HYDROMATRIX®

Innovative Solution for Low Impact Hydropower at Existing Engineered Structures

Presentation at Hydrokinetic and Wave Energy Technologies
Technical and Environmental Issues Workshop
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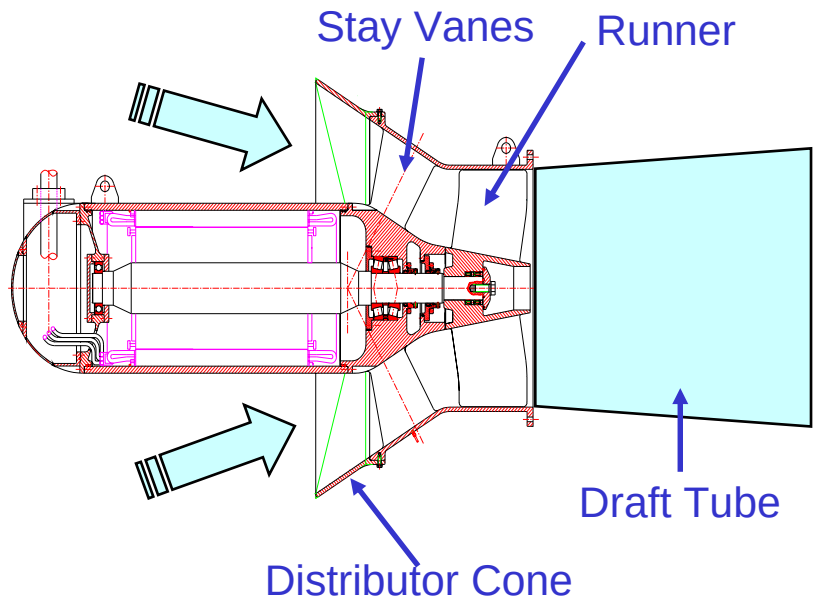
Topics

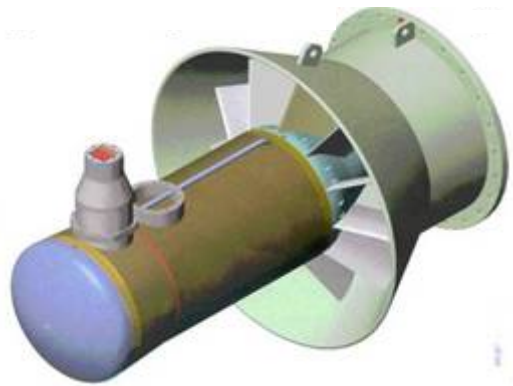
- Description of Technology Class & HYDROMATRIX® concept
- Application Criteria
- Development Status
- Reference Applications
- Market Potential – Market Cost
- Development Obstacles

Axial Type Reaction Turbines

- Inward flow reaction turbine -> water changes pressure as it moves through the turbine and gives up its energy
- Water is directed through the stay vanes and spirals on to a propeller shaped runner, causing it to spin.
- Draft tube helps decelerate the water and recover kinetic energy

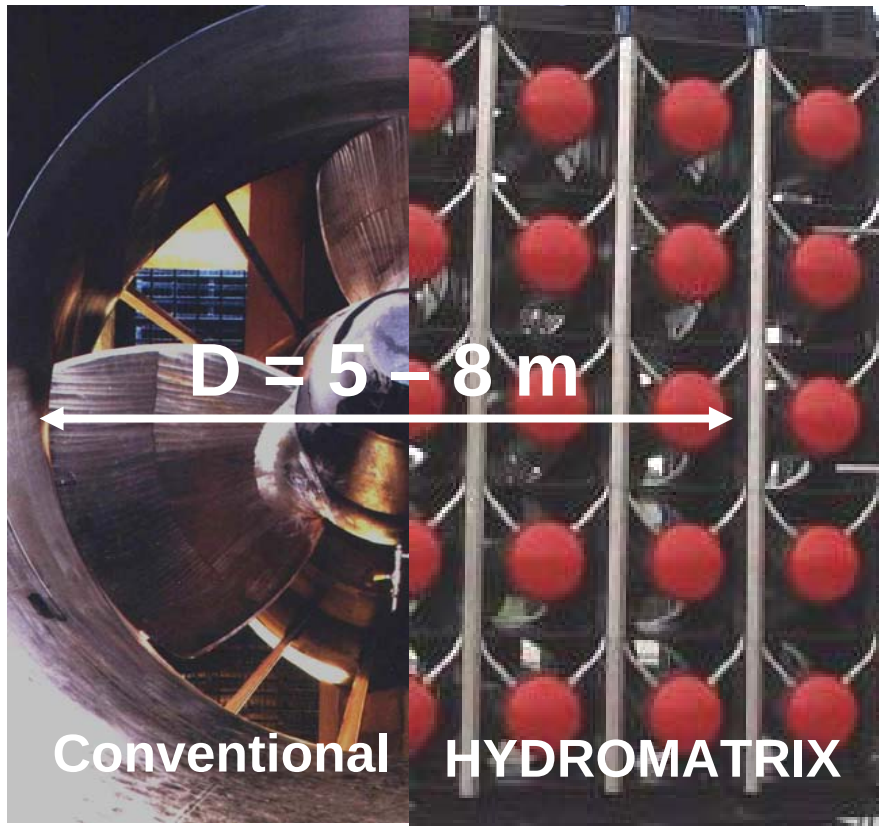
- Hydromatrix -> Axial type, fixed blade runners -> no wicket gates and adjustable runner blades !



