How should Myanmar tackle the need to electrify the country?

- **Key pointers for a framework for the Electricity Supply Industry**
- **IPP's or distributed renewables - is it either/or both?**
- **The role of Government policy vs private sector**

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How should Myanmar tackle the need to electrify the country?

- By now we have all heard the details of the problem:
  - Low electrification
  - High latent demand

- In this presentation, I will go through some pointers for where the Government needs to start
  - The importance of the over-arching policy framework
  - The role of the private sector vs the public sector
  - Some thoughts on whether Myanmar should be pushing for private sector IPP's; mini-grids; distributed renewables or other approaches

But first, let's be sure we all agree it's necessary!

The first, obvious, question is “Is it necessary to have electricity at all”?

- The answer to this is clearly “YES”.
- A world bank report in 2008 highlighted that electrification brings many benefits, and people are often very willing to pay the associated costs:

> *Lighting alone brings benefits such as increased study time and improved study environment for school children, extended hours for small businesses, and greater security.*
>
> *But electrification brings more than light. Its second most common use is for television, which brings both entertainment and information. The people who live in rural areas greatly appreciate these benefits and are willing to pay for them at levels more than sufficient to cover the costs.*

Source: The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits, 2008, World Bank

So where should we start?

The first thing to do for any policy decision, is to frame the issue

Objectives	Constraints	Resource Availability
What is the ultimate goal	What might prevent this from happening naturally?	What resources are available to help and what might be needed?

Is you don’t know where you are going, how can you plan how to get there?

- Having the right objective is a crucial first step in policy formation
- Having the right objective is important, but so is framing it objective correctly
- For example:
  - An objective of “building more power stations” has already closed out many options
  - An objective of “having a sustainable electricity supply industry, which delivers the right amount of power to the right consumers at the right price” is a better objective to start from
- Once you have such an objective you can see more clearly what needs to be done to achieve it

A sensible objective helps to frame the problem and avoids closing out options too early

So what are the current objectives?

- From a previous conference, I deduced that the objective was currently to deal with the shortages of power and to electrify the population
- In addition, the Government wished to do it in a way that:
  - Is as fast as possible
  - Benefits all the people
  - Introduces Good Governance
  - Attracts the best companies
- These are not bad objectives however they are not necessarily all compatible:
  - Doing things well is often at odds with doing things fast, for example
  - It is hard to benefit everyone at the same time, meaning some choices will need to be made along the way about who gets power first
  - It was never clear that “at least cost” was an objective – and really it should be!

Objectives change as the situation changes

The objective today of "getting more power to more people" is obviously correct given the benefits of electricity and the low current electrification rate…

… but in 10 years time, the objectives might be more focused on how to recover the costs of the system through tariffs …

… and 10 years after that, perhaps "how do we increase the share of renewables and lower carbon dioxide emissions"?

You can obviously change objectives as the industry matures

- Or, with some additional thought upfront, design a more “future-proof” industry from the beginning
  - Focusing on economic, least-cost choices at all stages of development
  - Ensuring consumers pay cost-reflective prices from the start
  - Including the full costs of all options in evaluations – including the opportunity costs of fuels

The best outcomes come from making good decisions. Good decisions require a clear objective, information and objective analysis. A lack of time, money and skills may hinder decision making; but prioritising good decision-making early will save time and money in the long run, as well as building skills that add value in many areas.

Constraints – Or - What might prevent this from happening?

- Obviously, the constrains link to the actual objective
- But some of the obvious issues include:
  - Lack of a good legal and regulatory framework for the electricity industry
  - Lack of clear policy direction
  - Residual concerns by some potential investors
  - Money
  - Ability of consumers to pay full costs of electricity
  - Very low level of existing infrastructure

And these are just the high level ones that come to mind quickly … many other more details constraints exist

Some constraints are real; others are self-imposed

- A constraint of having no money is real – very little can be done to turn a poorer country into a rich one overnight
- Similarly countries with no indigenous fuels are always going to be at a disadvantage relative to those with plenty
- However constraints relating to policy are self-imposed:
  - Policy can be improved if the political will exists
  - Co-ordination between departments is a matter of choice
  - Policy, decision making and planning skills can be learnt quickly and cheaply if the right training is undertaken

Good policy can overcome many real constraints. Focusing on improved decision-making could be the single most value-added activity at this stage in development

Resources: What are available and what are needed?

