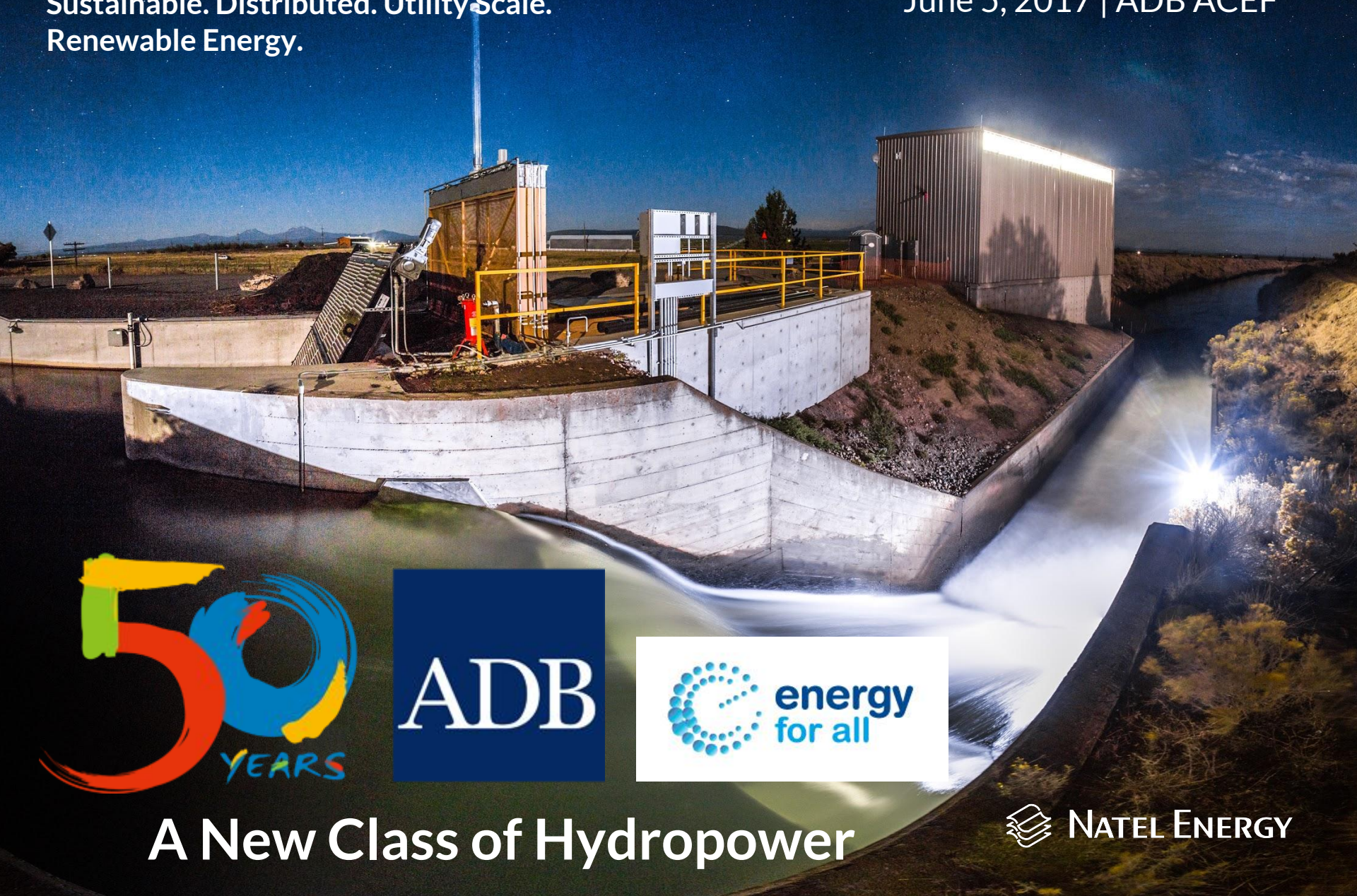


Natel Energy

Sustainable. Distributed. Utility Scale.
Renewable Energy.

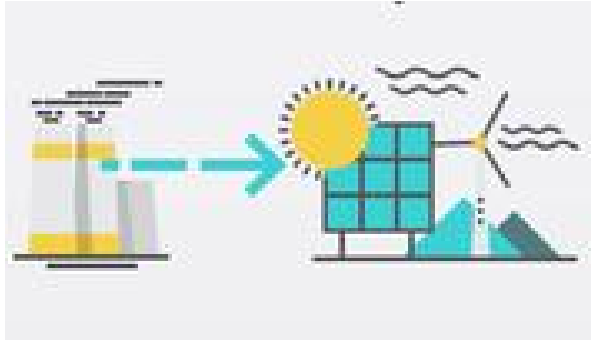
Michael J. Spolum
June 5, 2017 | ADB ACEF