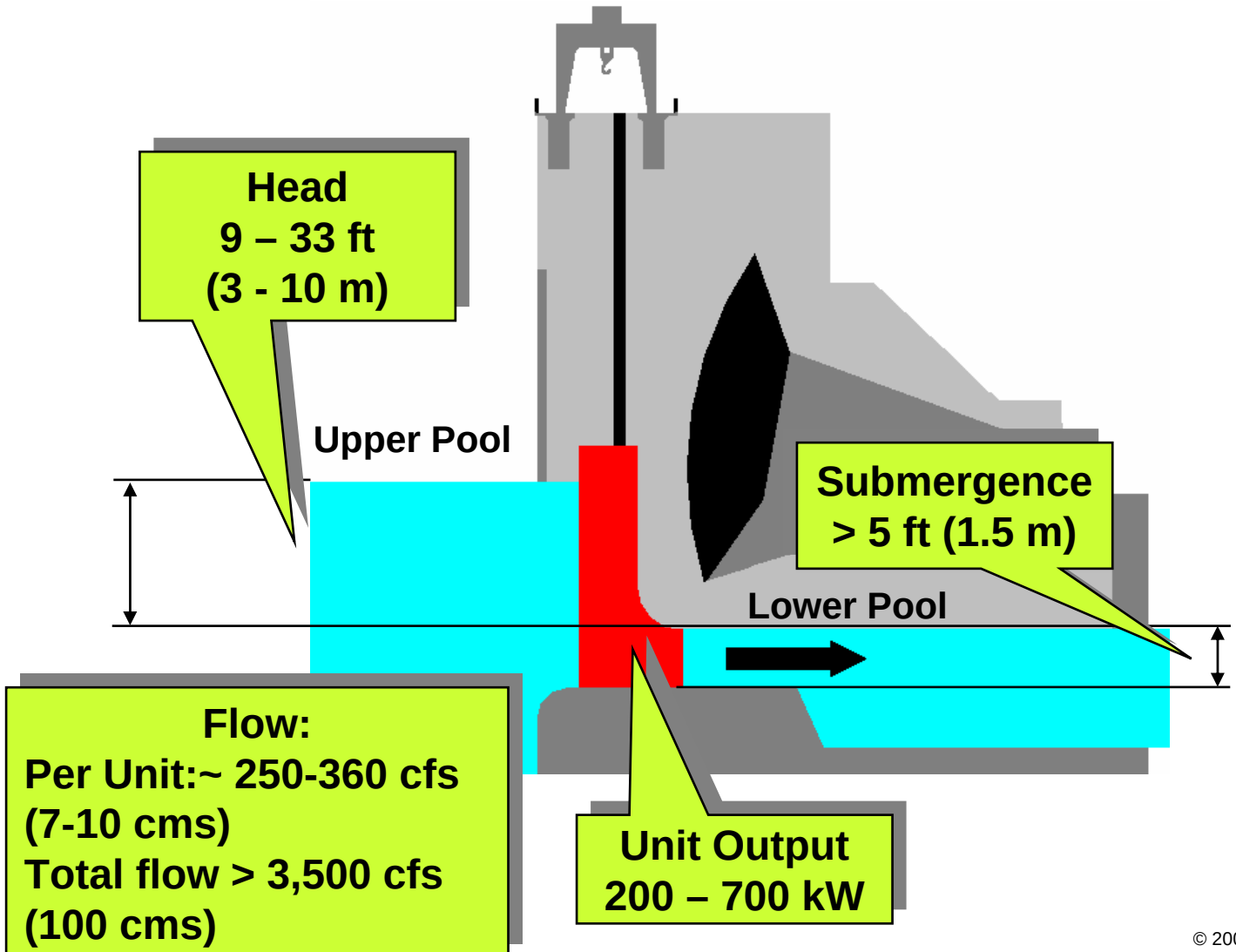


The HYDROMATRIX® Concept

- Many small turbines instead of conventional large size turbines
- Simple and robust turbine and generator design
- Turbines can be lifted out of the water during high flows or flooding
- A solution for low head / high flow sites at existing engineered waterways
- Not a small hydro solution



Application Range & Criteria



HYDROMATRIX® - Development Status

HYDROMATRIX®

1980´s	Henry Obermeyer patents Hydromatrix concept in the US First 3 MW plant becomes operational in CT
1990	VA TECH HYDRO Engineer “reinvents“ concept
1995	5 MW plant installed in a shiplock at Freudenau dam, Austria Development of Ohio River projects starts
2000	30.4 MW Jebel Aulia plant (Sudan) under Contract
2001	85 MW Smithland & 88 MW Cannelton plants under Contract
2003	First lot of Jebel Aulia in operation Design of Smithland project completed & approved
2004	700 kW Agonitz Plant commissioned
2005	6.55 MW Nussdorf Plant commissioned Jebel Aulia Plant (80 Units) completed