- Myanmar does have the one resource that many countries lack – plentiful fuels. It has a wide range of different fuel options.
  - However, where many fuels exist, the question is raised as to which fuels to use for domestic electricity, which for exported electricity, and which to export as fuels themselves. There are a number of tradeoffs needed.
- The most obvious resource needed is money
  - Government money, aid money or private sector money?
  - This is not a simple question as a mix of all three will introduce additional complexities
- Next is skills
  - Most developing countries focus on technical skills – building things
  - But planning, designing markets, regulating and overseeing policy are also necessary skills to set the industry up on the right foot
  - But skills can be learned so fall more into a current constraint than a real lack of resource

Every journey starts with a single step

- Where are we today?
- The current situation is problematic
- Lack of a clear, coherent and over-arching policy
  - Need to take into account both transmission, generation and supply not deal with each individually
- Current IPP process is random and unfocussed
  - We understand it involves the IPP submitting proposals to the MOEP….
    - But it is not clear how those proposal are evaluated
    - Or how the MOEP chooses what to ask for
    - Or how the relative attributes of different proposals are compared

The starting point is not ideal, but the next steps are critical

Some of the implications of the desire for speed may have unintended consequences

- We understand that some power station developers start building BEFORE they have a final PPA
  - This is very uncommon internationally, as it puts a very large risk on the project
  - Developers that do this may 1) very small or 2) be financing by equity or 3) have some Government backing
- Financing by equity is very expensive – equity costs more than debt – so power stations may be more expensive if done this way
- Some companies that take this risk may be Government owned… particularly Chinese companies … and there are hidden costs to Myanmar in accepting this "help".
- The "best" companies will not accept this structure … if Myanmar wants to attract the best companies at the lowest cost, it needs a good structure in place

Running rather than walking does not help if you are running in the wrong direction

But Myanmar is not alone is striving for a better future, as fast as possible

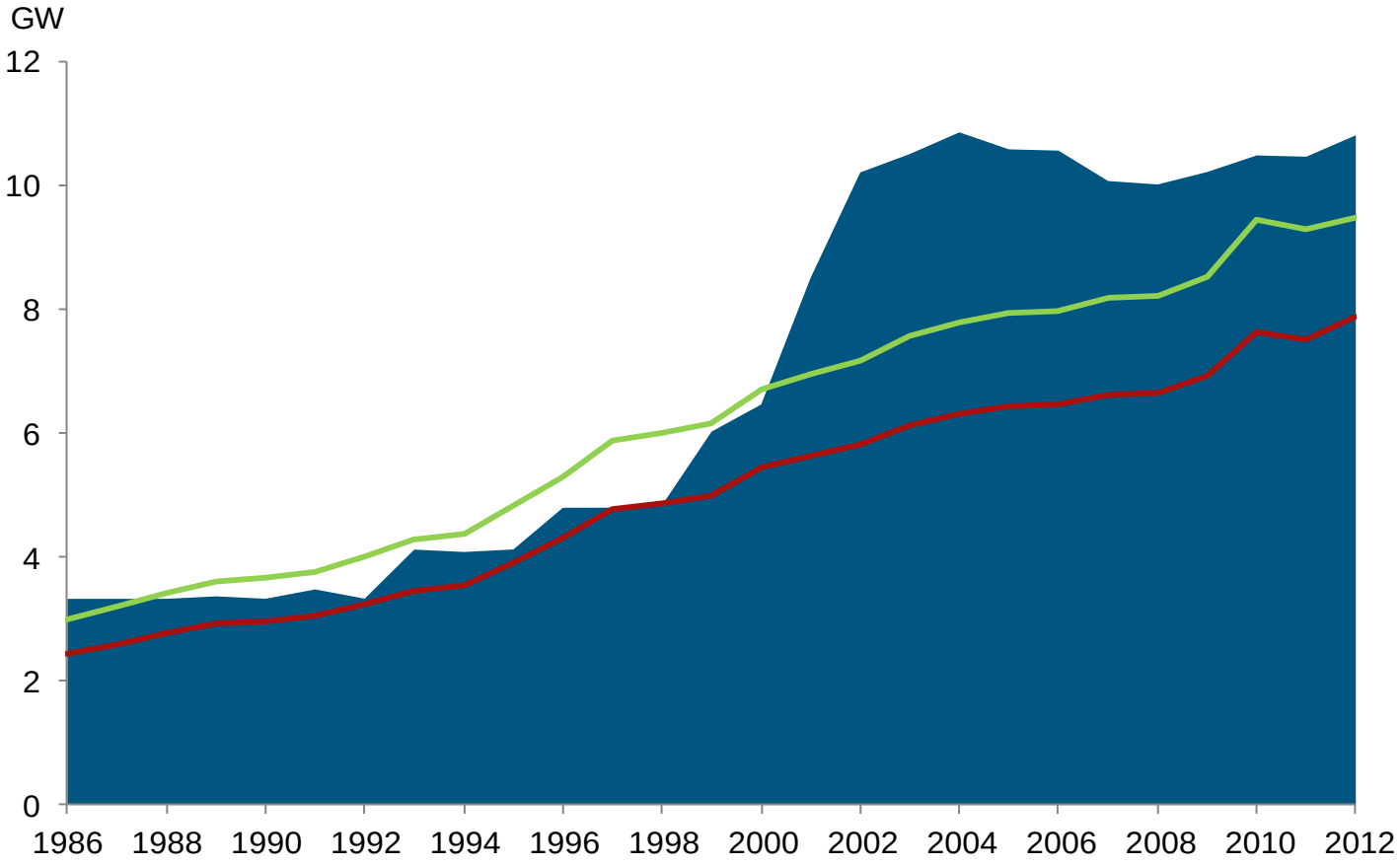
- Plenty of Asian countries have done this, many are still paying for their mistakes
- The good news is that you do not need to experience the problems oneself to learn from them – and there are plenty of lessons to be learnt

