SUSTAINABLE HYDROPOWER FOR THE 21ST CENTURY

Asia Clean Energy Forum

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Millison's Hydro experience

- 2002 Zhanghewan Pumped storage
- 2002-03 Xiaogushan Hydro 98 MW
- 2004-06 India Uttarkhand MFF: grid expansion to support 2000+ MW of large hydro
- 20013-14 Nepal SASEC: grid expansion to support 2000+ MW of large hydro + RE mini-grids
- 2014-16 India Assam Lower Kopili120 MW

Nepal hydro: an embarrassment of riches?

- Economic potential: 40,000+ MW
- Installed: < 2% of potential   787 MW
- 61 plants
- Average size 12.9 MW
- Only 1 > 100 MW - Kaligandaki A 144 MW
- Today only 3 plants under construction with capacity > 100 MW, including
  Upper Tamakoshi 456 MW

What's wrong with this picture?

Traditional Design: Maximize MW

$$P = n \times p \times g \times Q \times H$$

- Traditional design basis:
  - 40-70% reliable flow Q40 to Q70
  - 4000 hours per year @ rated capacity (PLF ~ 50%)
  - Ignore risks until design is fixed, then try to de-risk
- Sustainable Design: Optimize MW-hours
- Modular: Ashta 50 MW hydro IFC

Knowledge base for sustainability by design

- 1970 Aswan High Dam
- 1990s Pangue (Chile) & Narmada (India)
- 2001 World Commission on Dams
- 2003 World Bank *Good Dams, Bad Dams*
- 2006 - 2010 International Hydropower Association sustainability rating system
- 2013 Ashta 50 MW modular hydro IFC
- 2014 Ansar *et al – Should we build more large dams?*
- 2015 Poff *et al* – ecological engineering decision scaling

Traditional vs. Sustainable Design

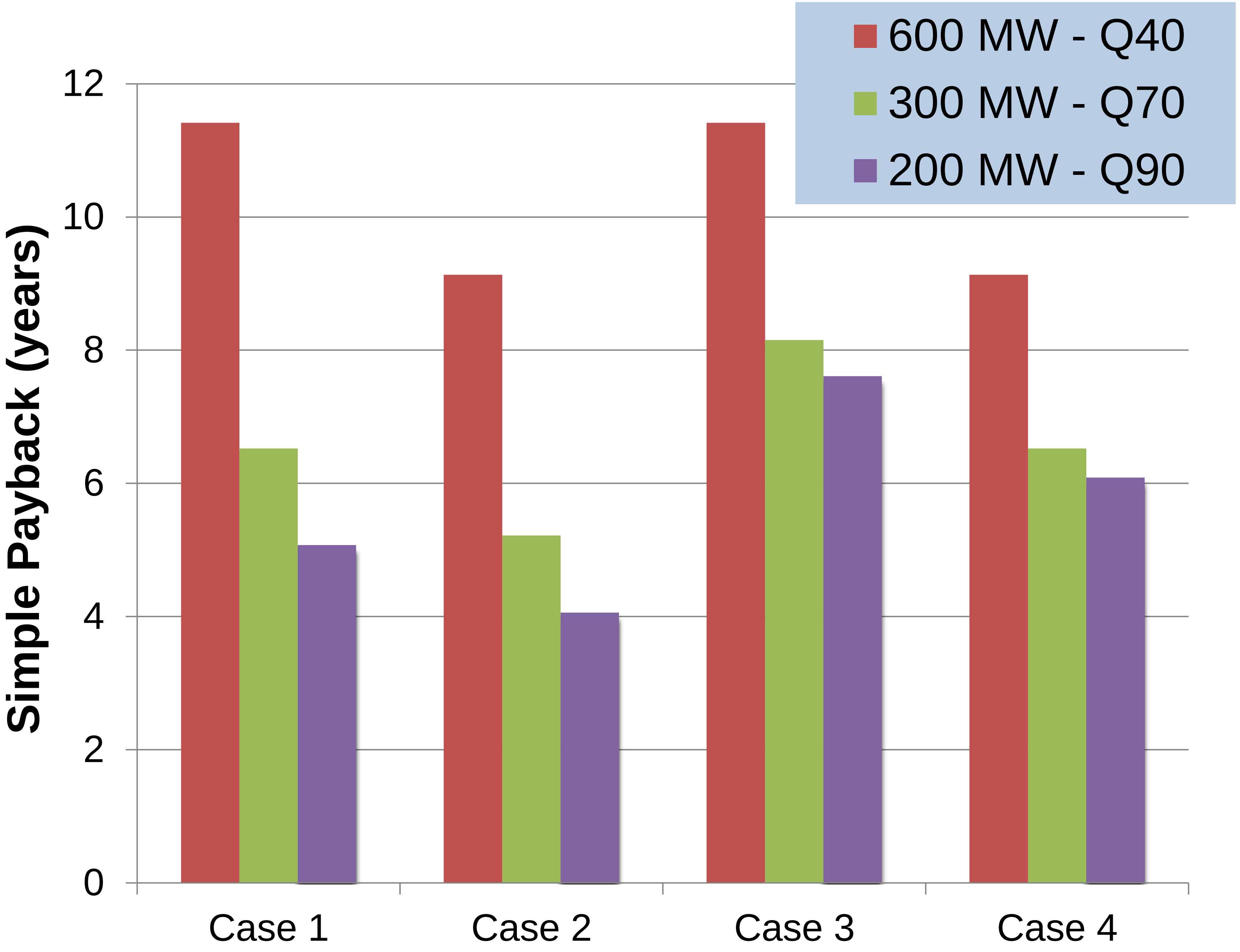
Risk Factor [a]	Conventional Approach	Sustainability Approach
High up-front capital cost	Inherent in traditional development approach	Down-scale capacity ; modular design
Hydrological risk	Q40 – Q70	Design for Q90
Geological Risk	Related mainly to dams and tunnels	Overflow or trench weirs. Low-head design with multiple smaller installations.
Permitting Risk	Multiple parties at central, state/provincial, and local level; difficult to satisfy all stakeholders.	Minimize by shift to smaller installations based on sustainability principles