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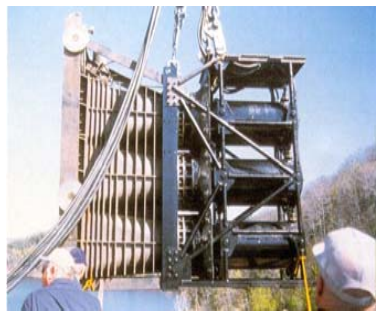
Potential Applications

Navigation Dams

Ohio River

Jebel Aulia

Irrigation Dams



Colebrook

Intake Towers

Freudenau

Sluice in Shiplocks

HYDROMATRIX® Reference - Intake Tower COLEBROOK / USA

Client:

City of Hartford, CT

D = 660 mm

n = 900 rpm

H = 8 - 35 m

P_{tu} = 500 kW

6 Units in 2 Modules

P_{total} = 3 MW

Contract award: 1987

Commissioning: 1988

HYDROMATRIX® Experience
Irrigation Dams - Jebel Aulia / Sudan

Existing irrigation dam on the White Nile

National Electricity Corp.

Contract award: 2000

Commissioning: Nov 2003 – Nov 2005 (8 lots)

80 units in 40 modules

P_{tu} = 380 kW

P_{total} = 30.4 MW

D = 1,120 mm (44 in.)

H = 5.5 m (18 ft)

Jebel Aulia - Modules in raised position

TG Unit – Close up

Modules in lowered position

HYDROMATRIX® Reference Plant
Nussdorf

Existing side canal of the Danube River in central Vienna

Customer: VERBUND Austrian Hydro Power AG

Contract award: 2004

Commissioning: May 2005

Technical Data:

Plant Capacity: 6.55 MW

Voltage: 690 V

Head: 5.86 m (19.2 ft)

Speed: 336.7 rpm

Runner diameter: 1,320 mm (52”)

Annual production: 24.7 GWh

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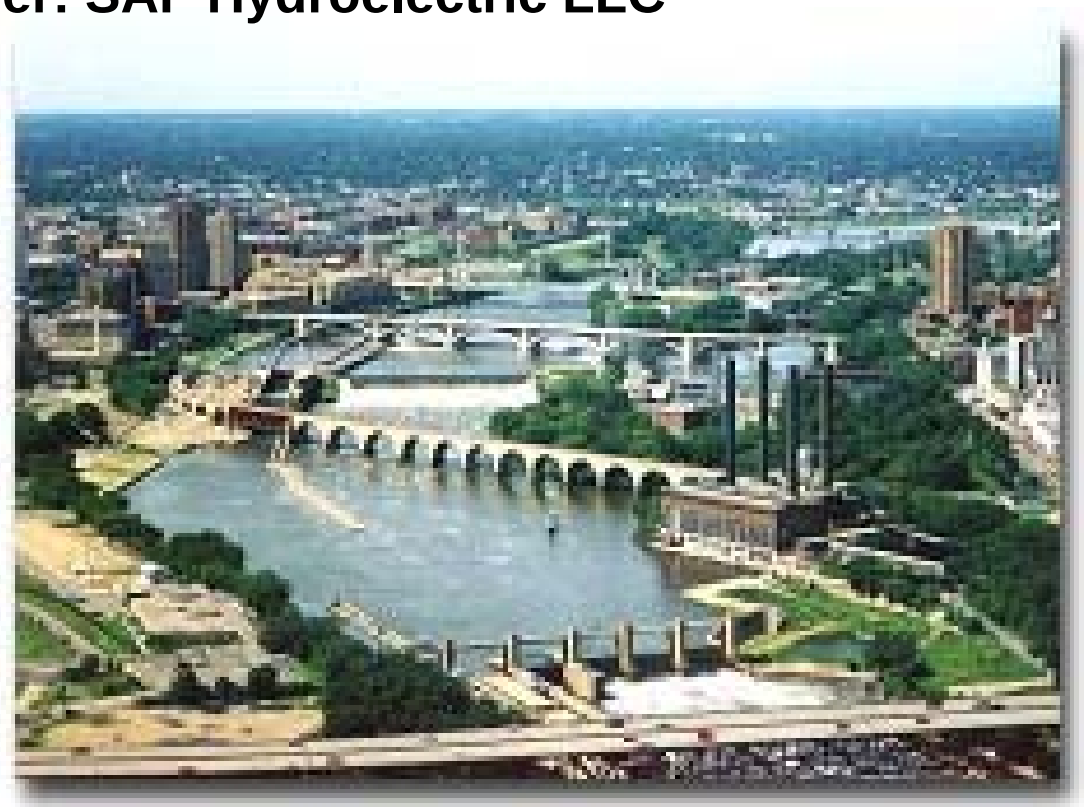
- 100 ft long, 40 ft wide and 23 ft high overflow hollow body weir
- Hydraulically operated spillway gates
- 12 Turbine-generator units
- Operation building

