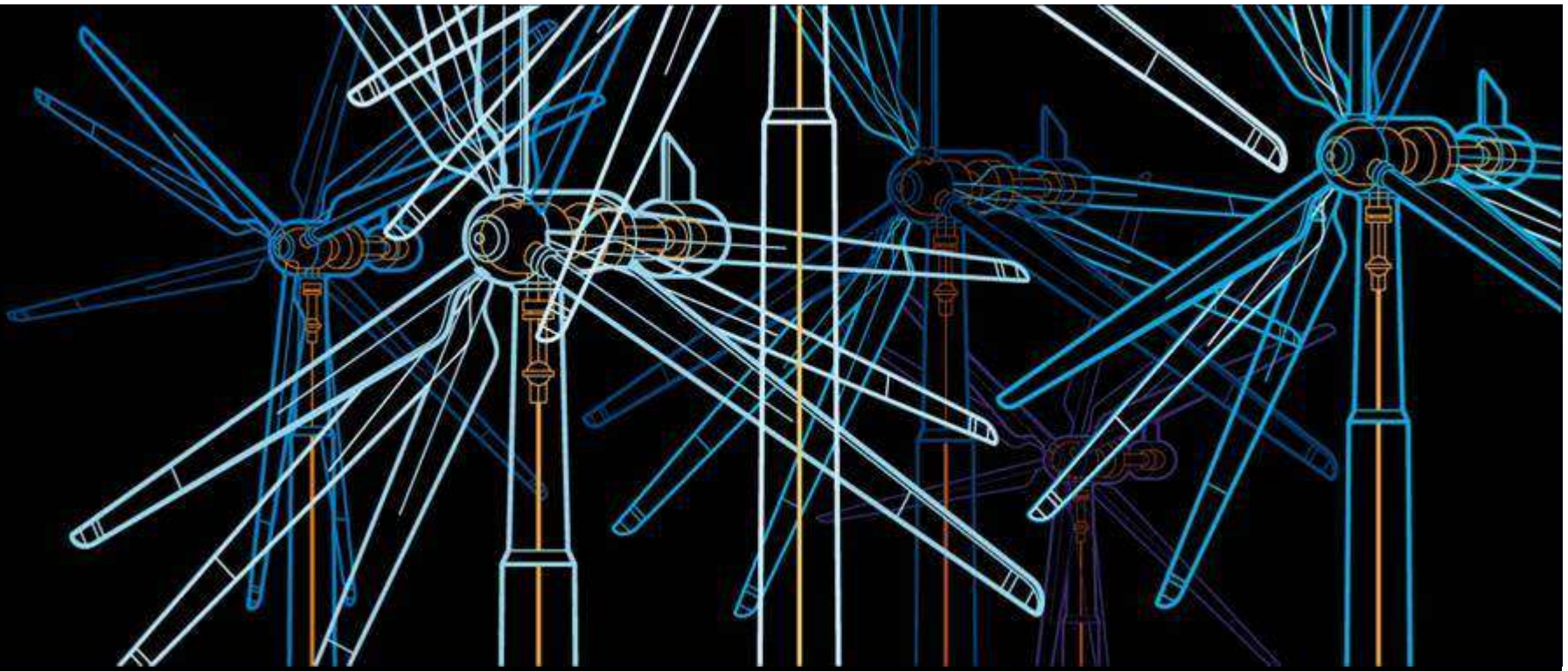




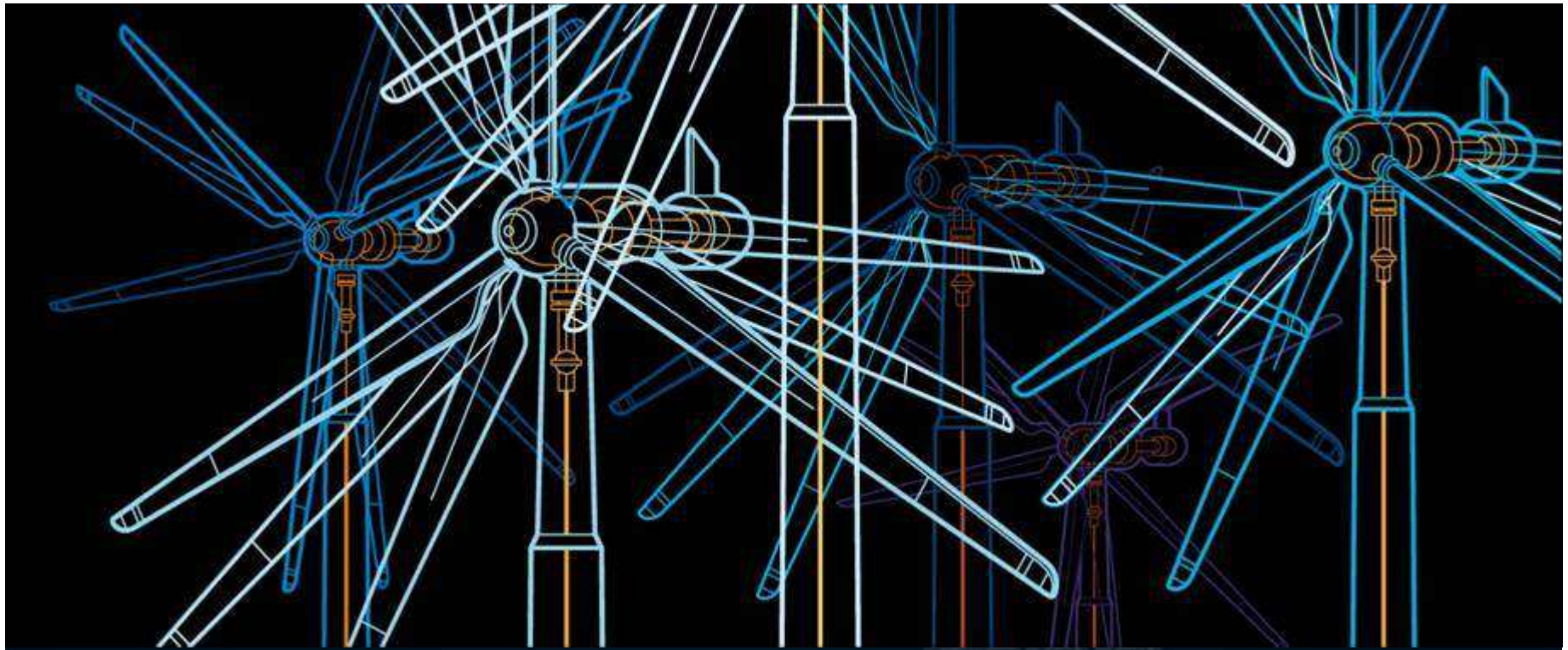
Profibus- Profinet User Conference , 30th June , Steve Moore

