

Compact and Ultra-light Wind Turbine for Efficient Wind Power

# AIRDOLPHIN Series


- Z-1000-250 AIRDOLPHIN GTO
- Z-1000-48 AIRDOLPHIN PRO
- Z-1000-24 AIRDOLPHIN Mark-Zero


AIRDOLPHIN Zephyr



# Growing with the Wind — For Future Generations™

State-of-the-art technologies for achieving sustainable development



AIRDOLPHIN  Zephyr

Zephyr's dream is to transform ever-changing winds into clean electric energy, and to make this power available at any location in the world. So we launched Project Z — the most ambitious small wind turbine technology project in Japanese history — combining the research and intelligence of leading experts in government, academia, and private industry.

Project Z spent six years and successfully developed the Airdolphin — a next-generation, low-mass wind turbine which can instantly adapt to changing wind conditions.

Through extensive testing in windy sites around the world, Airdolphin has proven to be tough, efficient, and reliable. It instantly responds to the vagaries of wind, while delivering over 170 kWh per month at average wind speeds of 6 m/s (13.4 mph).

## Ten State-of-the-Art Technologies Inside Every Airdolphin

### 1 Extremely Low Mass

Airdolphin Pro/Airdolphin Mark-Zero only weighs 17.5 kg (38.5 lbs.), with 17.5 g (0.6 oz.) turbine weight per generated watt, while Airdolphin GTO weighs 19.5 kg (42.9 lbs.), with 17.7 g (0.6 oz.) weight per watt — one fifth of mega-class wind turbines. They can be mounted on existing structures as well as near roads, railways and airports. The low mass allows swift response to volatile wind conditions for efficient power production. We call this feature the Airdolphin's "Dynamic Wind Captureability".

### 2 Swing Rudder System

Our patented Swing Rudder System is an attitude control system inspired by fish tail fin, which allows the turbine to instantly respond to subtle wind shifts for improved power generation.



### 3 Intelligent Power Management System

With our original patented technologies, the intelligent power management system (patents pending) realizes consistent blade rotation speed while encountering turbulent gusts. Even during hurricanes, Airdolphin can still deliver stable output power after reaching peak wind speed. This is a crucial attribute for small wind turbines which often face turbulence caused by tall city buildings. When the wind speed exceeds 20 m/s (44.7 mph), Airdolphin continues delivering output power at a reduced rotation speed with no need for cut-out. The outstanding performance is achieved by software driven microprocessors. Airdolphin also has various safety features enabling it to detect adverse conditions for automatic shut down.



Generator and Control Boards

### 4 Seamless Response Rotor

The rotor system seamlessly responds to various wind conditions, offering a high wind-to-power conversion factor by utilizing ultra low mass stiff blades, a multi-stagger blended airfoil blade, and a dynamically balanced blade and hub system. These elements work together to constantly control the rotor speed for maximum power output.



Rotor

### 5 Innovation for Low Noise

The Silent Disrupter (SD) Blade features numerous thin grooves on its surface, which significantly reduce air flow noise. The design was inspired by the wings of an owl that enable it to fly silently while approaching its prey.



SD Blade



Owl Wing

### 6 Robust Body Structure

The screw-less assembly of the body is inspired by Japanese traditional block puzzle structure. This ensures precise fitting and superb resistance to adverse weather conditions, requiring minimum maintenance.



Body Joints



Blade and Hub Cover

### 7 Power Assist Function

When there is no wind, the Airdolphin uses previously generated power to rotate for 10 seconds every minute. This lets the rotor start up from a subtle wind and efficiently reach the cut-in point. The function also prevents freezing in cold weather.

### 8 Generator

The light-weight generator achieves remarkably high power density with tightly wound coils and powerful neodymium iron boron magnets. These two features combine to implement the optimum duty cycle by electronically damping the rotor.

### 9 Data Communication System

Every Airdolphin comes equipped with an RS-485 protocol wiring harness, allowing both on-site and remote monitoring via our RM-1000\* unit and an optional IP address.



RM-1000

### 10 Life Cycle Assessment

An extensive survey based on Japan's LCA (Life Cycle Assessment) standards showed that an Airdolphin offsets its manufacturing carbon footprints (180 kg CO<sub>2</sub>) with less than three months of operation in Japan at an average wind speed of 4.5 m/s (10.1 mph).

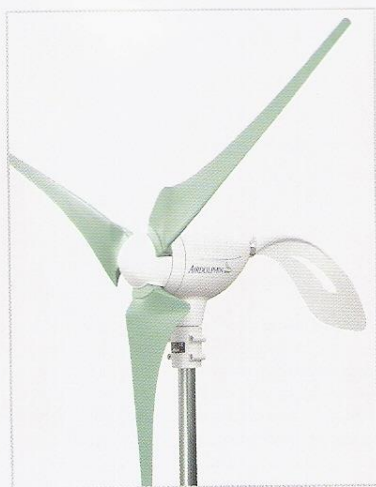
Data source: The University of Tokyo's Hirao Laboratory.

\*Remote Monitor RM-1000: Displays accumulated generated output (daily, monthly, total) as well as real-time generation output, wind direction/speed, and battery voltage. Features PC connection by wired LAN, flash memory slot, AC adapter, 24V/48V DC converter, and analog output.