Lower St. Anthony Falls

Lock and Dam on the Mississippi River, Minneapolis, MN

Customer: SAF Hydroelectric LLC



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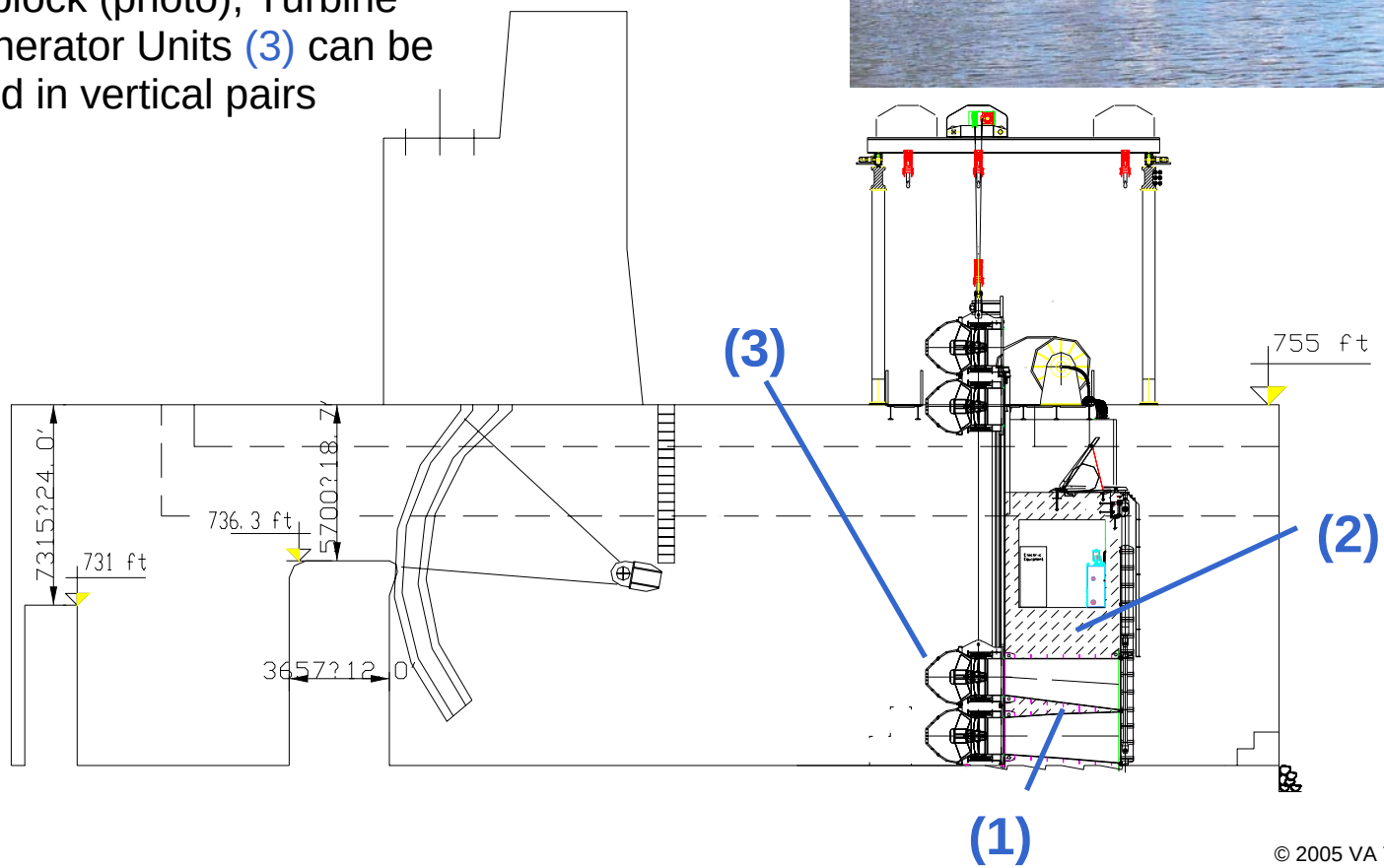
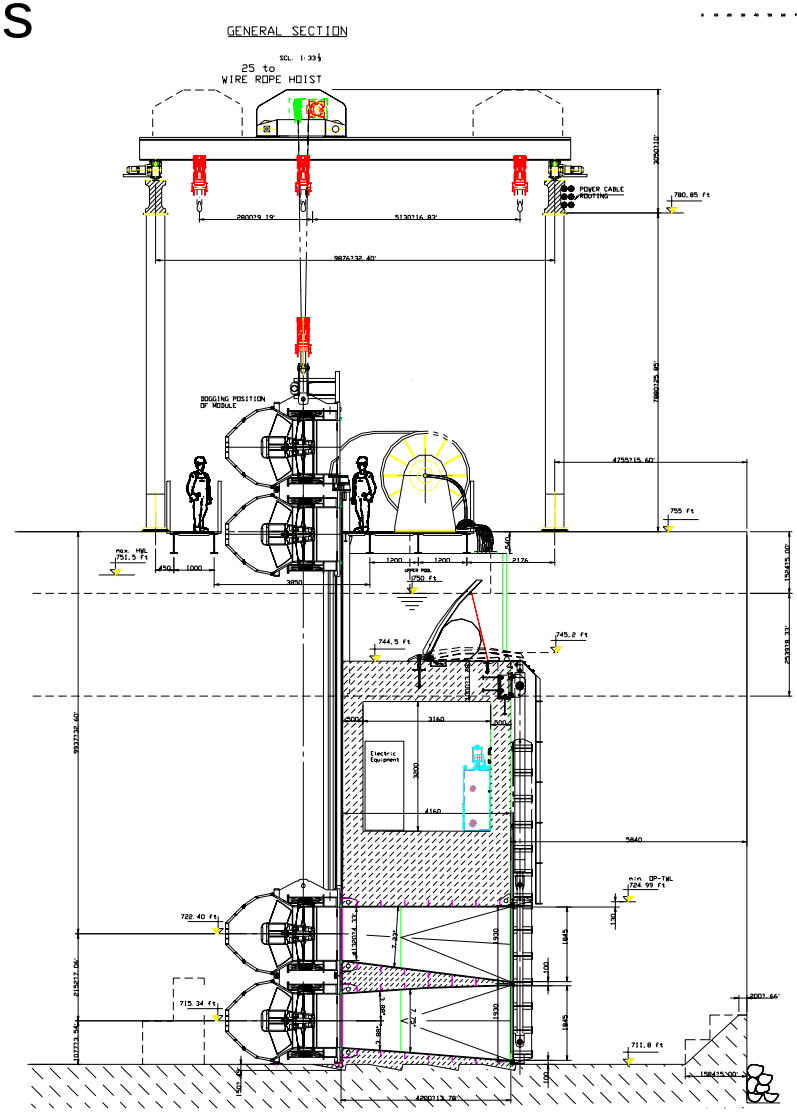
Lower St. Anthony Falls Plant Layout (I)