The Use of Profibus in a Renewable Energy Application

PROFIBUS - PROFINET
user conference

Introduction

- **Application description**
- **System Development**
- **Decision Making**
- **Control & Monitoring Requirements**
- **Process Optimisation**
- **Application Video**



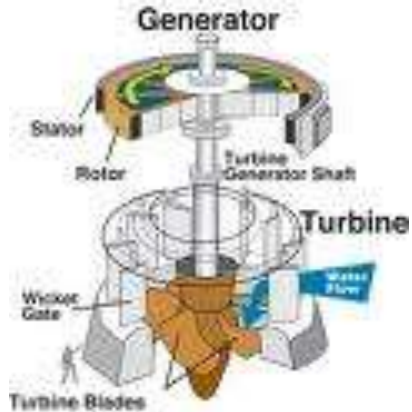
Application Description

Renewable Applications

- **The renewable energy market presents an extremely large opportunity for power electronic equipment suppliers**
- **Examples of current Renewable Energy applications**
 - **Wind**
 - **Tidal**
 - **Hydro**
 - **Solar (Photovoltaic and Thermal)**
 - **Biomass**

Hydro Applications

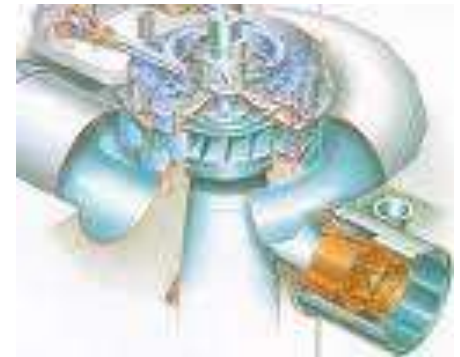
- Typical hydro turbine application examples