A New Class of Hydropower

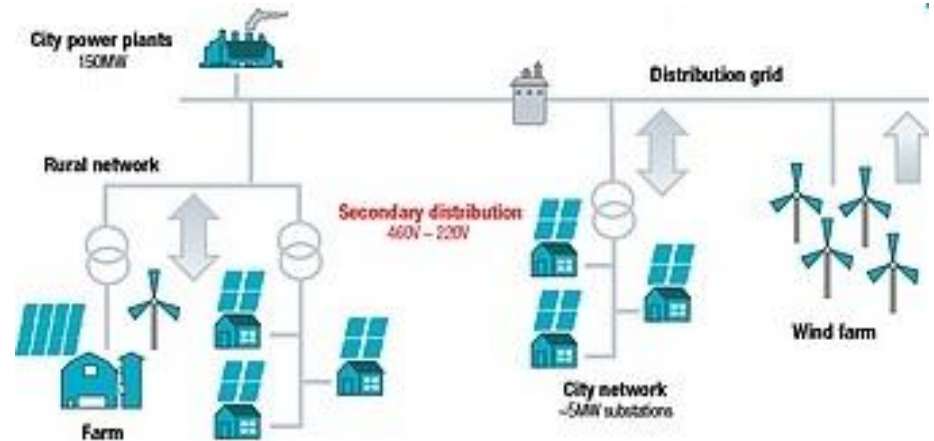


The MEGATREND D's of Energy Innovation



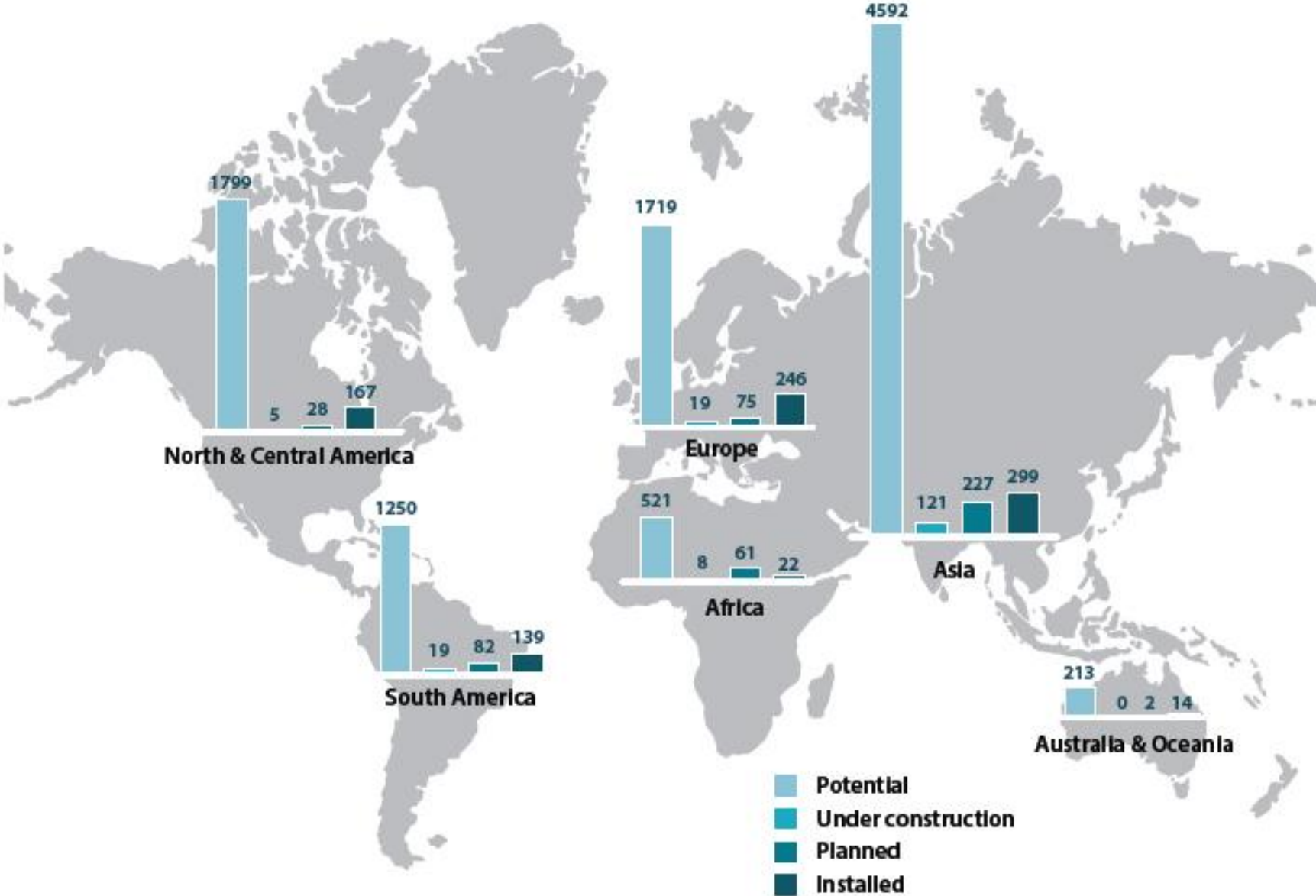
D ecarbonation

D ecentralization



D atafication

Global hydropower resources



Natel Energy is...

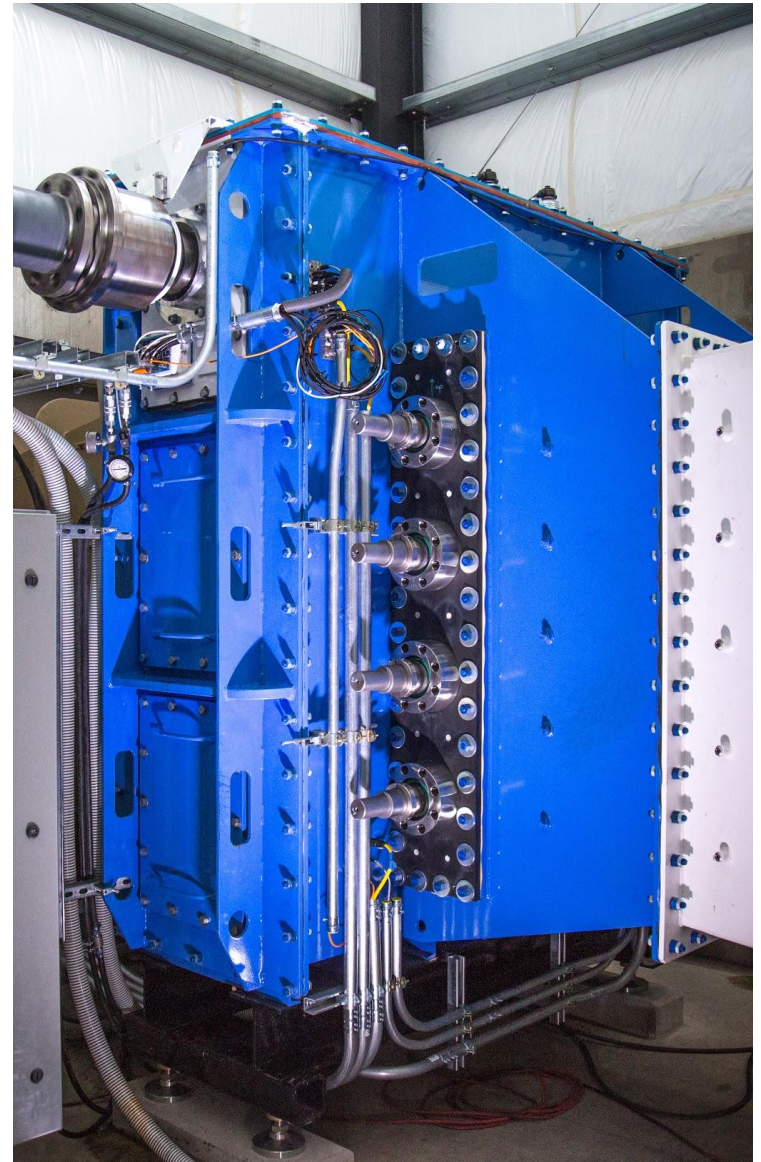
...a **water+energy** company based in California.