Draftubes (1) embedded in retaining wall (2) inside an abandoned auxiliary shiplock (photo), Turbine Generator Units (3) can be lifted in vertical pairs



Lower St. Anthony Falls Plant Layout (II)



Technical Data:

16 TG-Units (2 rows of 8)

Max. Plant Capacity: 10 MW

Max. Gross Head: 24.9 ft

Av.Annual Energy Production: 62 GWh

Project Start: **End 2005**

Commissioning: **May 2007**

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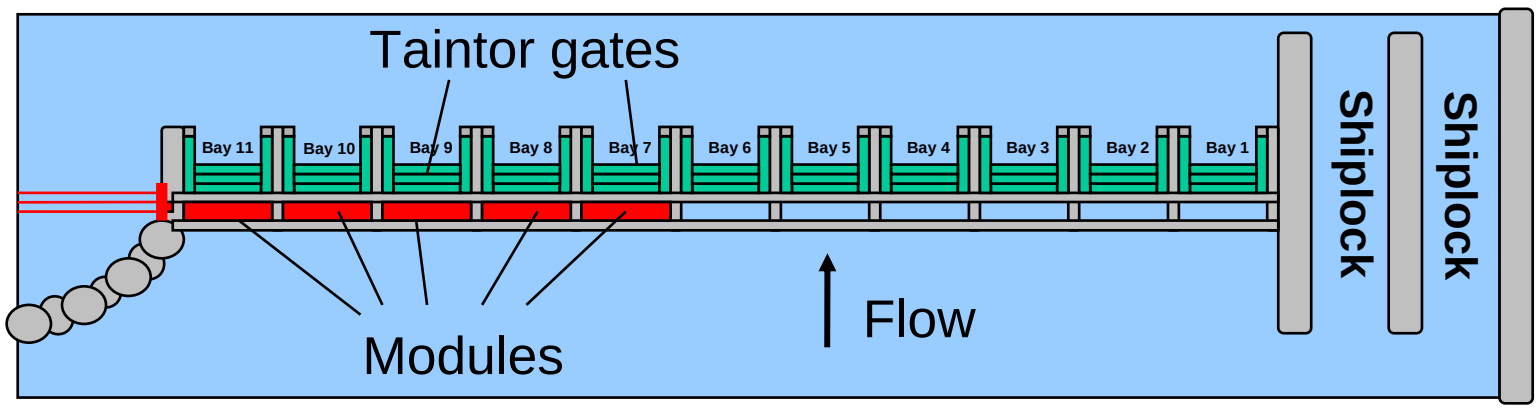
GENERAL PLAN – SMITHLAND DAM

- Installation of movable modules in bulkhead gate slots of five spillway bays
- 170 turbine generator units – rated head 21.3 ft
- Rated plant capacity: 82.7 MW
- Annual energy 327 GWh