[a] Source of risk indicators: Bill McCormack, Partner of Shearman and Sterling LLP, *Hydropower Projects in Asia*, presentation at Asian Development Bank, 9 December 2015

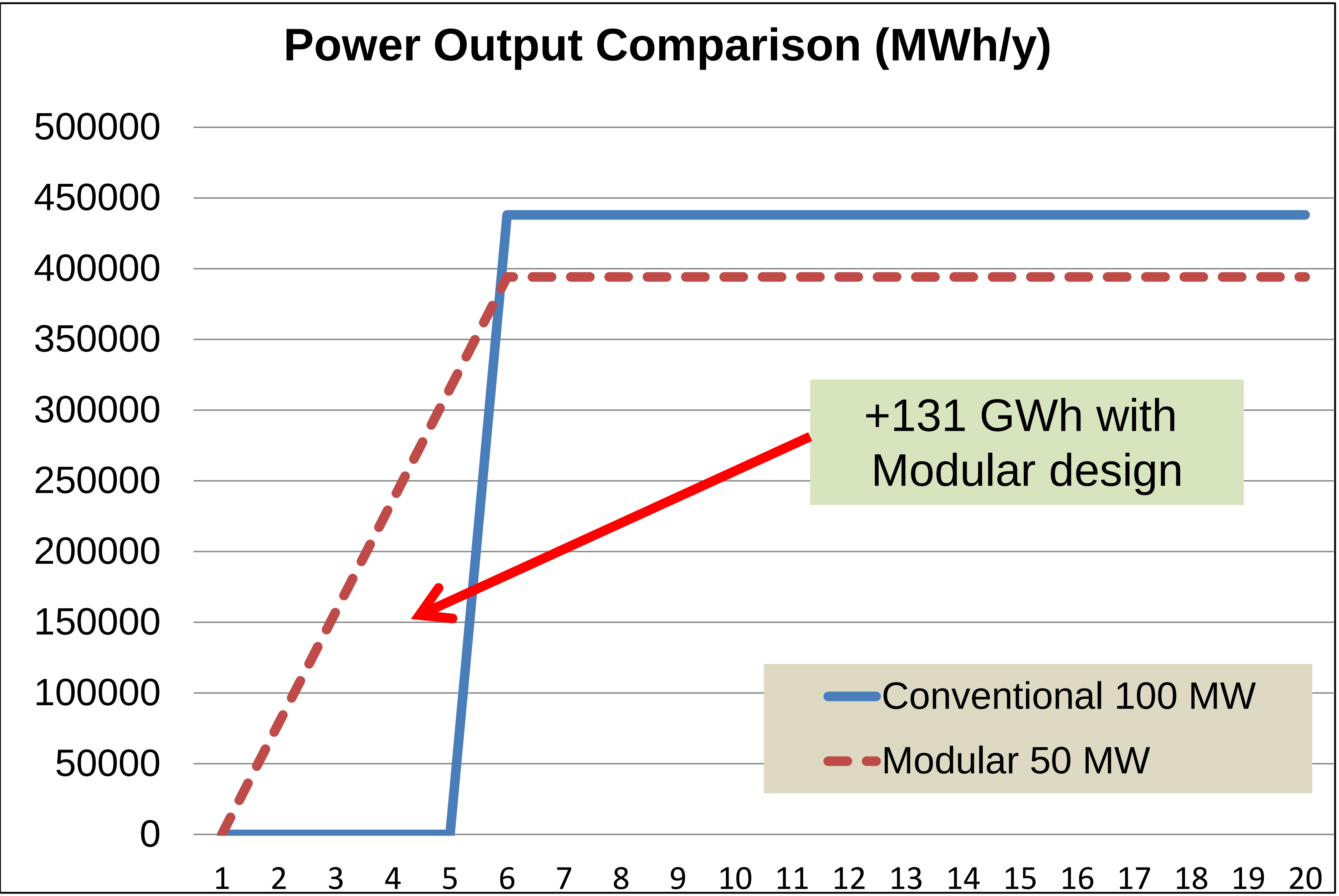
Traditional vs. Sustainable Design

Risk Factor [a]	Conventional Approach	Sustainability Approach
Land Acquisition Risk	Local opposition to resettlement cannot always be de-risked	Include local land-owners and non-titled tenants into project ownership structure
Construction Risk	Related to geological risks	Minimize through modular design using simplest generation technology (ASG)