- Kaplan



- Pelton



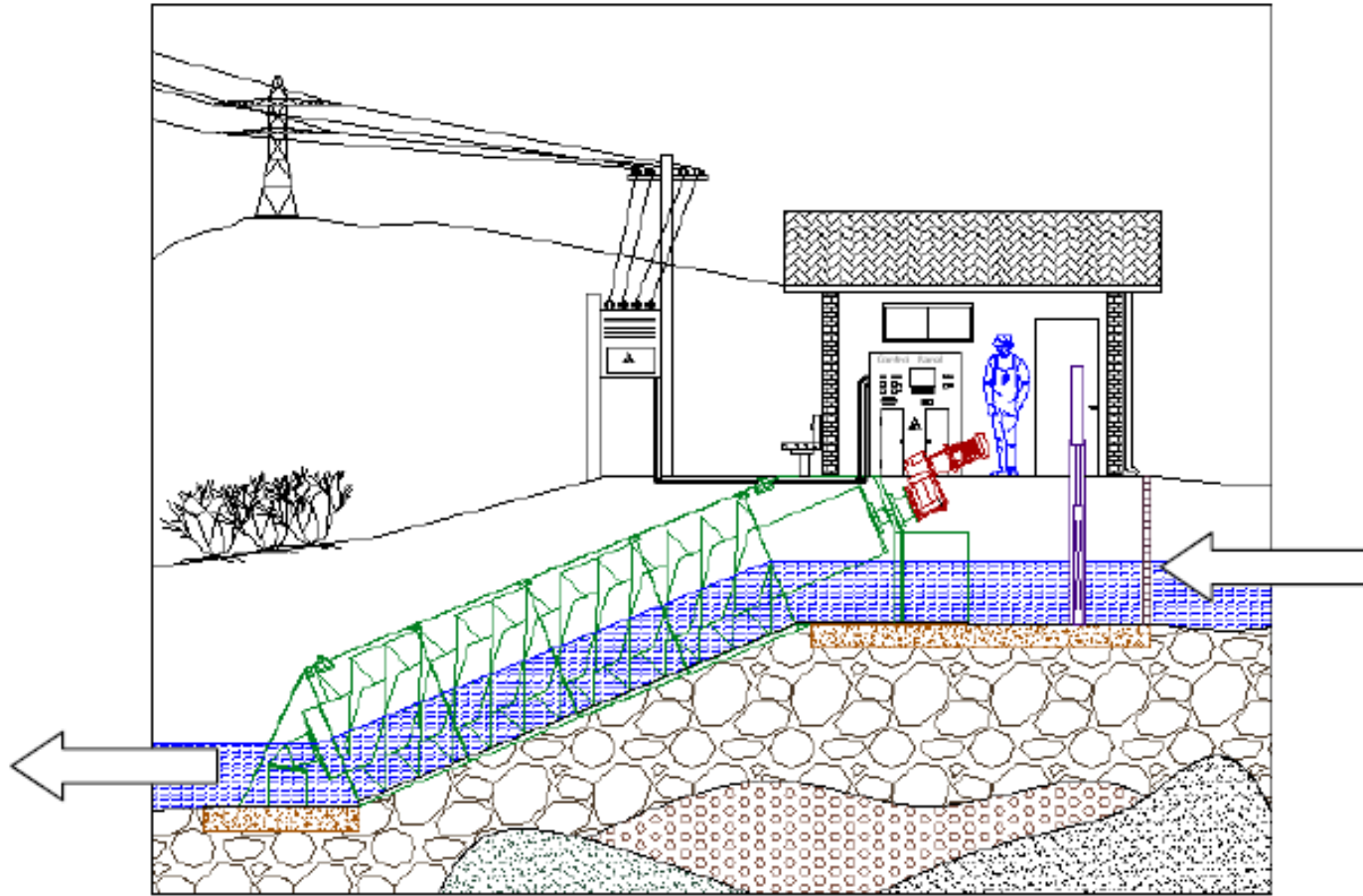
- Francis

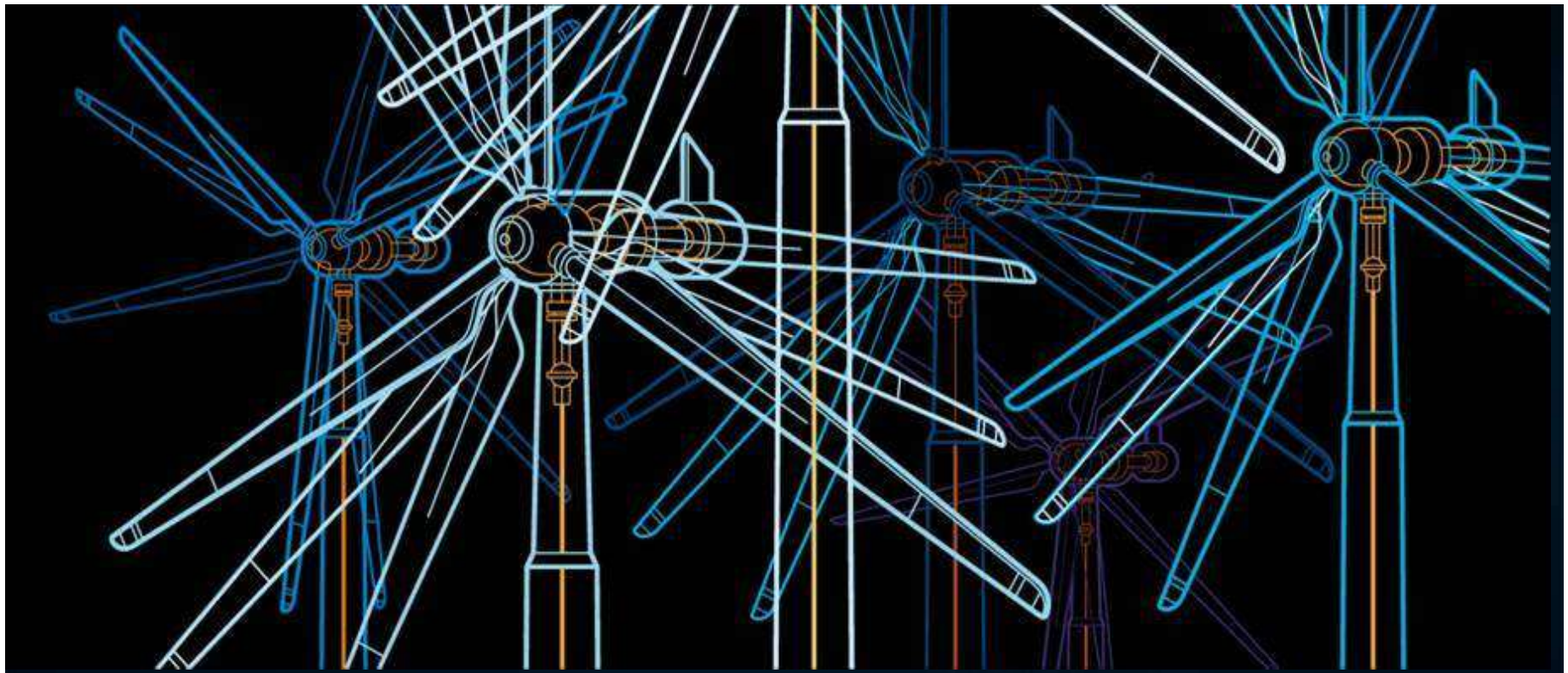
Archimedes Screw Generator

- **Solution been used as a method of raising water for centuries**
- **Recent trials have proven that they can also be used for generating electrical power**



Typical Screw Generator Installation





System Development

System Development

- **Screw rotates at low speeds (typically 25-35 rpm)**
- **Typical powers from 1-100's kW**
- **Two generator options available in conjunction with a gearbox**
 - **Induction generator**
 - **Commonly available in 4 to 8 pole designs**
 - **High efficiency**
 - **Permanent magnet synchronous generator**
 - **Lower speed options available**
 - **More complex machine**
 - **High efficiency**