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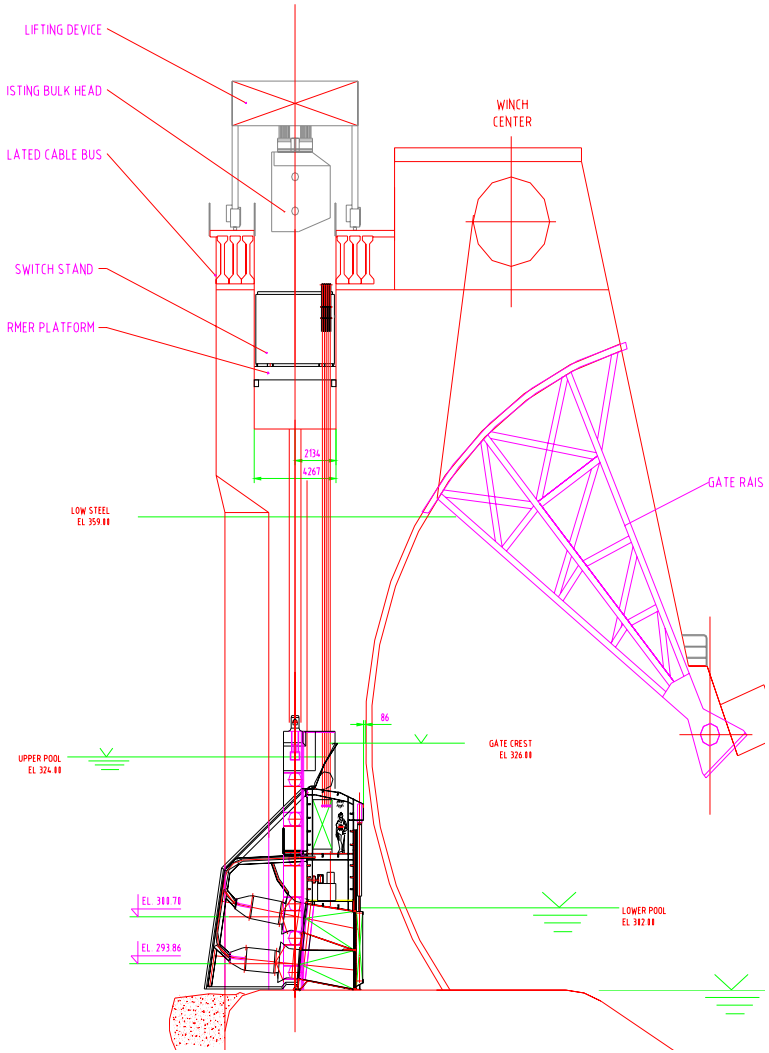
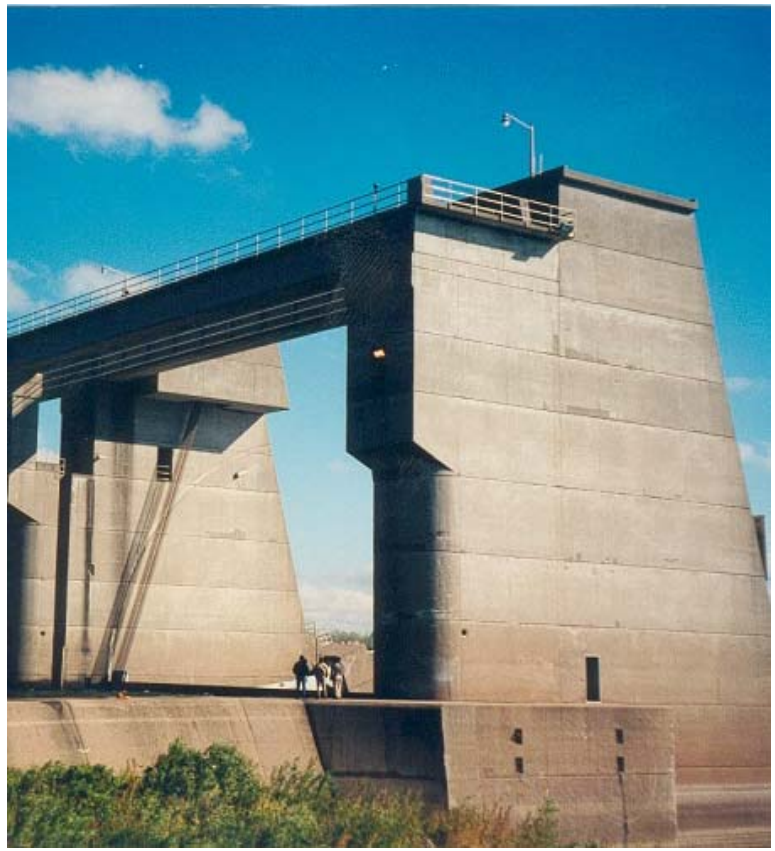
SMITHLAND – Sectional View





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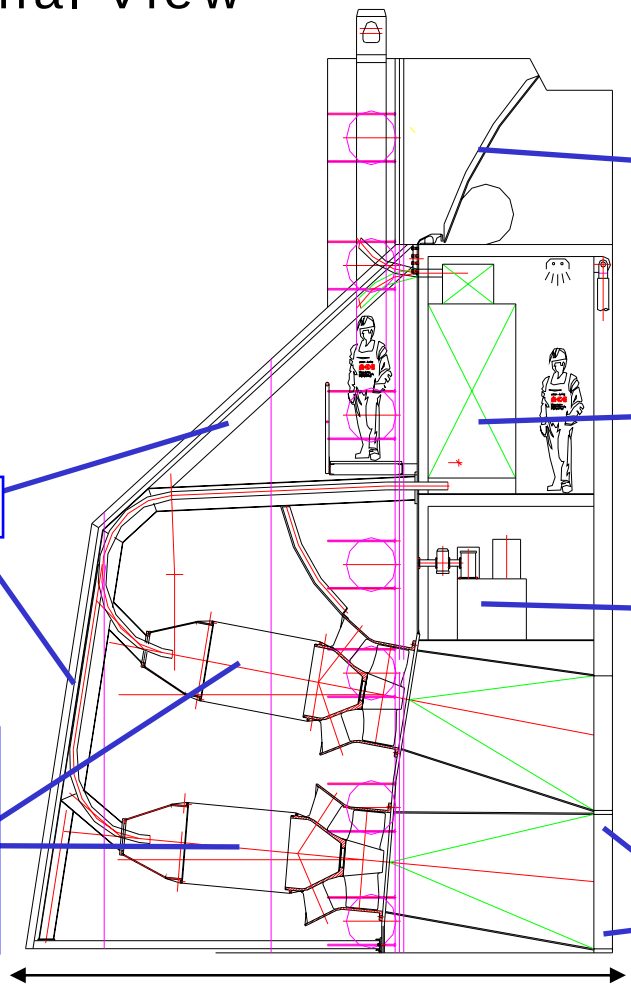
Module Sectional View



