred to the NLECI.

According to John Torkington, Senior Advisor on Climate Change Policy at Gorgon, (Torkington, 2009) the LETDF funding contract had not been executed as at late August 2009 since the company was awaiting State Government approvals and LETDF contractual commitment was subject to final investment decisions by commercial partners in the project. There is some argument that the delay may have diminished the benefit of the proposed demonstration funding.

The contractual status of other approved projects is unknown. While press releases suggest that some progress has been made at Hazelwood with the installation of a $10 million pilot project, this seems inconsistent with the original project estimates of $369m and LETDF grant of $50m. It is believed that no LETDF or LSDP funding has been committed at this time to either the HRL nor Hazelwood projects, based on exchanges with the Victorian DPI. According to the ANAO "LETDF spent less than five per cent of its budget over a five year period" and in comparison with the originally allocated $500m budget for LETDF only "$335 million has been approved ... with total project costs estimated at approximately $2.6 billion. Actual expenditure in comparison to the original budget estimate has been minimal, with only $23.8 million actually paid out"

Secondly, considering the timeframes and process for the LETDF to reach this point, one must wonder what the status of the "unsuccessful" 25 LETDF applicants is and the 62 initial registrations that were received (of which 17 "were assessed as being ineligible" and "15 decided not to proceed" according to the ANAO). The government had selected 6 projects from among thirty applicants. Of these, only one appears to have had any real traction while at least one other did not proceed. So, despite the intention to fund a diverse mix of technology agnostic projects at the inception of the LETF, the outcome some five years later has been non-specific progress in relation to one project focussed on efficient burning and subsequent sequestration of carbon emanating from a coal fired power plant. The range of alternative technologies that may have benefited from LETDF funding would, no doubt, have included solar, tidal, alternative fuel, geothermal, wind and a range of other promising technologies. Perhaps recognising this failure, the present government announced a successor grants programme called the Renewable Energy Demonstration Program (REDP) to which it has allocated (subject to successful commercial negotiations) $235 million to four commercial-scale renewable energy projects which include two geothermal technologies - MNGI[1] and Geodynamics[2], one wave-power technology (Victorian Wave Partners P/L[3]) and one integrated renewable energy plant (Hydro Tasmania[4]).

Other criticisms of the design of the LETDF program are the limited extent of funding contribution as a proportion of total project costs and the real contribution or impact of LETDF funding to project success. John Torkington advised that the total investment as of 2009 on the Gorgon project has been about $2 billion since initial studies of the opportunity began over a decade ago. The investment to date on CO2 injection alone has been nearly $200m and the expected investment in the carbon dioxide separation, transport, sequestration and ongoing monitoring will be approximately $2 billion when complete. In this context, the LETDF funding of only $60m will have "made no difference to whether the project would proceed or to the facilitation of the project". While a funding approach where the Government makes a commitment of a significant proportion of project costs could be a determining factor in whether a project proceeds or not such an approach would be at odds with the requirement to pass risk from the public to the private sector. It is believed that Chevron had indicated disappointment that its expectation that the Government

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1 MNGI Pty Ltd has been allocated $62.762 million to develop a 30MW engineered geothermal system based on Petratherm's 'Heat Exchanger Within Insulator'. The project is located adjacent to the Beverley uranium mine

2 Geodynamics Limited has been allocated $90 million to demonstrate a 25 MW Geothermal energy plant in the Cooper Basin. The Project will be the world's first multi-well hot fractured rock power project.

3 Victorian Wave Partners Pty Ltd (a joint venture between Ocean Power Technologies and Leighton Contractors) has been allocated $66.465 million to construct a 19 MW Victorian Wave Power plant which will be the first commercial scale ocean energy project in Australia.

4 Hydro Tasmania has been granted $15.280 to demonstrate the potential for integrating wind, solar, storage and biodiesel generator technologies into an established electricity network on King Island.

would provide 1:2 matching funding for its sequestration proposal at Gorgon was not fulfilled. Carbon Capture and Sequestration projects alone may require of the order of $4-5billion in investment to prove up against a government commitment to date of about $1bn.

The LETDF process attracts criticism due to the absence of transparency regarding the selection process and criteria for approved projects. Obviously, commercial confidentiality must be maintained in the evaluation of project proposals where detailed economic and intellectual property details are likely to be disclosed. However, while the ANAO is generally complementary about the process, criteria and transparency of the assessment process for LETDF, there is little or no material published which provides guidance for unsuccessful applicants, discloses selection criteria or the make-up and biases of selection panel members.

There is little information providing accurate reporting of evaluation and contractual status and no convenient publicly available reporting on LETDF project status or the progress of approved projects and little scrutiny of expected project outcomes. ANAO reports that in relation to the climate change programs it reviewed "performance reporting is inconsistent and inaccurate". Budget estimates (DRET, 2008) for administration of the programme of only $1m for 2007/8 versus an initial estimate of $15m suggests that the progress and success of approved projects, and the LETDF program as a whole, is not being actively measured or monitored.