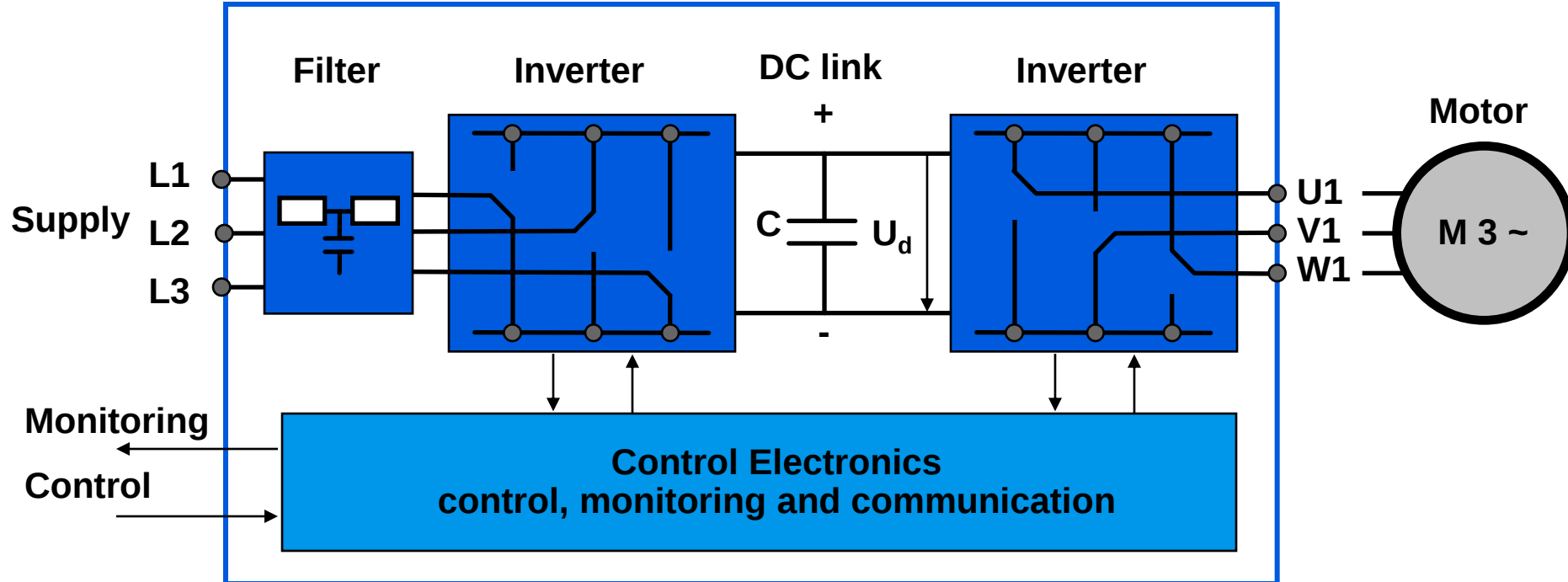
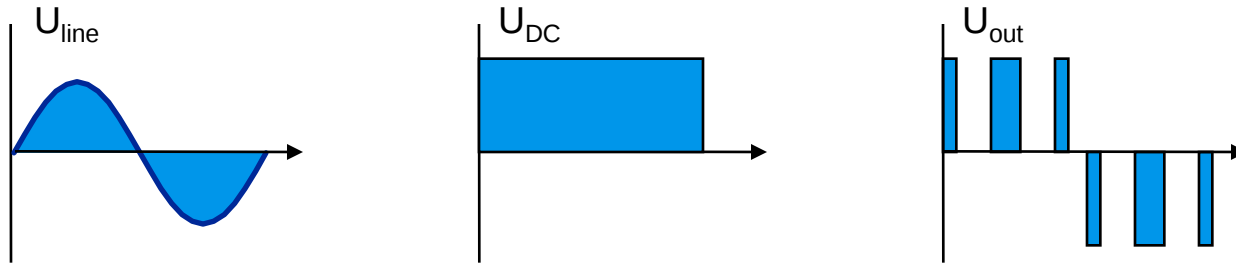
System Development