Spillway Gates

4.16 kV Electric Switchgear & Control System

Intake Trash Racks

Hydraulic Power Unit

Turbine Generator Units
D = 1,250 mm (49”)
n = 360 rpm
P_{tu} = 500 kW

Draft Tube Gates

41 ft

24.7 ft

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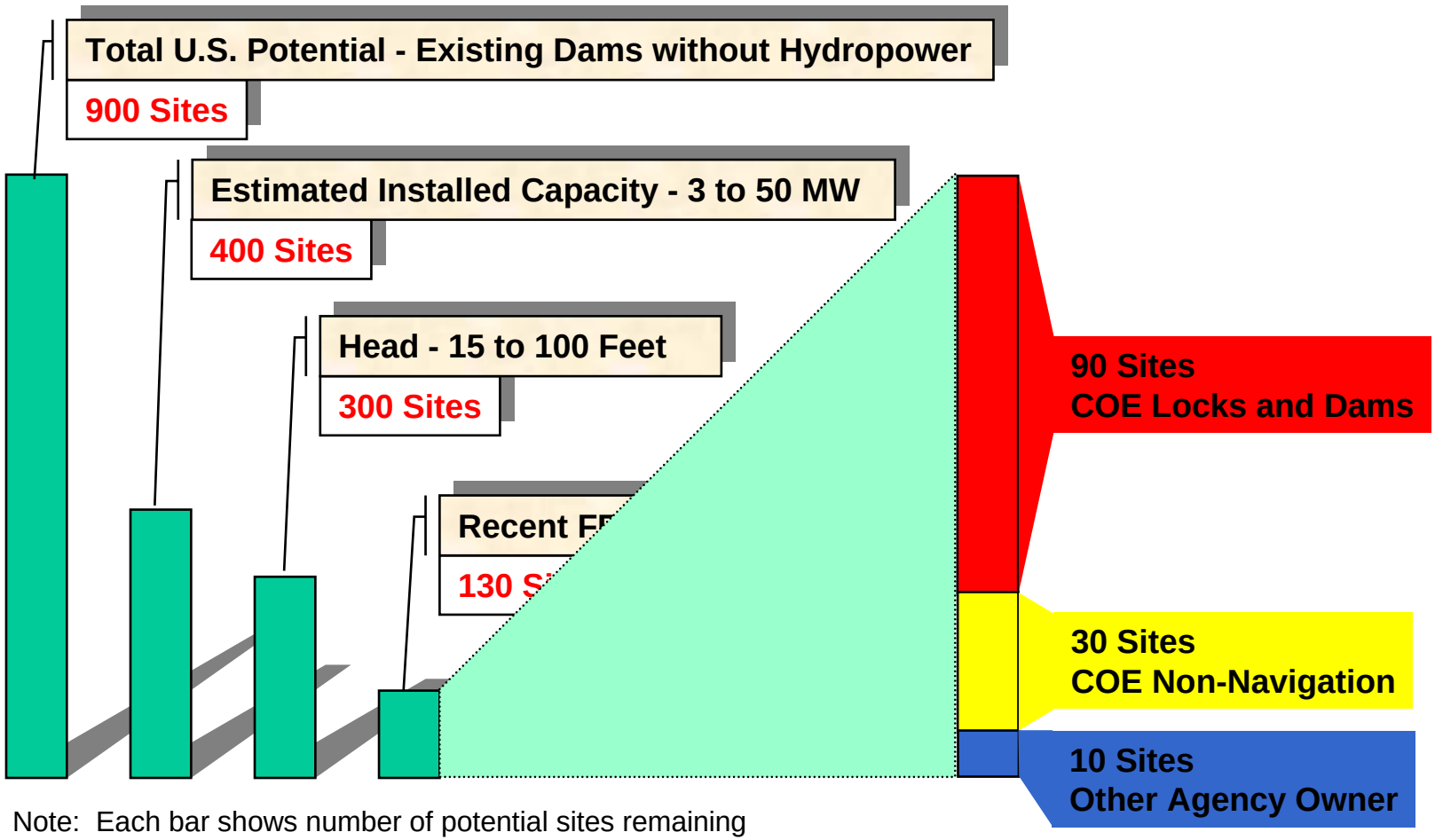
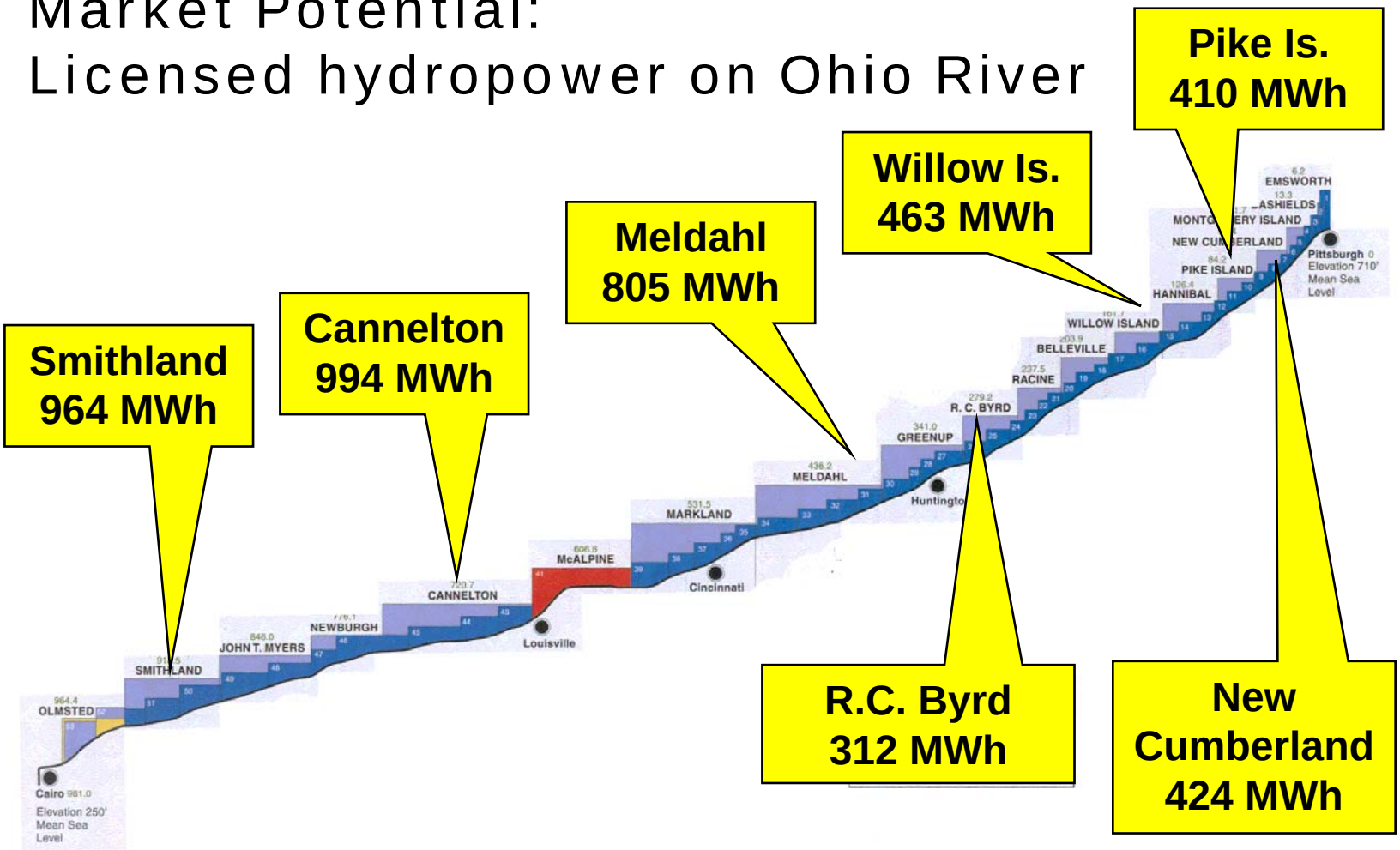
U.S. Market Potential - Site Selection Process



Note: Each bar shows number of potential sites remaining after "filtering" with stated criteria

Market Potential:
Licensed hydropower on Ohio River



⇨ **Total average daily energy: 4,372 MWh**

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Energy Capital Cost & Economy Factors[1)]

	At existing structures	At open waterways
Cost per installed kW Cost per kWh	1,500 – 3000 < 5 cents / kWh	3,500 – 5000
Typical capacity factor	35 – 75 %	45 – 85 %
Dispatchable Backup power generation needed ?	With restrictions Yes	With restrictions Yes

[1)] Source: Navigant Consulting, Inc., 2005: used by permission

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Obstacles to Project Development...

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Conclusion

- **Proven technologies for reaction type turbines available on the market today**
- **The technologies have to be used in an innovative way to be economically viable**
- **Use of existing engineered structures is key to success**
  – no / minimal civil construction cost
  – no geological risk, no civil contracting risk
  – no additional land usage, low addtl. impact on environment
- **Technologies have to address concerns and requirements of major stakeholders**
- **Power industry looks for simple and reliable designs to minimize operation and maintenance cost**
- **Short project schedule is more important than low equipment cost**

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Stakeholders in the Development Process