9. Implications for future program design

The Grattan Institute (Daley et al., 2011) has determined that "Over the past decade Federal and State Governments have announced around $7.1 billion dollars to grant tendering schemes aimed at reducing greenhouse gas emissions. Yet only a small fraction of the money has ever been allocated to viable projects. Most projects selected are never built." Demonstration programs are a meaningful subset of such grant tendering schemes. While Grattan did not assess the economic efficiency of demonstration funding it did conclude that "Every million dollars of announced funding produces on average just $30,000 worth of operational projects within five years and $180,000 within ten."

Despite this and other design and implementation failures, Government policy continues to employ demonstration programs as a significant tool to bridge the gap between technology development and market adoption. In Australia alone, a further $2.5bn in demonstration program funding has been committed to the energy sector (excluding the $2.4bn CCS flagship program). For example, the $1.5bn Solar Flagships was announced on 18 June 2011 with two projects (a 150 mW photovoltaic and a 250 mW solar thermal project) soon after selected for funding to provide a foundation for deployment of large scale, grid connected, solar power in the Australian electricity supply market. The $180m Victorian Energy Technology Innovation Strategy (ETIS) was announced with "the single objective of driving prospective sustainable energy technologies down their respective cost curves and, in so doing, ensur(ing) that a portfolio of low cost, low emissions technologies are available for commercial deployment to minimise the economic impact of a cost on carbon" (Victorian Government, 2010). The Renewable Energy Demonstration Project (REDP) announced $235 million in funding to four commercial-scale renewable energy projects which were expected to "deliver approximately $810 million in renewable energy investment in Australia" in the wave, geothermal and an integrated renewables.[5]

The reader may well ask a number of questions about the efficacy, efficiency and desirability of demonstration projects in Australia in the field of energy technology. While it may not be fair to judge the value of demonstration projects based on an assessment of the success or failure of these programs (notwithstanding the Wilkins Review conclusions or those of the Grattan Institute), they must certainly leave us with some lessons to consider in relation to program design, implementation and assessment. Some key questions, the answers to which have gone begging in respect of the above-mentioned programs, but which must be asked of future government support programs, include:

- How should the success or failure of a program be measured? Should a substantial government initiative such as LETDF demand hard measurable objectives in relation to deployment of technology, commercialisation, private sector investment and the related timeframes for these?

- What is the relative economic efficiency of support measures such as demonstration project funding? If grant programs are not the most efficient means for promoting the transition from pilot to production scale deployment, what other means exist that are better? Should the Government, for example, directly increase funding to agencies to make risky investments in new technology or infrastructure? Or, should the government do, as agencies such as the EPA in the USA have done, and provide funding guarantees for private and public sector operators to undertake such risky investments?

- Assuming that support for demonstration funding remains, what is the relevant commitment and financial contribution (or other contribution such as expedited regulatory approval processes, etc) that the government should make to ensure that selected projects proceed to successful implementation (whether or not successful technologically or commercially)? Is the extent of commitment purely a factor of the size (or relative size) of financial assistance versus total project expenditure or does it vary depending on the nature of the project, an assessment of the project risks, an assessment of

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[5] MNGI Pty Ltd (Petratherm)-$62.5m; Geodynamics Pty Ltd-$90m; Victorian Wave Partners Pty Ltd-$66.5m; Hydro-Electric Corporation (Hydro Tasmania)-$15.3m.

the private sector funding environment and other macro factors such as carbon pricing, scarcity of alternatives, etc?

- How should programs be assessed in terms of the relative benefits they provide to successful applicants (and thus, hopefully, to the general economy and environment) versus the risk should the program fail to operate in a timely manner and thus delay the imperative to make hard decisions or result in other promising technologies or initiatives being buried or failing to attract requisite investment having been passed over for publicly funded support? Can the painful conundrum of government "picking winners" in a complex and dynamic technology and pricing environment be solved by government demonstration programs, or does the LETDF demonstrate that government intervention of this form only exacerbates the dilemma?

- Would the market not benefit from readily available status updates on publicly co-funded projects in order to make more informed decisions about different investment options in relation to emerging technologies?

- Finally, should program transparency in relation to selection criteria, evaluation process, contractual progress, project monitoring and assessment be a primary objective in order to ensure accountability of Government, administering departments and funding recipients? Or, would the risk of disclosing commercially sensitive information deter potential demonstration project funding applicants and severely restrict the range of solutions available to the market? At what point, does the scale tip in favour of loosening concerns about commercial confidentiality in order to secure attractive funding support? And, surely, would the market as a whole not benefit more from Government expenditure on demonstration projects if more information about the projects economics, technology successes and failure and operational status were made publicly available? Was Thomas Jefferson right in saying *"The same prudence which in private life would forbid our paying our own money for unexplained projects, forbids it in the dispensation of the public moneys"*

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