...driven by a vision of resilient, low cost, hydropower that solves the problems inhibiting traditional hydropower:

- slow and capital intensive to develop
- negative E&S community impacts
- inflexible in the face of climate uncertainty

Our mission?

To redraw the map of how and where hydropower is developed.

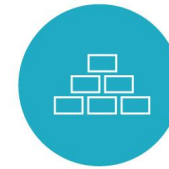


Hardware Innovation: the hydroEngine®

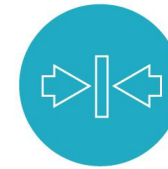
- **Patented** turbine designed around a linear powertrain
- **Modular, standardized** units
- **Fish friendly** design
- Designed for high performance (**90% turbine efficiency**) in low pressure, high flow settings
- Simplified **civil works** and installation



Modular, mass-produced



Simple plant, minimal excavation, less concrete



Compact, high performance



Moderate operating pressure



15% to 20% less expensive turbine



30% to 50% lower installed cost

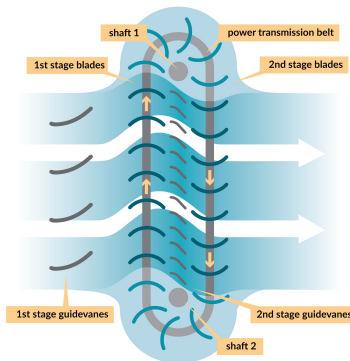


3 to 5 cents per kWh

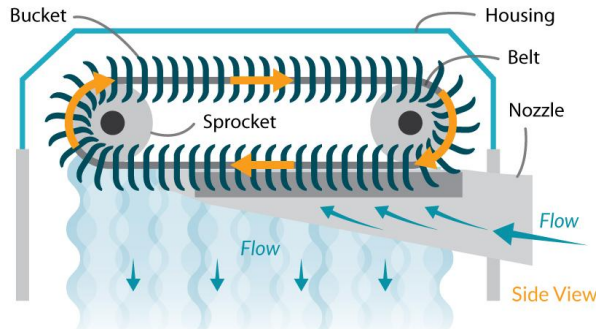


Fish friendly operation

Fully flooded



Free Jet: Linear Pelton

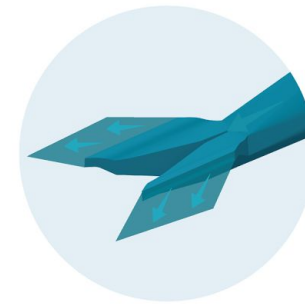


- No cavitation
- Self-cleaning blades
- Works with draft tube to enable very low-head operation in sites with large tailwater fluctuations
- High specific speed (large flow, high speed, low head)
- 90% hydraulic efficiency
- Jet deflector: instant depower with no change in flow rate; no water hammer and no overspeed risk
- Powertrain in air
- No draft tube

How it works: the hydroEngine®

Linear Pelton

High Efficiency, Low Part Count, No Draft Tube



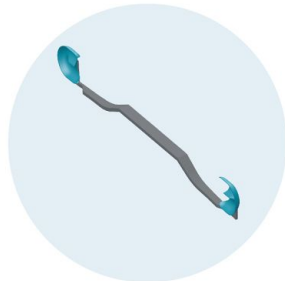
Nozzle

Water entering into the machine passes through the penstock and then a nozzle. The nozzle distributes the water along a linear array of buckets.



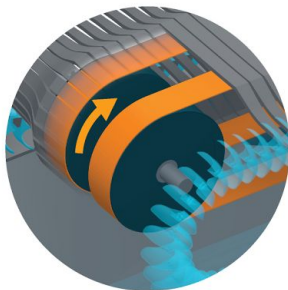
Flow

After the high velocity water exits the nozzle, its momentum is captured by the buckets. Water exits with just enough velocity to cleanly exit the buckets. The buckets are designed with rounded edges to be fish friendly.