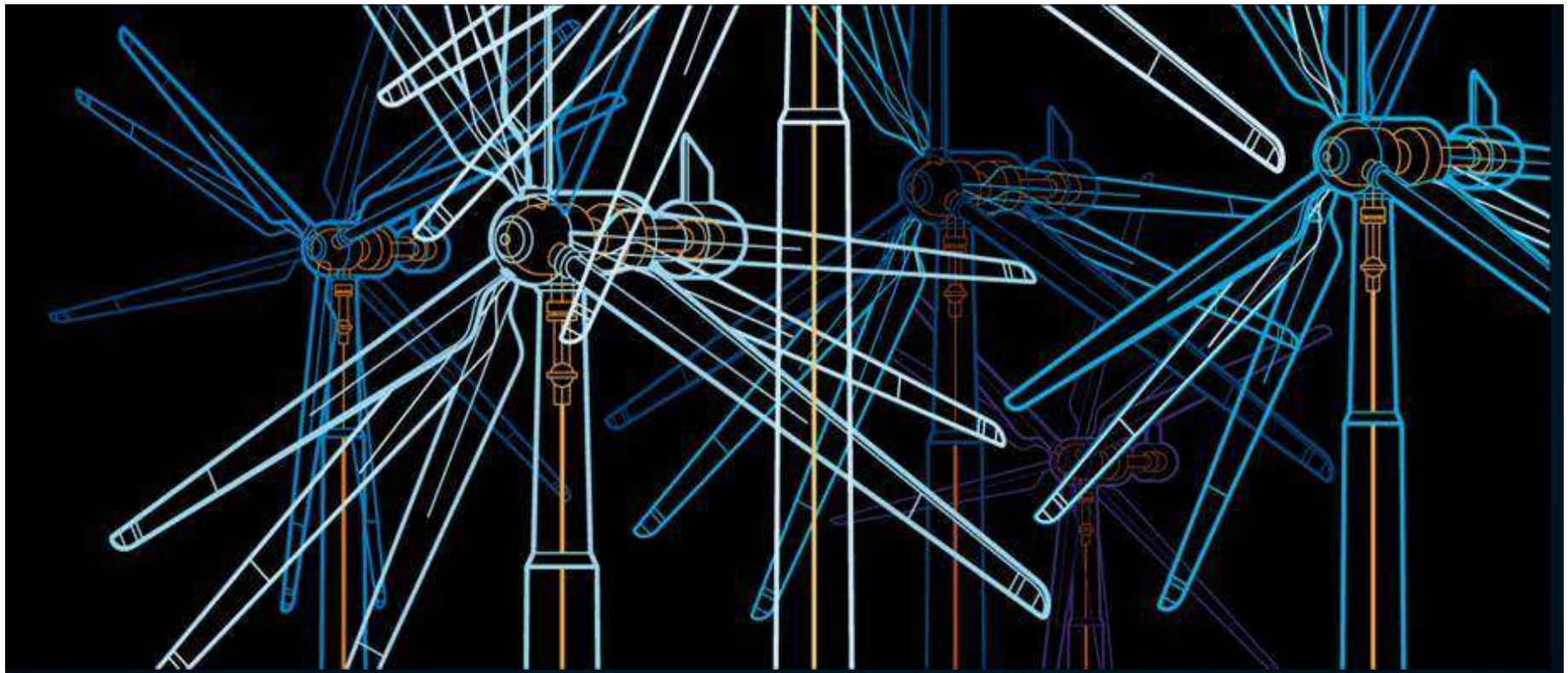
- **Before the first trial system order two options were investigated**
- **Option 1**
 - **4 pole induction generator with three stage gearbox**
- **Option 2**
 - **~300 rpm base speed PM generator with two stage gearbox**
- **Overall system efficiency was calculated at different loads and speeds**
- **Which one do you think was used ?**

System Development

- **With this type of hydro turbine you cannot control the prime mover to give a constant screw speed (same as a wind turbine).**
- **This means the use of an inverter to control the generator and return energy to the grid.**
- **This is done using standard variable speed drive hardware.**