Poor decisions cost consumers

- The Philippines turned to IPPs to try to solve the looming power crisis in the 1990s
- By 1998, foreign-owned IPPs had build **4,800MW** and invested US$6 billion
- But, just as the Asian financial crisis took its toll and demand flattened, **2,700MW** of natural gas-fired generation came online
- This meant that the government, through the National Power Corporation (NPC), quickly racked up debt, which accumulated to **US$22.35 billion** by the end of 2003
- Despite raising about **US$10.2 billion** from privatizing assets and contracts between 2007-11, Filipinos have only really just begun paying off these debts …
  - *Directly* through separate Universal Charges levied on every kWh consumed, currently PhP 0.1938/kWh (about 4.25 Khat per kWh), and
  - *Indirectly* through expensive gas-fired generation when coal could have been cheaper
    - since July 2007, Meralco alone has spent an extra US$300m on its gas-fired IPPs compared to the cost saving it could have got from its coal IPP

The Government's boom in capacity came just as demand flattened

Supply and demand in Luzon (1986-2012)



	%CAGR (1986-2012)
Demand + Required Reserve*	4.5*
Peak demand	4.6
Dependable capacity	4.6

Note: * Philippine Grid Code previously mandated 23.4% reserve be available, since 2011 it has required 4% for frequency regulation, a quantity equal to the most loaded unit for contingency and a quantity equal to the second most loaded unit for dispatchable

Source: DOE

So far we have identified that we need to

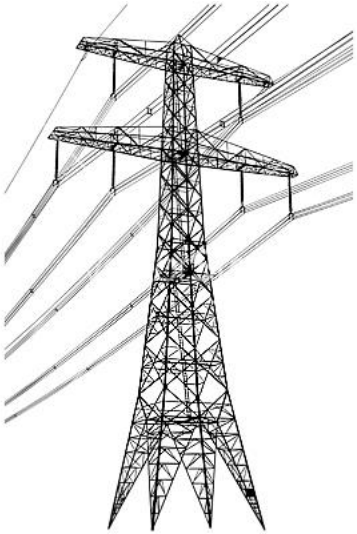
- Clearly define the objective
- Identify constraints and resources needed
- Know where you are starting from

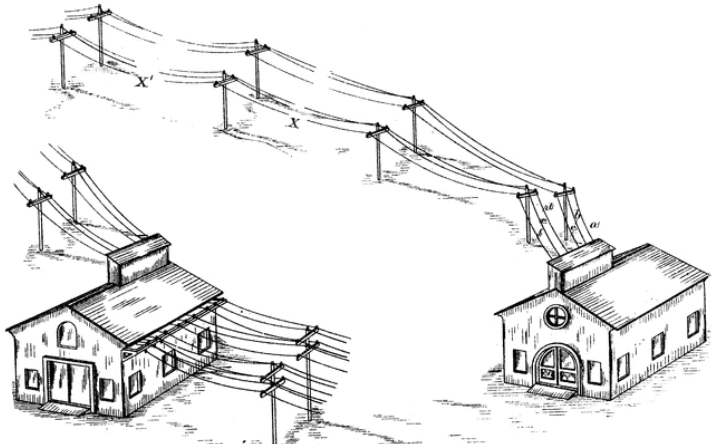
The next section reviews how to decide where to go next

- Plan how to meet the objective
- Then implement.

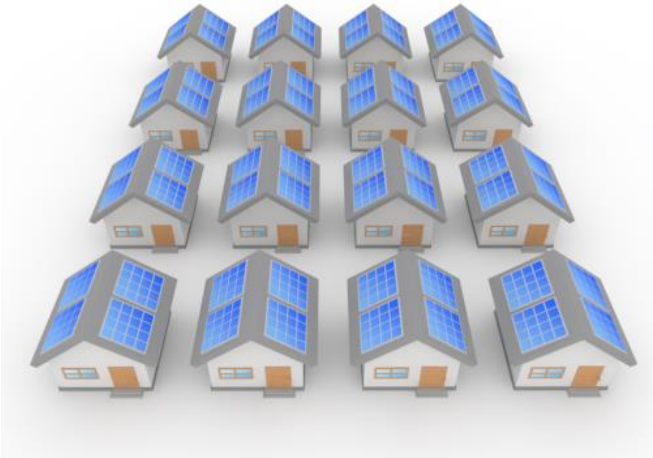
So – what should be implemented?

- This?