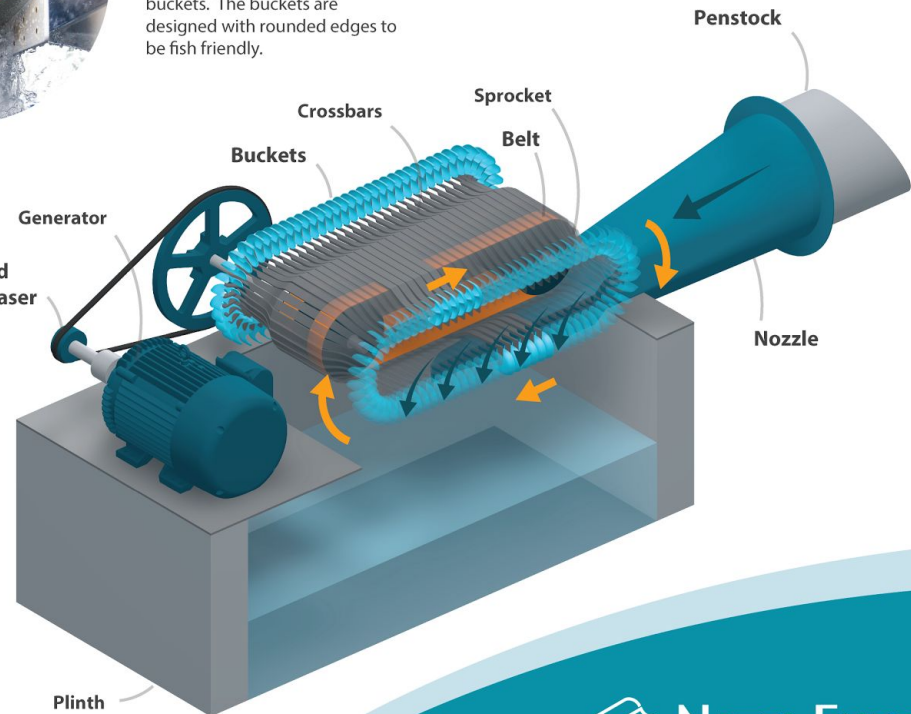
Buckets / Crossbars

After the water's momentum has been transferred to the buckets, force is delivered to the belt through a metal part called the crossbar. The buckets and crossbars are carefully designed to minimize rolling and pitching moments. This dramatically simplifies the crossbar to belt attachment.



Belt / Sprocket

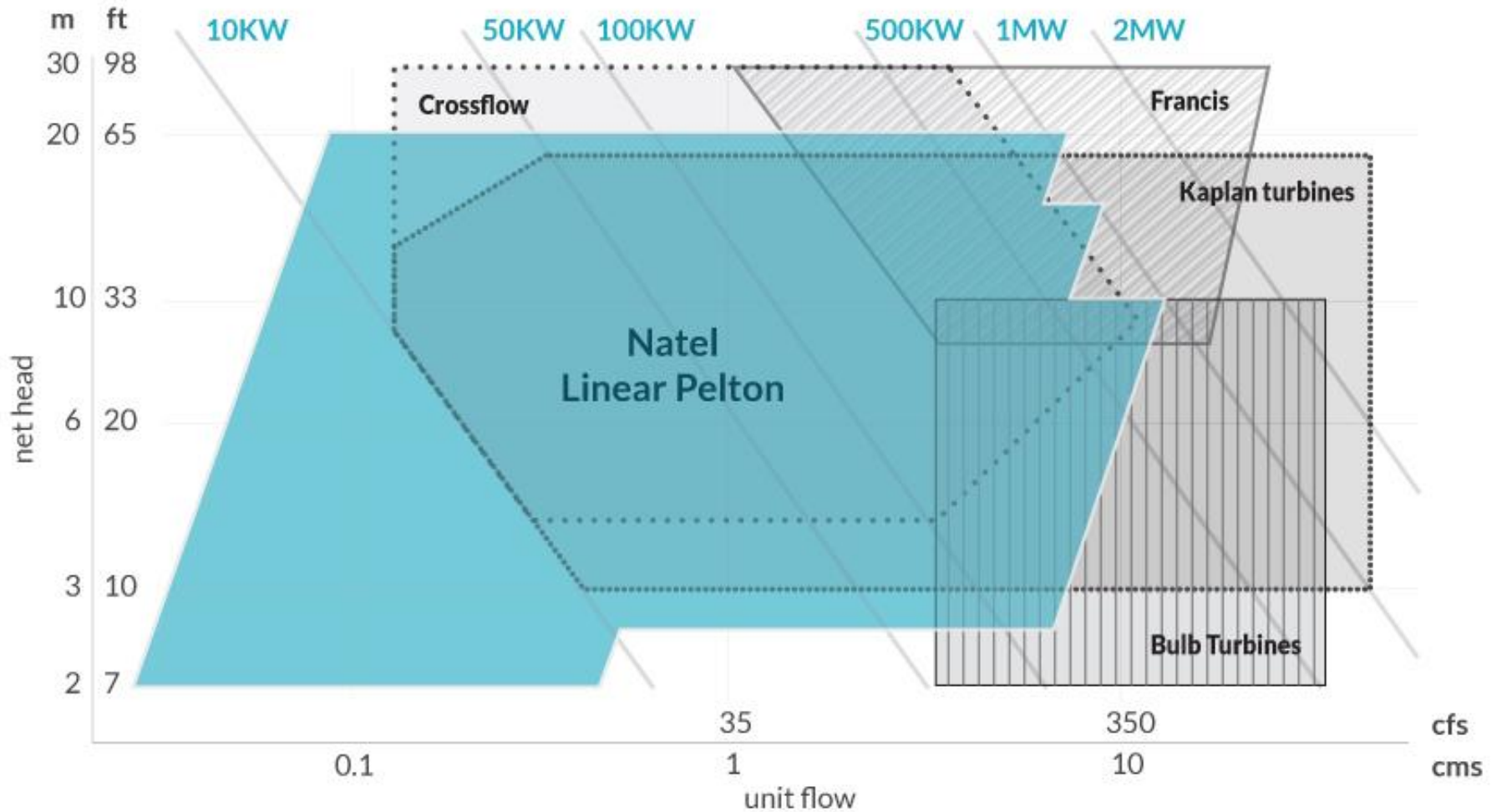
The machine's composite belts transfer force from the crossbars to the sprockets. The sprocket and the belt convert the machine's linear motion into rotary motion, which is then converted to electricity by a conventional generator.