Environmental and Social Risk	Largely ignored until late in development process	Ecological engineering decision scaling eliminates most risks upfront.
Revenue Risk	Mainly related to financial health of off-taker	Can be reduced indirectly by shifting to smaller capacity design with faster pay-back period

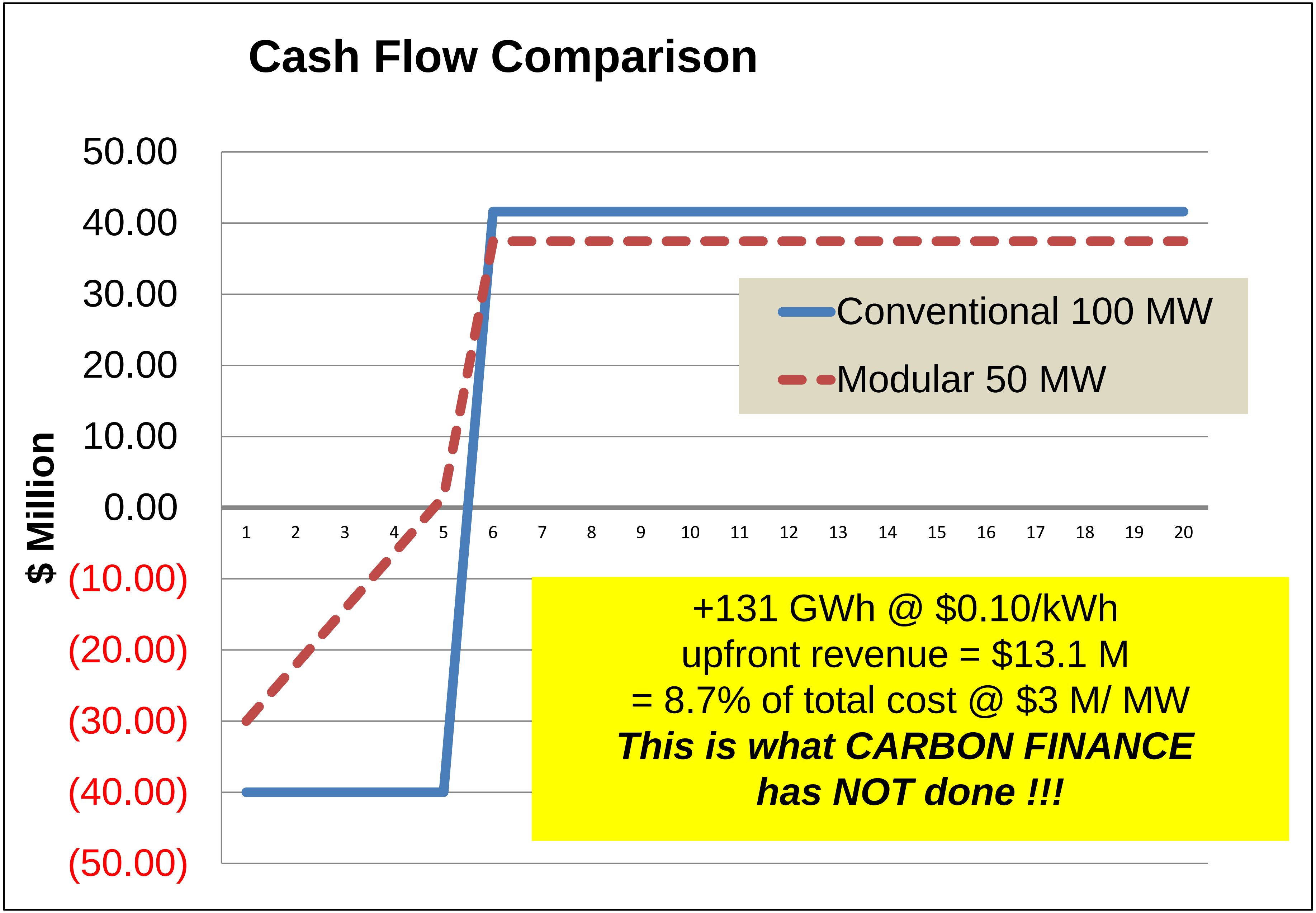
[a] Source of risk indicators: Bill McCormack, Partner of Shearman and Sterling LLP, *Hydropower Projects in Asia*, presentation at Asian Development Bank, 9 December 2015