- Or this?



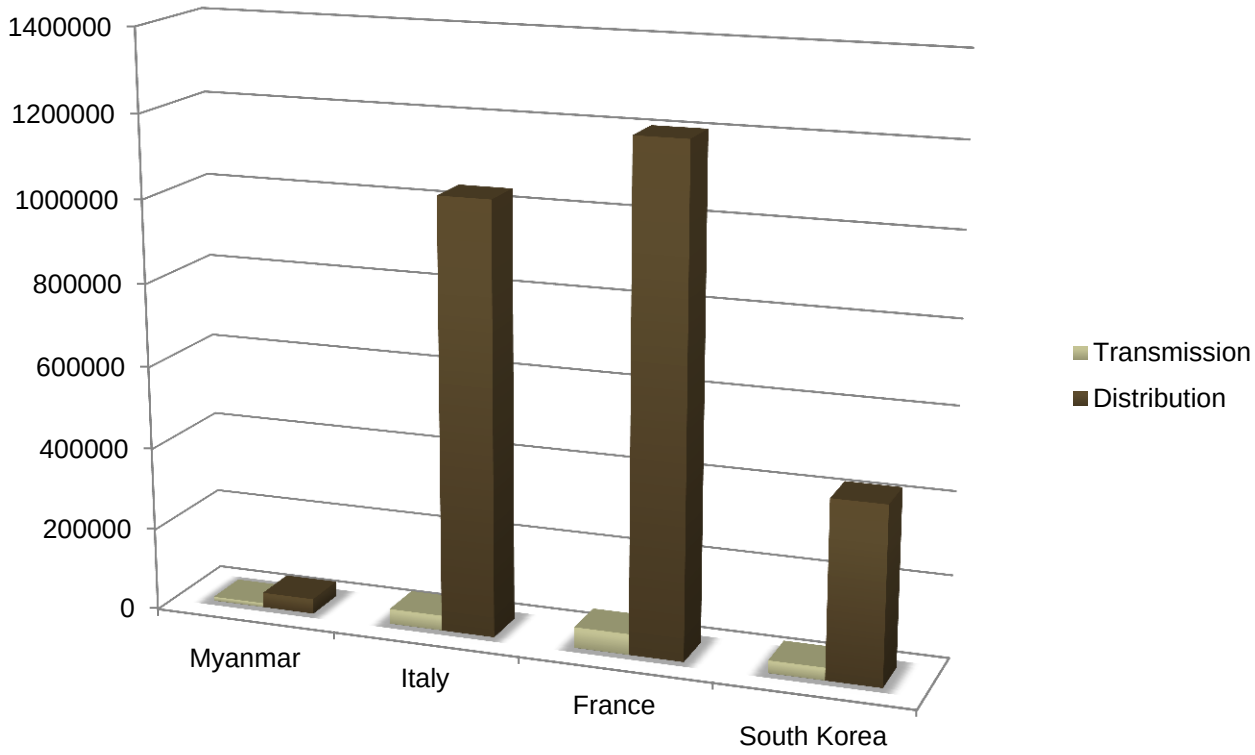
Just because everyone else has a grid, does that mean Myanmar should too?

- Most countries aim for a “traditional” grid system
  - Large (100MW and up) power stations located close to the fuel
  - A backbone of transmission lines linking the power stations with the major centres of demand
  - A network of smaller distribution lines connecting each customer with the transmission system
- However, these systems were installed at a time when:
  - There were very large economies of scale associated with generation
  - There were no small power stations
  - There were no economic renewable options, such as wind, solar, geothermal or micro-hydro
  - Reciprocating engines were dirty, unreliable and inefficient
  - Battery storage did not exist

Assuming a traditional grid is the only answer ignores the changes in technology since the 1940’s

How does Myanmar compare internationally? Or, what is the size of the gap?

- In terms of population, with approx. 55m people Myanmar is squeezed between Italy (61.5million) and South Korea (49m) on an international scale
- In terms of land area, with 677 thousand sq km, Myanmar is a little larger than France (643 thousand sq km).