hydroEngine Advantages

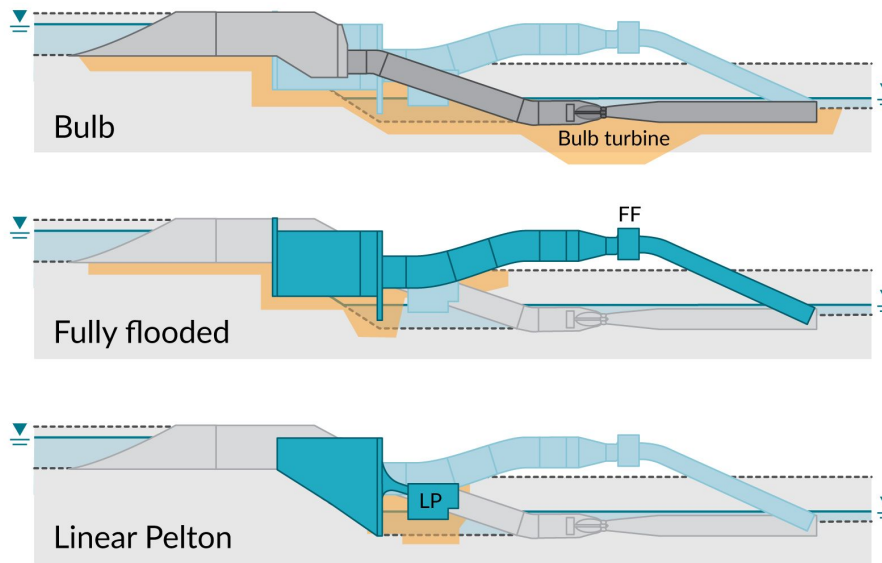
	hydroEngine™	Kaplan	Propellers	Archimedes Screw	Crossflow
Applicable under 6 m of head	<input checked="" type="radio"/> Yes	<input checked="" type="radio"/> Yes	<input checked="" type="radio"/> Yes	<input checked="" type="radio"/> Yes	<input type="radio"/> No
Compact Turbine Size	<input checked="" type="radio"/> Compact	<input type="radio"/> Moderate	<input type="radio"/> Large	<input type="radio"/> Large	<input type="radio"/> Large
No Cavitation Issues	<input checked="" type="radio"/> No	<input type="radio"/> Yes	<input type="radio"/> Yes	<input checked="" type="radio"/> No	<input checked="" type="radio"/> No
Civil Works & Excavation	<input checked="" type="radio"/> Low	<input type="radio"/> Substantial	<input type="radio"/> Moderate	<input type="radio"/> Moderate	<input type="radio"/> Moderate
Wide Flow Range for High Performance	<input checked="" type="radio"/> Wide	<input checked="" type="radio"/> Wide	<input type="radio"/> Narrow	<input checked="" type="radio"/> Wide	<input checked="" type="radio"/> Wide
Fish Friendly	<input checked="" type="radio"/> Yes	<input type="radio"/> No	<input type="radio"/> No	<input checked="" type="radio"/> Yes	<input type="radio"/> Maybe
Low Cost	<input checked="" type="radio"/> Low	<input type="radio"/> Med to high	<input type="radio"/> High	<input type="radio"/> High	<input type="radio"/> Med to high

hydroEngine Operating Envelope

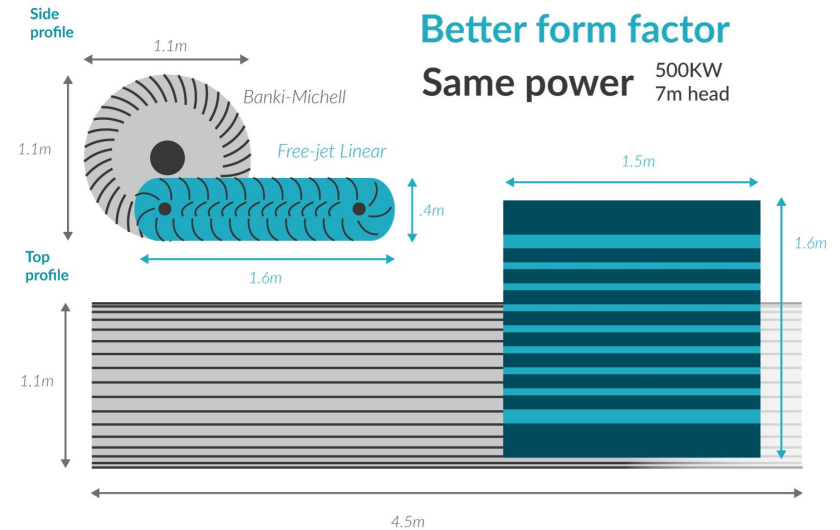


hydroEngine vs. Conventional Options

- Up to 80% less excavation → Higher Flexibility and Lower Cost
- Up to 25% less expensive equipment
- Better form factor