600 MW - Q40
300 MW - Q70
200 MW - Q90
Simple Payback (years)
12
10
8
6
4
2
0
Case 1
Case 2
Case 3
Case 4

Modular design: more power faster = more $$$ faster



Modular design: less equity, higher return

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ASGs: minimum moving parts, simple civil works, fish friendly, OK for high sediment loads

ASGs: At outlet of sewage treatment plants

ASGs: At outlet of sewage treatment plants

ASGs: At tailrace at existing larger hydro plants

The lesson of "too big to succeed" hydro development

"Policymakers, particularly in developing countries, are advised to prefer agile energy alternatives that can be built over shorter time horizons to energy megaprojects."

– Atif Ansar

Atif Ansar, Bent Flyvbjerg, Alexander Budzier, and Daniel Lunn. 2014. *Should we build more large dams? The actual costs of hydropower megaproject development*. Energy Policy (2014), http://dx.doi.org/10.1016/j.enpol.2013.10.069i

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- International Hydropower Association Sustainability Assessment Protocol
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- N. LeRoy Poff, Casey M. Brown, Theodore E. Grantham, John H. Matthews, Margaret A. Palmer, Caitlin M. Spence, Robert L. Wilby, Marjolijn Haasnoot, Guillermo F. Mendoza, Kathleen C. Dominique and Andres Baeza, *Sustainable water management under future uncertainty with eco-engineering decision scaling*. Nature Climate Change, Perspective, Published online: 14 September 2015. DOI: 10.1038/NCLIMATE2765
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- UNESCAP. 2008. *Greening Growth in Asia and the Pacific: Follow-up to the World Summit on Sustainable Development: Taking action on the Regional Implementation Plan for Sustainable Development in Asia and the Pacific, 2006-2010*.
- World Bank. 2003. *Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects*. Latin America and Caribbean Region, Sustainable Development Working Paper Number 16. World Bank; Washington, D.C., November 2013.
- ***Additional Notes on ecological engineering decision scaling:***
- http://source.colostate.edu/researchers-building-better-dams-starts-with-ecological-insights/
- http://alliance4water.org/events/files/2014_xi_9a.html
- Natel Energy Schneider Linear Hydroturbine; notes that shifting from high-head / large dam to multiple smaller low-head installations gets about 90% of power output while flooding less than 10% of land area, and using 1/3 of the concrete:
- http://www.natelenergy.com/vision/ecosmarthydro/