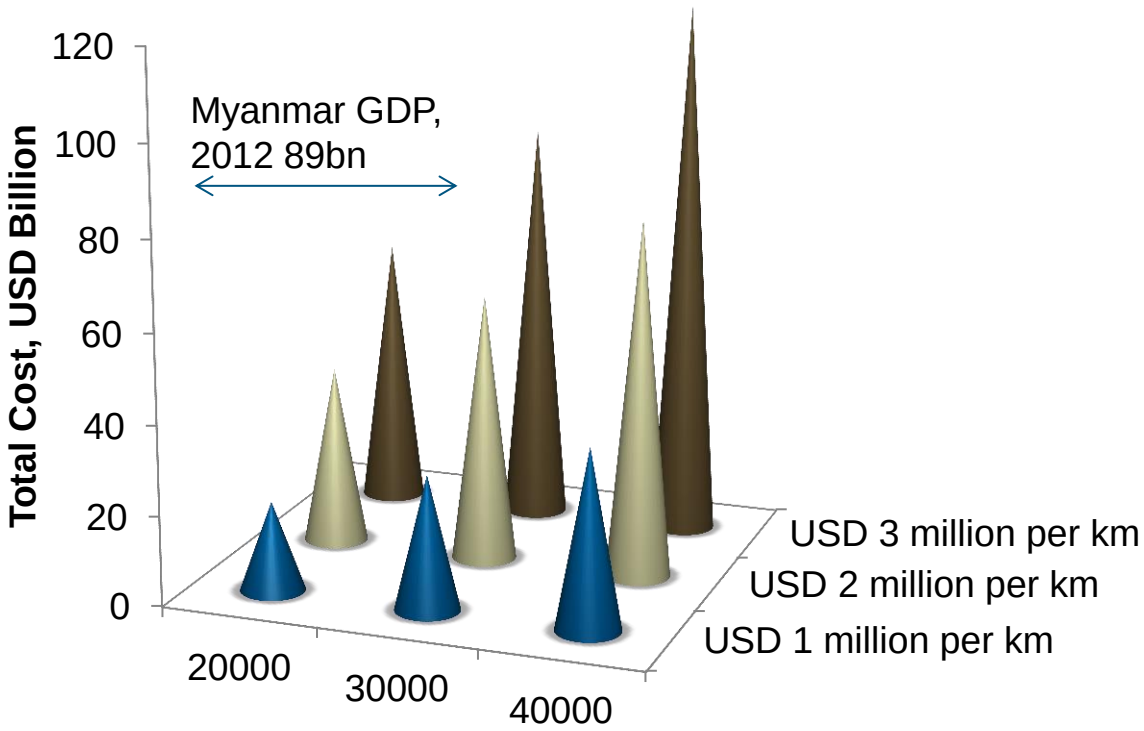


When it comes to transmission and distribution lines, there is no comparison

And transmission and distribution do not actually create electricity, they merely move it around

The cost of a transmission grid alone could rival total annual GDP

- Looking at the statistics of Italy, France and South Korea, we can see that Myanmar needs perhaps 400,000 to 1,000,000 km of additional distribution lines and around 20,000 to 40,000km of transmission



- The costs of transmission and distribution lines vary wildly around the world, making it very hard to estimate how much this would cost – however estimates in the order of USD 1m – USD 3m per km are not unusual
- Maintenance is also not trivial – estimated to be in the order of USD1000 per circuit-km pa

However, the question of exactly what should be done is less obvious

- Money is like any other scarce resource and should be rationed appropriately. However the key is to think through what is needed and make good decisions upfront rather than tackling the problem using the status quo
- Focus on where the most benefit can be achieved for the least cost
  - Which requires a clear framework for identifying "benefit"
- Save money wherever possible using optionality and flexibly size assets
- Optimise the timing of spend
  - There is no point building a transmission line too far in advance of the power station whose load it will carry; and visa versa for the power stations
- Use "out of the box" thinking to lower costs and achieve benefits – even if these are not the "traditional options" or the "way things are done in other countries"

Some examples of how this kind of thinking is working elsewhere follow

Much analysis has been done in Africa on how to electrify at lower cost

- Like Myanmar, Africa has large land areas and low electrification rates
- Recent research by the World Bank identified a number of ways to cut costs in Africa:
  - Appropriate Engineering – designing the system (e.g. the minimum standards required for each component) to meet the actual needs rather than having a single “minimum standard” for all conditions irrespective of whether ice-loading, for example, is relevant in tropical areas
  - Institutional Cost Cutting Culture – where all aspects of installations are questioned as to whether they are actually needed and unnecessary costs removed
  - Single Wire Earth Return – used extensively in NZ and Australia for distribution to sparsely populated areas
  - Shield Wire System (SWS) - This system enables high-voltage transmission lines to deliver power to communities with a much reduced cost in building separate distribution networks, transformers etc.

Exactly what would work in Myanmar may vary, but ensuring the framework is set up to question all costs and design appropriate and flexible installations is robust

Other ways to improve efficiency and lower costs includes

- Procurement practices that increase competition and avoid wastage
- Functional procurement that gives some flexibility to vendors
- Good inventory management
- Overall quality control, with improved operational maintenance, to reduce lifetime costs.