Excavation

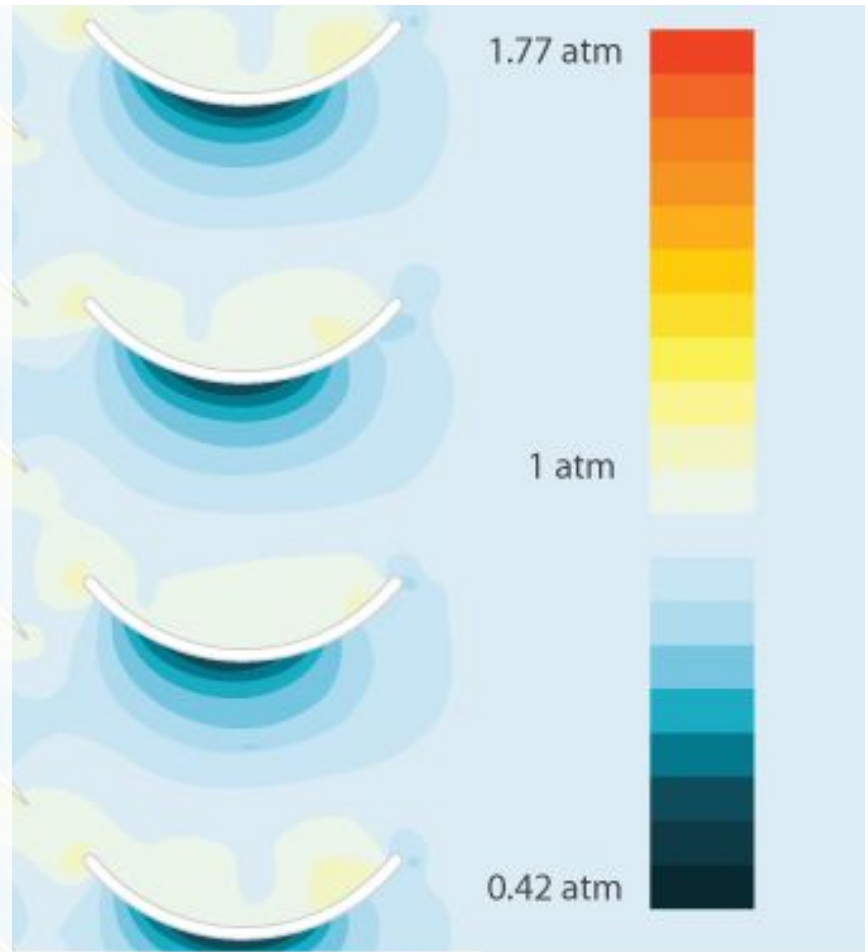


hydroEngine Advantages: Fish Passage

Eliminates 2 of 3 primary modes of fish mortality in turbines and substantially reduces the third mode.

- No pressure drop across moving blades
- No zones of fluid shear
- 40-100X lower impact energy due to blades moving at half of water velocity

Sensor and real fish passage tests in development based on positive analytical results.



hydroEngine Advantages: Controlled Capital Costs

- 10 to 25% cost savings on civil works due to shorter penstocks, reduced excavation and simpler configuration
- 10 to 30% cost savings on equipment due to less expensive turbines