System Development – Regenerative AC drive





Decision Making

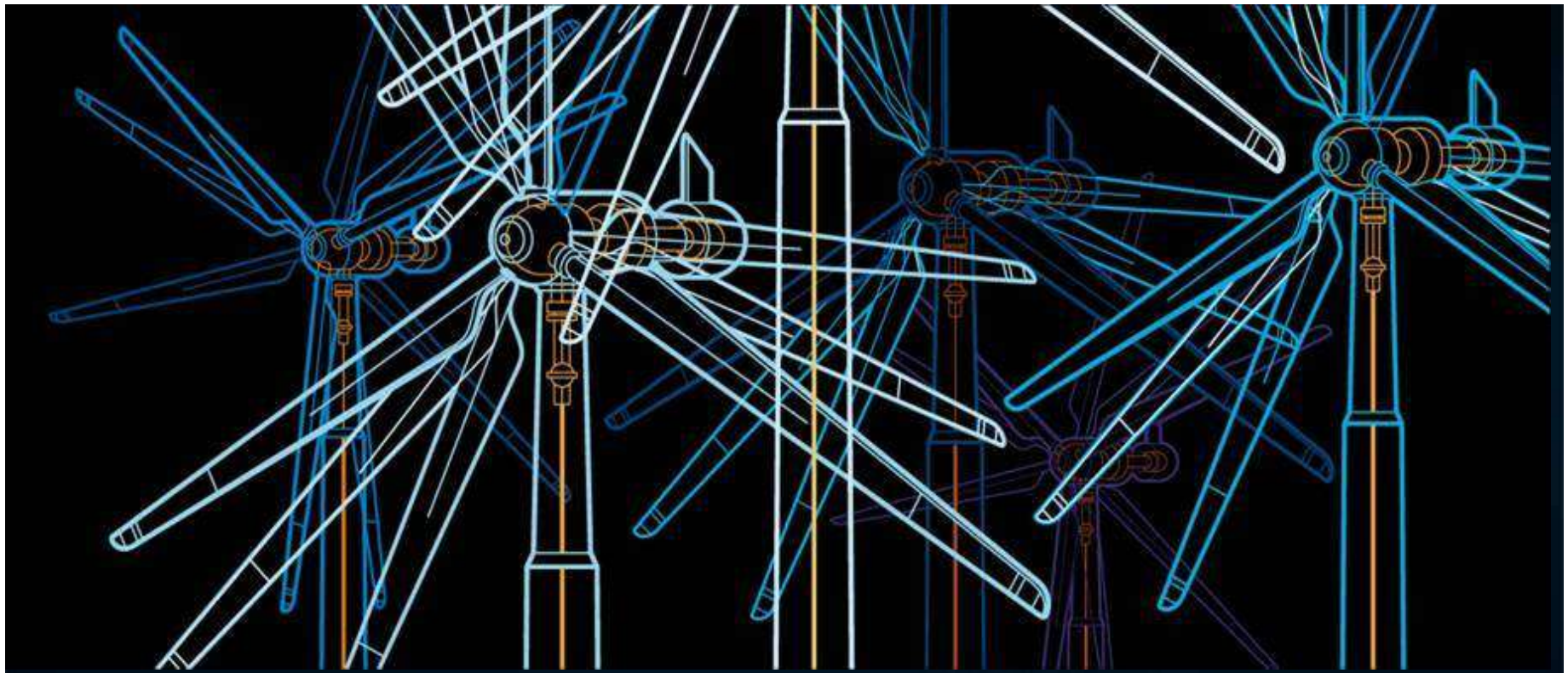
Decision Making

- **The decision was made to use induction generator with higher ratio gearbox**
- **Why ?**
 - **String efficiency was only 1-2% lower than for the PM design but the initial cost was approx 50% higher for the drive and motor**
 - **Motor was readily available (ex stock) , easy to maintain and serviceable by existing site workforce**
 - **VSD spares already available locally**

Decision Making

- End user
 - YW Esholt WWTW
- OEM
 - Spaans Babcock Ltd
- Main Contractor
 - JN Bentleys Ltd
- Panel Builder
 - CEMA Ltd
- 2 x 90kW generators in series
- Approx 2,700 l/sec flow
- 10m drop





Control & Monitoring Requirements

Control & Monitoring Requirements

- **End User specified Mitsubishi PLC's for the site and required the control and monitoring to be performed from this device**
- **PLC to send**
 - **Command word**
 - **Speed reference**
- **PLC to receive**
 - **Actual motor power , torque and current**
 - **Motor nominal power**
 - **Fault code**
 - **Digital input status**
 - **Regenerative power**

Control & Monitoring Requirements

- Decision made to use Profibus for this functionality and implemented in the drive as follows

The screenshot shows the DriveWindow software interface. The title bar indicates the file is 'Esholt - as left 29_5_09'. The interface is divided into a left sidebar with a tree view of drive parameters and a main right pane showing a table of parameters.

Left Sidebar Tree View:

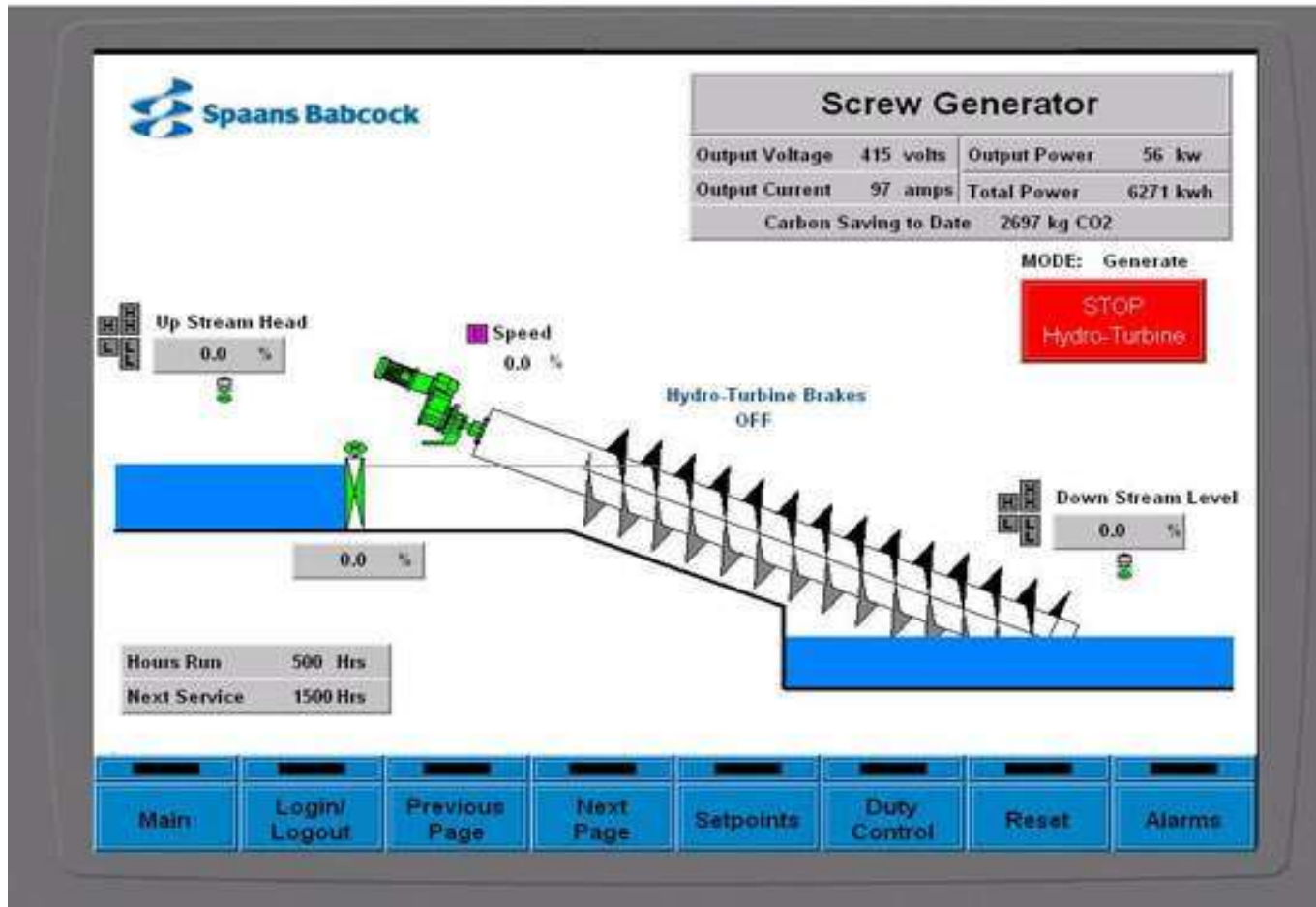
- 27: BRAKE CHOPPER
- 30: FAULT FUNCTIONS
- 31: AUTOMATIC RESET
- 32: SUPERVISION
- 33: INFORMATION
- 34: PROCESS VARIABLE
- 35: MOT TEMP MEAS
- 40: PID CONTROL
- 42: BRAKE CONTROL
- 51: COMM MODULE DATA**
- 52: STANDARD MODBUS
- 60: MASTER/FOLLOWER
- 70: DDCS CONTROL
- 72: USER LOAD CURVE
- 83: ADAPT PROG CTRL
- 84: ADAPTIVE PROGRAM
- 85: USER CONSTANTS
- 90: D SET REC ADDR
- 92: D SET TR ADDR
- 95: HARDWARE SPECIF
- 98: OPTION MODULES
- 99: START-UP DATA
- 101: Group 101 Backup
- 110: Group 110 Backup
- 112: Group 112 Backup
- 190: Group 190 Backup
- 191: Group 191 Backup
- 192: Group 192 Backup