Renewables are becoming popular in many developed countries ….. for reasons that are entirely different to why they might have a place in Myanmar

- In many countries, renewable and distributed solutions are being touted as part of a "smart grid" to solve global energy problems
  - Wind, solar, geothermal, micro-hydro, wave power have no carbon emissions
- However, barriers to entry are many – often revolving around the need to recover the costs of existing infrastructure (regulatory barriers) or fitting "new" solutions into the existing system (technical barriers)
  - Meaning that developed countries have had to implement a slew of incentives, cross-subsidies, renewable credit schemes or feed-in tariffs to encourage renewables
- A developing country should not be wasting money on technologies which are not cost-effective and should certainly not be subsiding them
- However, the lack of existing infrastructure in Myanmar actually means many of the barriers to entry for renewables in developed countries are lower; and the small-scale, distributed nature of the "fuel" may actually mean renewables are more cost effective than a traditional grid for some consumers

Developing a traditional system will require a huge injection of capital

- A “traditional” system may require the following:

	Requirements		Costs (USD billion)	
	Low	High	Low	High
Transmission	20,000km	40,000km	40	80
Distribution	400,000km	1 million km	80	200
Generation	40 GW	60GW	52	78
Total			172	358

- Assumptions:
  - Transmission lines cost USD 2 million per km
  - Distribution lines cost USD 200,000 per km
  - Generation stations cost USD 1.3 million per MW
  - **No fuel is included**
  - **No operating costs are included**

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THESE ARE HUGE NUMBERS!

Compare this to a hypothetical solar mini-grid system

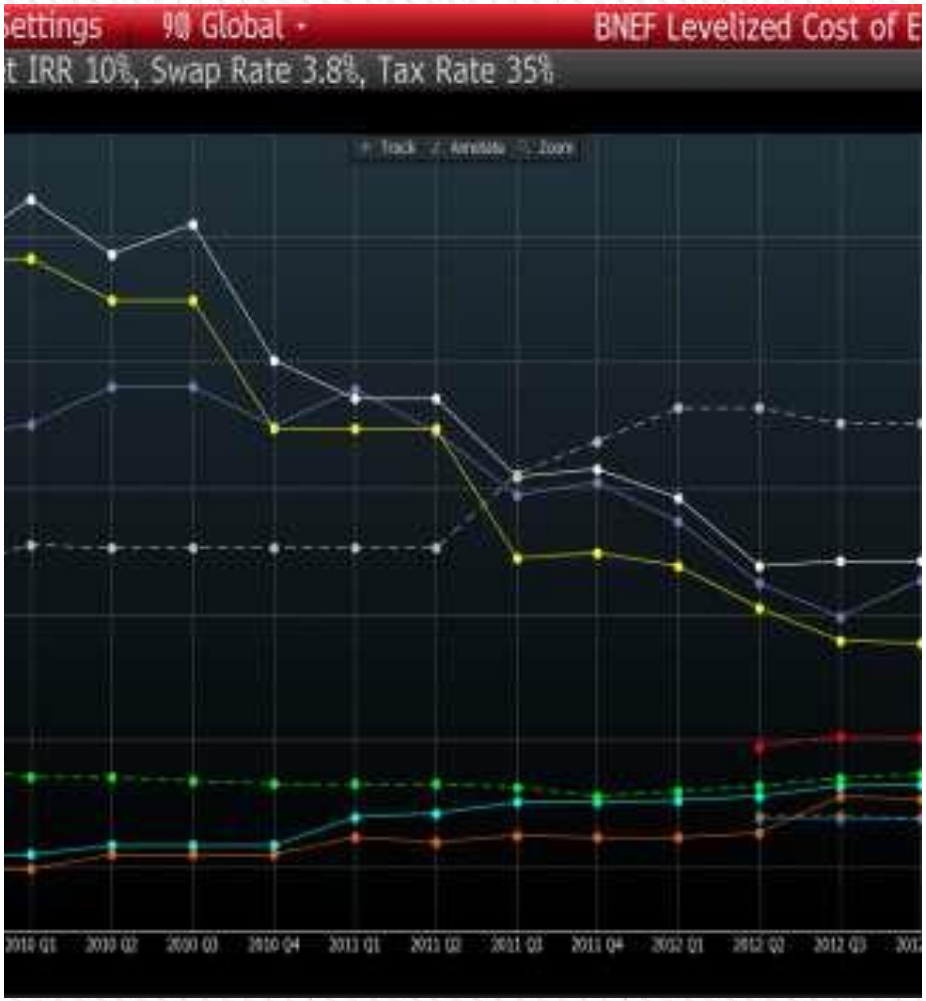
- Assumptions:
  - Solar panels at USD 0.7/kW
  - Inverter and balance of system, circa USD 0.5/kW
  - Battery approx USD 3/kW
  - Total cost, approximately USD 4.2 million per MW
- Assuming Myanmar needs 40,000GW of generation in total, the total cost of this would be USD 168 billion

Still a large number – but comparable or lower than the “traditional grid”