\$4.35 / W



Kaplan



\$2.73 / W



hydroEngine™

Deployment

Grid & Electrical Infrastructure

Civil Work

Turbine Package

Licensing

Interconnection

Project management

Installation

10% Contingency on Natel

Turbine

Generator + Gearbox

Switchgear

Controls

Projects with the hydroEngine



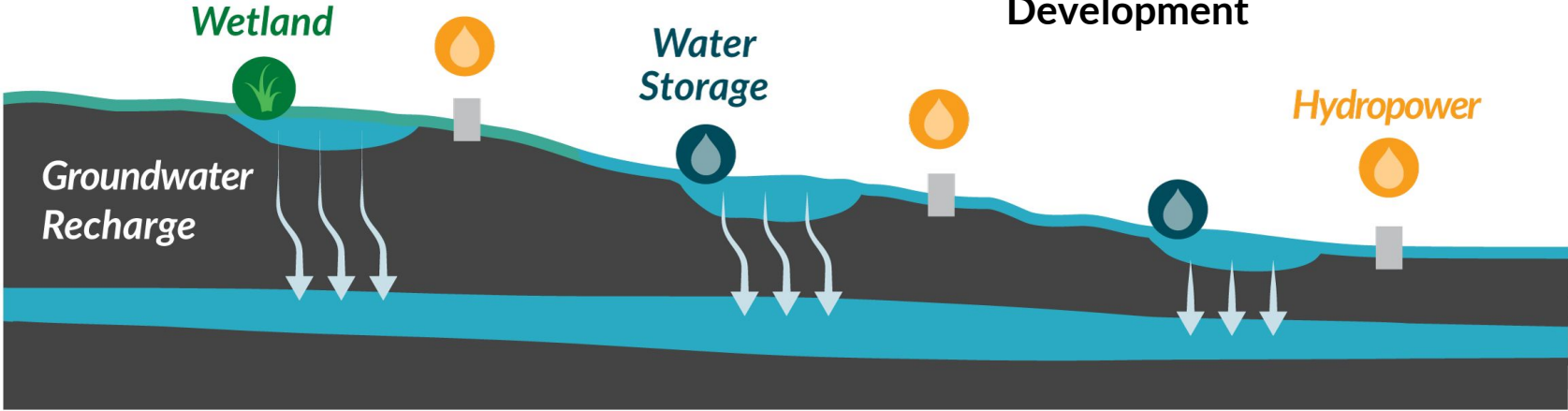
Irrigation
Canals



Non-Powered
Dams

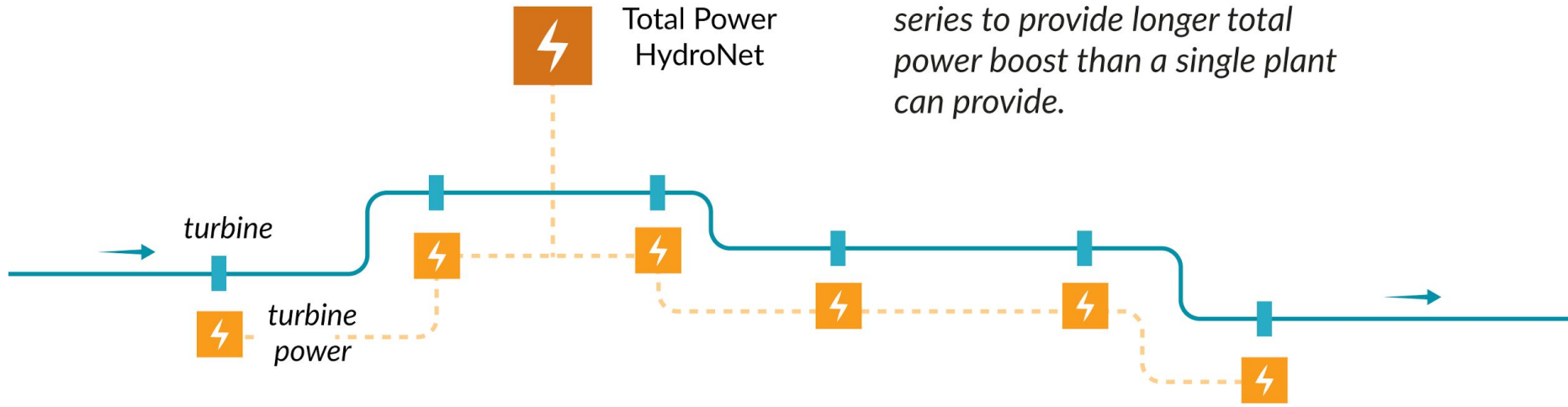


New
Stream-Reach
Development



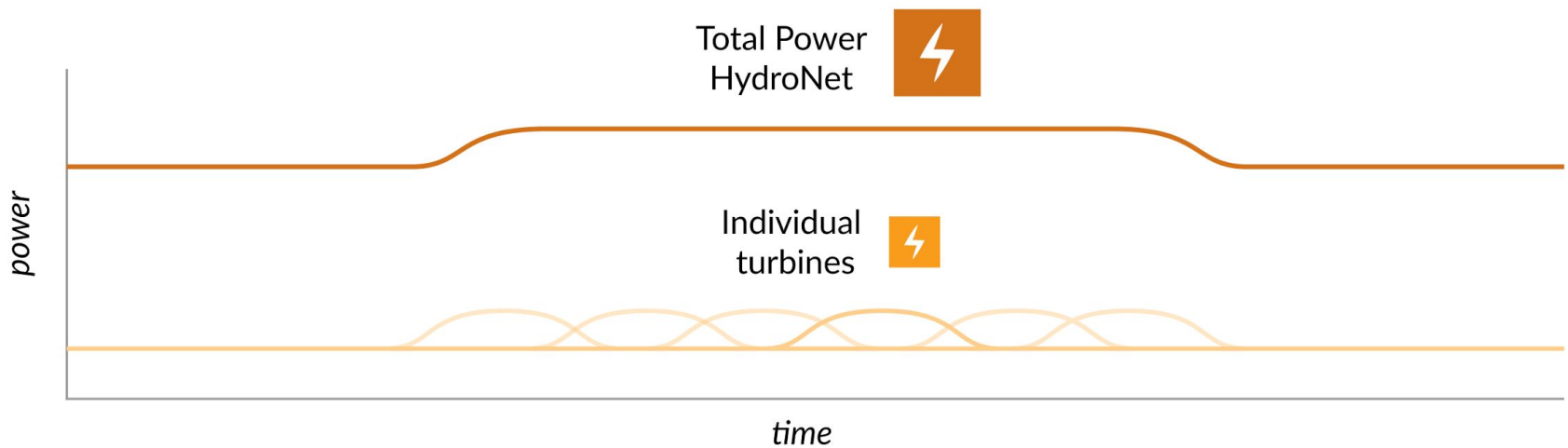
HydroNet - Grid Services from Irrigation Canals

Plants in HydroNet ramp up in series to provide longer total power boost than a single plant can provide.