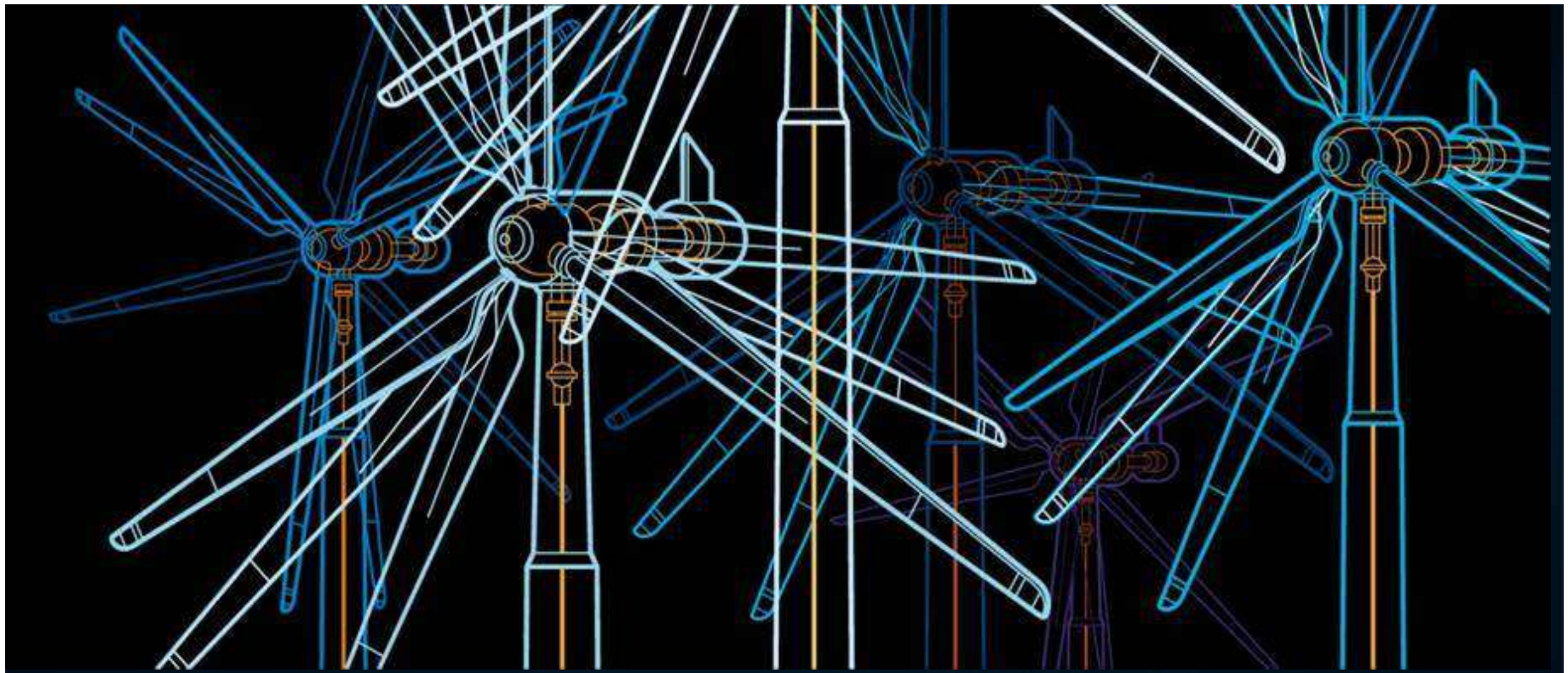
Main Pane Table:

Name	Value	OPC Address
51.01: MODULE TYPE	PROFIBUS DP	Par.51.1
51.02: Node address	5	Par.51.2
51.03: Baud rate	187	Par.51.3
51.04: PPO-type	5	Par.51.4
51.05: PZD3 OUT	0	Par.51.5
51.06: PZD3 IN	106	Par.51.6
51.07: PZD4 OUT	0	Par.51.7
51.08: PZD4 IN	104	Par.51.8
51.09: PZD5 OUT	0	Par.51.9
51.10: PZD5 IN	320	Par.51.10
51.11: PZD6 OUT	0	Par.51.11
51.12: PZD6 IN	117	Par.51.12
51.13: PZD7 OUT	0	Par.51.13
51.14: PZD7 IN	9909	Par.51.14
51.15: PZD8 OUT	0	Par.51.15
51.16: PZD8 IN	105	Par.51.16
51.17: PZD9 OUT	0	Par.51.17
51.18: PZD9 IN	913	Par.51.18
51.19: PZD10 OUT	0	Par.51.19
51.20: PZD10 IN	0	Par.51.20
51.21: DP MODE	0	Par.51.21
51.22: FIELD BUS PAR22	<Read-protected>	Par.51.22
51.23: FIELD BUS PAR23	<Read-protected>	Par.51.23
51.24: FIELD BUS PAR24	<Read-protected>	Par.51.24
51.25: FIELD BUS PAR25	<Read-protected>	Par.51.25
51.26: FIELD BUS PAR26	<Read-protected>	Par.51.26
51.27: FBA PAR REFRESH	DONE	Par.51.27
51.28: FILE CPI FW REV	114h	Par.51.28
51.29: FILE CONFIG ID	101h	Par.51.29
51.30: FILE CONFIG REV	10h	Par.51.30
51.31: FBA STATUS	ON-LINE	Par.51.31
51.32: FBA CPI FW REV	128h	Par.51.32
51.33: FBA APPL FW REV	216h	Par.51.33

Control & Monitoring Requirements

- System HMI display as follows

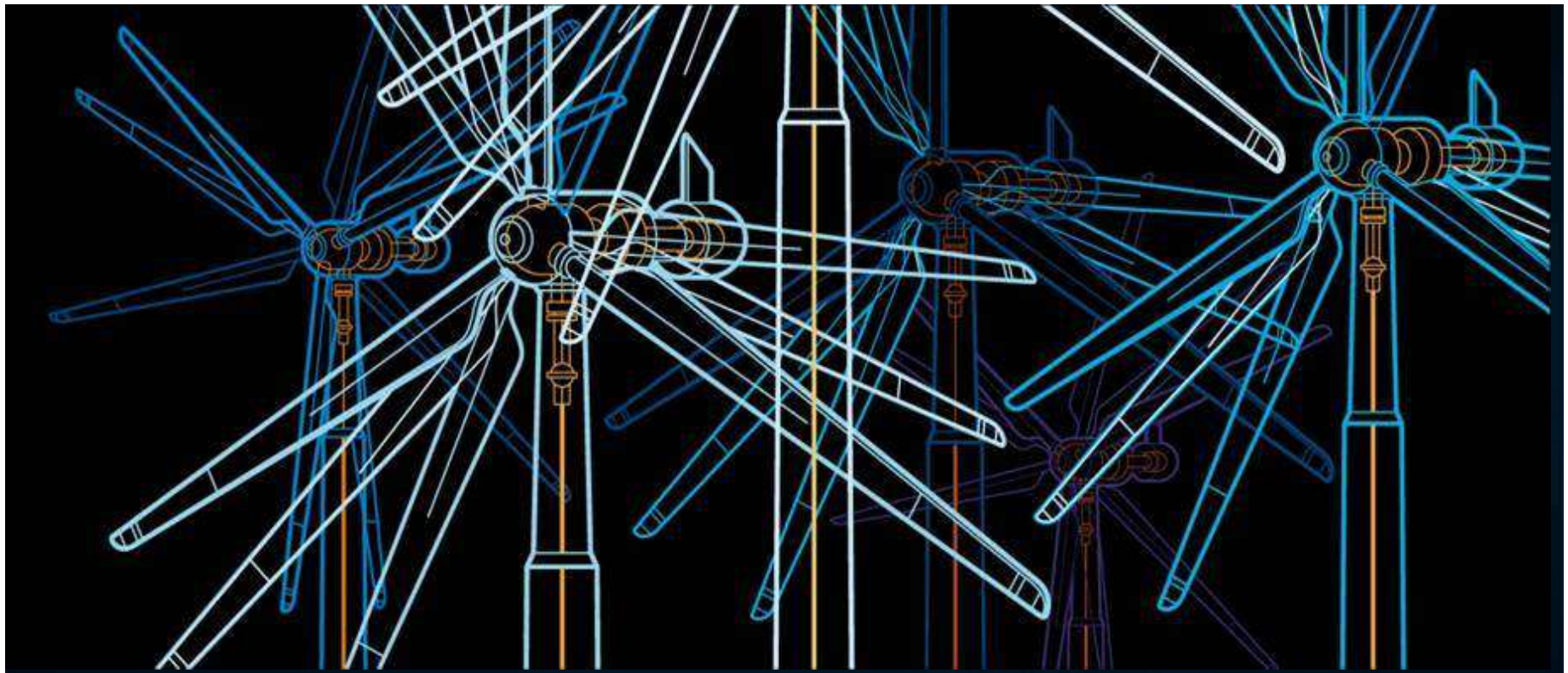




Process Optimisation

Process Optimisation

- **How can we be sure that we are extracting the maximum energy from the system ?**
- **ABB and Spaans Babcock have worked together to model the power output from the system at different loads and speeds**
- **Screw speed should follow the flow rate of the river but this is often difficult and expensive to obtain**
- **It has been found by calculation that the maximum power can be extracted by controlling the height of the water in the penstock preceding the turbine itself**
- **An ongoing project is to collect the site data to back up the calculations**
- **This data is already available over the Profibus link**



Application Video

Application Video

- Application Video

Power and productivity
for a better world™