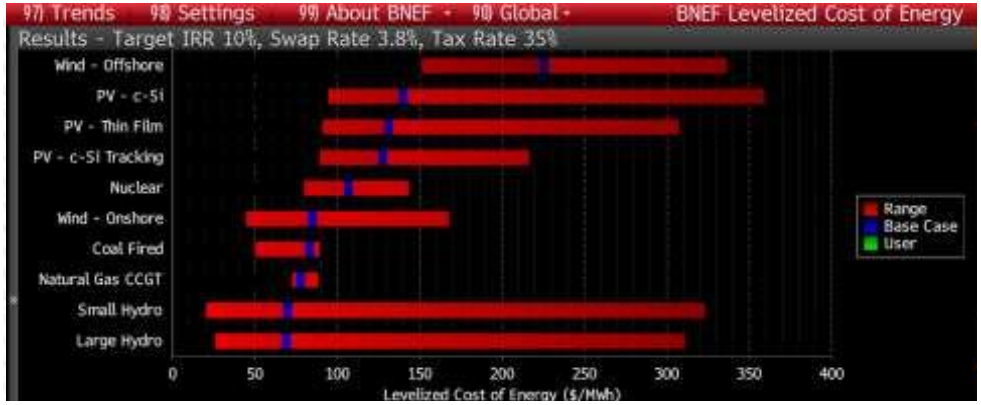
There are other benefits to distributed and mini-grid solutions

- The skills required can be taught to a wide range of people, meaning that locals can install and maintain many of these systems
  - Unlike distribution and transmission systems, which require skilled personnel to maintain power lines to avoid electrocution
- The distributed skill base means that a wide base of people can benefit from this industry – spreading the value of the development across the economy rather than focusing it in a few specialized ESI staff
- Systems are modular – a small system can be upgraded to a larger one at a later point in time as demand grows, or integrated into a traditional grid as the grid expands
- Renewable solutions have “free fuel” – insulating the cost from world fuel prices – unlike coal or gas fired power generation

The costs of renewables have fallen significantly over the last few years



- As technology costs fall, the most economic new technology in any situation changes
- Economic analysis should review not only what is the most economic option today, but also how this might change in the future



Source: Bloomberg Industries <BI GO>

It would obviously be nonsensical to suggest the entire Myanmar system is developed using solar mini-grids!

- That is not the point
- The point is that, today, various technologies exist that did not exist previously
- The cost of those technologies is at its lowest point in history, and options that did not previously exist may now be worth examining
- Following “what others have done” may miss the opportunity to create something entirely new, completely different, and much more cost-effective than other markets

Myanmar may have the opportunity to leapfrog the situation in many countries and go straight to a “smart grid” and the most efficient mix of transmission, distribution, centralised generation, mini-grids and decentralised generation options

The key is to step back and think about what is the best to be achieved

- How can policy be designed to encourage home-installations; small mini-grids, fast track IPP's **and** the most cost effective larger grid infrastructure and power stations?
- How can the regulatory and policy frameworks be designed so that no cost-effective options are overlooked or discriminated against?
- Where is the money (limited resource) best spent?
- What are the best options for Myanmar's indigenous resources (fuel)?
- What training and capacity building will result in the most effective improvements in technical skills?

Think first; act later. The frameworks which are set up now will set the scene for the future and may preclude or close out sensible options if not well designed

This is where economic analysis can help

- The problem is that Myanmar wants electrification, but lacks the money and skills to make it happen “tomorrow”
- It needs to decide how to get the best outcome for the limited resources (time, money, skills) it currently has
- This requires a clear policy framework that results in the right kinds of investments
- Economics is about maximising utility when you have limited resources
  - Choosing which options have most benefit
  - How to ration resources
  - How to maximise utility (or benefit) from what is available
  - How to use optionality and flexibility to keep

A clear economic framework can assist in decision making and critical thinking

Economic Analysis is not that common in Asia

- We have already seen, in our example from the Philippines, the result of this
- The USA is a bastion of free markets and economic thinking – how has this helped in their energy sector?

The US Shale Gas Revolution –
An Example of Free Markets and Innovation

- Shale gas in the USA is an excellent example of market forces working in an environment which enables small and private sector players.
- The US commercial environment allows investors to make commercial decisions and take the rewards of good (and bad) investments.
- The energy sector in the USA has a good basis for allowing supply/demand factors to flow through to price and the infrastructure means that new discoveries can easily come to market in a network of pipelines with open access.
- This fostered an environment of innovation where high oil prices led to a focus on discovering new oil and gas reserves - the end result of which was the shale gas revolution which has increased US gas reserves by multiples over the previously known commercial reserves.

A good, economic framework for the energy sector in Myanmar would

Have an over-arching policy which:

- Encourages innovation
- Fosters an environment where decisions are open, transparent, based on sound analysis and consultation (without being bogged down in bureaucracy)

Has a regulatory environment which:

- Rewards good decisions and allows the impacts of poor decisions to flow through to the decision maker (and not the customer)
- Does not penalize good decisions that happen to have bad outcomes (luck is a factor)

Is implemented by companies and government departments that

- Question each decision
- Review each investment for efficiency, appropriateness, size and timing

For example: Cost drivers in distribution systems

- Econometric analysis identifies two major cost drivers, they are:
  - *Connection density:* measured as the number of connections or capacity provided per km line length; and
  - *Customer class:* measured as the average level of energy consumption of end- users. Load factor, a variation of average consumption levels, is measured as the ratio of average demand to peak demand.
- The influence of these conditions on network costs reflects the productivity of capital.
  - Connection density reflects the productivity of capital invested per *length of line,* that is, how many end-users can be connected to a given length of line.
  - Customer class or load factor measures the productivity of the capital invested in the *capacity* of the system, that is, how many units of energy are conveyed for a given level of capacity?