Physical Layout

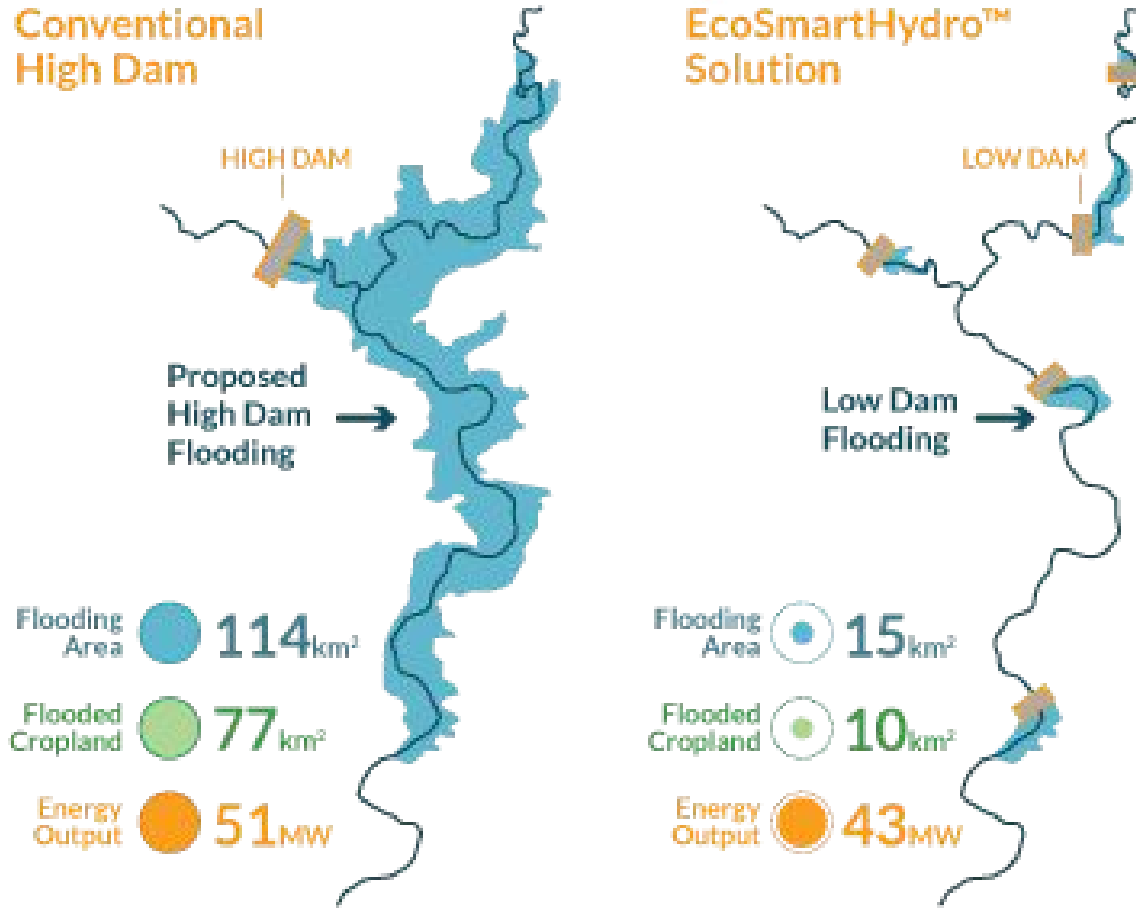
Timeline



EcoSmartHydro™

Conventional High Dam

EcoSmartHydro™ Solution



...is a blueprint to develop distributed, utility-scale, impact-minimizing cascades of climate-resilient hydropower projects - both **retrofits of existing infrastructure** and for **new stream-reach developments**.

Faster to construct / commission

Shorter time to service debt and generate returns

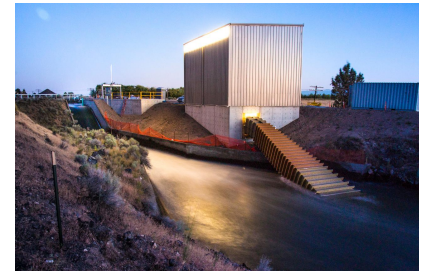
Lower impact, multiple co-benefits

70-90% of the energy, 5-10% of the inundation

Materials efficient construction

40% less concrete, 50%+ less excavation

Completed Projects:



Natel Pipeline Detail

Global Project Portfolio



N.America.
Pipeline: 100 MW

Bhutan
Pipeline: 50MW

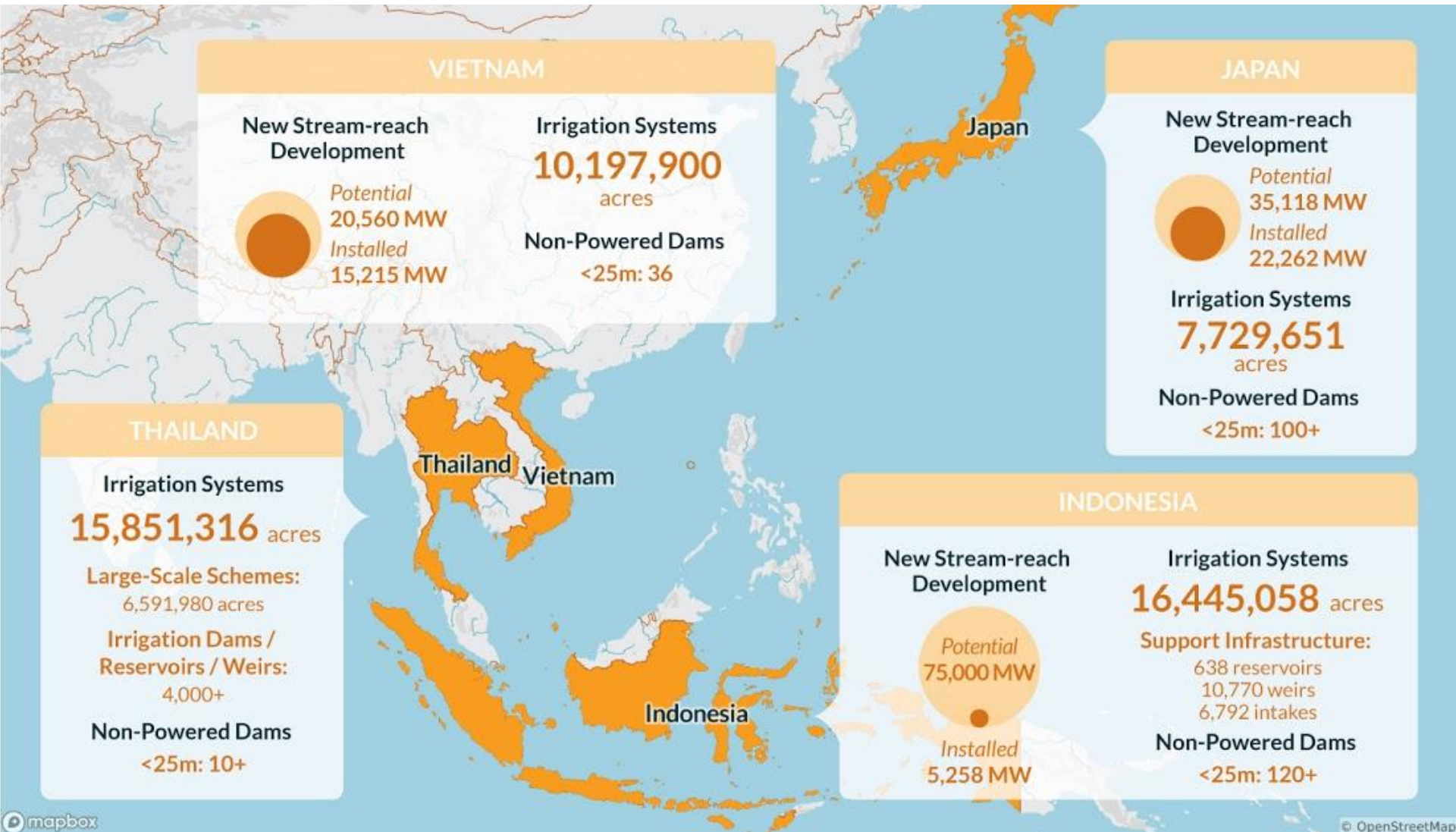
Myanmar
Pipeline: 20MW

Indonesia
Pipeline: 10MW

Chile
Pipeline: 100 MW



ASEAN markets have high potential



Thank you!

Michael Spolum

Regional Director of Business Development

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