This analysis has been done for existing systems in Australia. But would it not be better to base decisions on what to install on the same parameters and only install those that are cost effective?

“Appropriate Engineering” – a term used in the African study - is also another way of saying “only install equipment that is economic”

Some major capital cost items to be appropriately designed are:

- Network phase: Single-phase, instead of three-phase networks, are likely to be adequate in many situations, with the design permitting upgrading to three-phase in the future
- Transformers: In many cases, they operate at a fraction of their design output and do so for their entire life. Transformers should be closely sized to the actual load flows, with flexibility
- Poles: The traditional pole design has cross arms on the top of the poles. Modern designs use post-top insulators fixed directly to the side of the pole and there are no cross arms. Pole-mounted transformers should be mounted on a single pole instead of using the conventional three pole design.
- Conductors: Should be sized for the actual load conditions and smaller conductors should be used wherever possible, except where there is a high incidence of lightning strikes.
- House connections and ready boards: Traditional methods provide a circuit breaker with a protective housing mounted on the pole and a cable leading to the house. The expensive circuit breaker and its housing may be replaced by a fuse or even a piece of fuse wire and the cable to the house should be an aerial conductor of flat twin and earth construction (dumb-bell) cable.

What is the role of the Public vs Private Sector in this framework?

- In many countries, the ESI has been built by the public sector – often with a single, vertically integrated monopoly building the transmission, distribution, generation as well as retailing electricity – KEPCO, for example, in South Korea.
- In some countries, the ESI has been built almost exclusively by the private sector with various private utilities building transmission, distribution, generation and retailing (usually at regulated tariffs) to customers – The IOU's in the USA, for example
- In recent years, there has been an increasing move away from public ownership to private ownership – with privatisation processes in the UK, Australia, NZ, Singapore, Philippines, for example
- What works best in Myanmar is whatever fits with the framework of least cost, flexible development that leaves options open
- Private sector participation brings valuable capital, but also requires structures that may lock in rigidity; care needs to be taken to avoid the negative consequences of this

If the private sector builds a large power station (IPP) it generally has certain minimum requirements

- The key requirement for an internationally financeable PPA is certainty of revenues
- This means that payments must be made under a very wide range of situations.
  - Except for fault or negligence of the power station, most internationally financeable PPA's will put most risk onto the buyer.
- For example:
  - Transmission connections will not be the responsibility of the IPP and they require certainty of revenue even if the transmission connection does not occur
  - Fuel supplies are not the responsibility of the IPP and payments are made even if fuel shortfalls occur
  - Payments continue even if the demand falls and the power station is no longer required
  - Payments are set in hard currency and the buyer takes the risk of foreign exchange fluctuations
  - Construction will not start until all the agreements are in place and financing has been secured

Fitting IPP's into the system is different depending on the size of the system and the demand

- The features of IPP's, as noted on the previous slide, can create constraints in the system:
  - If transmission construction does not keep pace with IPP construction, payments for energy not delivered may occur
  - If demand does not keep pace with IPP construction, payments are made for capacity not actually required
  - The complexities of international financing may also delay projects
- Therefore, relying solely on IPP's in a small system may mean that these constraints put an unbearable burden on the system

Care is therefore needed in planning and implementation to ensure that IPP's are well thought through, so that the right plants are selected at the right time so as not to overly burden the system

So is there a “right” answer to who should own the assets?

- Not really
- Ownership is only one aspect of the ESI – and ownership is not the same as policy or regulation
- Governments should set POLICY – the over-arching framework within which everyone else operates
- Regulators should REGULATE – ensuring that costs are managed, consumers pay the right amount and nobody abuses a monopoly position in the market
- Ownership is really only about who provides the capital, and how that capital is rewarded. Either public or private is fine, provided the capital is recognised and rewarded at the appropriate rate. However, in a capital constrained world, private sector investment can help to alleviate constraints in infrastructure investment which is one reason private sector investment in energy is now so prevalent

With a good policy framework, ownership should not be the key question. Rather – efficiency and effectiveness are important.

In summary

- Good outcomes generally result from good decisions
- Good decisions:
  - Require a clear framework
  - Benefit from good data and information inputs
  - Are a product of good analysis
  - Should require the investor to take some of the risk of the outcomes
- The best advice for the development of the energy sector in Myanmar is to set a policy and regulatory framework for good decision making
- And allow the decisions made under that framework to guide development