# AIRDOLPHIN GTO

Connects to Grid via PV Inverters

The high DC voltage output Airdolphin GTO (Grid-Tie Optimized) is our latest small wind turbine model, rated 1.1 kW at 12.5 m/s (28 mph) with peak output reaching 4 kW at 20 m/s (45 mph). The Airdolphin GTO connects to the utility grid via PV inverters. Supported by its unique Intelligent Power Management System, the unit maintains seamless operation from cut-in wind speed of just 2.5 m/s (5.6 mph) to extremely windy conditions. Weighing less than 19.5 kg (42.9 lbs.) with a rotor diameter of only 1.8 m (6"), the Airdolphin GTO is the most efficient and easily installed small wind turbine in its class. Zephyr's Airdolphin Series is engineered and tested for reliability under every condition, providing years of maintenance-free operation.



\* Shown on right with black blades and pearl white body. Black blades are optional.

- Specifically designed for utility grid connections
- Peak (instantaneous) power output of 4 kW at 20 m/s wind speed
- Rated power of 1.1 kW at 12.5 m/s wind speed
- Allows low cost and easy connection with PV inverters
- New rotor/turbine control mechanisms (with instantaneous braking) to meet utility needs
- New turbine control system software

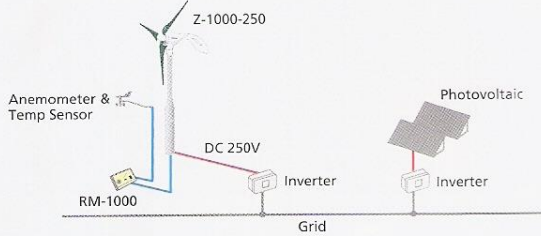


# AIRDOLPHIN Series

## Connects to Grid via PV Inverters

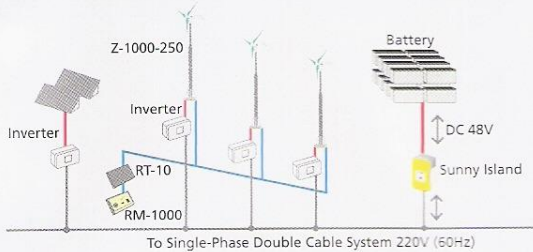
### On-Grid System

Previously, a dedicated grid-tie inverter was required to send back turbine-generated electricity (250V DC) to commercial utility grids. Since each country had different electric power specifications, it was difficult to meet every one of them. Airdolphin GTO's technology has solved this problem by enabling the use of commonly sold PV inverters. By connecting multiple Airdolphins to a single grid-tie inverter, the cost/performance ratio can be dramatically improved. Dedicated software prevents Airdolphin's maximum output from exceeding the inverter's capacity.

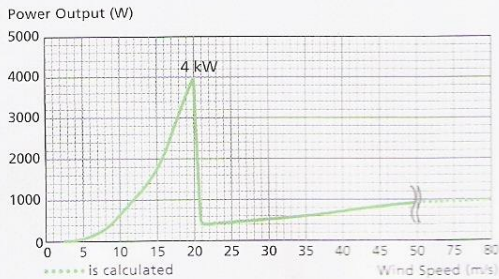


### Micro-Grid System

Collaboration with the SMA product lineup has made this micro-grid system a powerful and reliable power source for remote areas, such as off-shore sites and mountainous camps. The main power is provided by single-phase double cable AC 220V (60Hz) or AC 230V (50Hz).



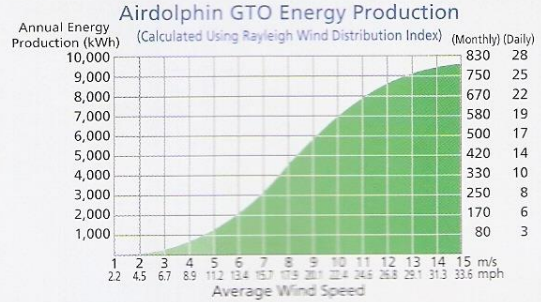
## Power Output Characteristics of the Airdolphin GTO



### Intelligent Power Management System

A truly seamless power generation can be achieved from wind speeds ranging from 2.5 m/s (5.6 mph) and above, never cutting out. At the rated wind speed of 12.5 m/s (27.9 mph), the system reaches constant rotation region of 1,280 r.p.m. and keeps it steady up to 20 m/s (44.7 mph) wind speed, where Airdolphin GTO (250V) delivers its peak power of 4 kW. Beyond that point, Airdolphin GTO still continues to deliver power output at a slightly lower level as the graph above shows, up to a very high wind speed region where almost all wind turbines are compelled to halt.

## Energy Production



### Captureability

"Captureability" is a new indicator created by Zephyr, showing how much energy can be captured from nature. Unlike static wind turbine performance on a test bench you often see in manufacturers' specifications, captureability is an absolute indicator which reflects wind turbine performance and wind characteristics collected from actual sites. Airdolphin GTO has been developed with an optimal design concept for maximum captureability as well as annual energy production (AEP). The key elements that ensure Airdolphin GTO's exceptionally high captureability are: advanced aerodynamic design/materials of the blades, sophisticated turbine power management technology, and the state-of-the-art turbine units.

Wind Speed m/s (mph)	Per Hour (kWh)	Per Day (kWh)	Per Month (kWh)	Per Year (kWh)	Wind Speed m/s (mph)	Per Hour (kWh)	Per Day (kWh)	Per Month (kWh)	Per Year (kWh)
2 (4.5)	6	144	4	53	9 (20.1)	660	15,840	475	5,782
3 (6.7)	29	696	21	254	10 (22.4)	792	19,008	570	6,938
4 (8.9)	74	1,776	53	648	11 (24.6)	901	21,624	649	7,893
5 (11.2)	144	3,456	104	1,261	12 (26.8)	983	23,592	708	8,511
6 (13.4)	242	5,808	174	2,120	13 (29.1)	1,040	24,960	749	9,110
7 (15.6)	368	8,832	265	3,224	14 (31.3)	1,076	25,824	775	9,426
8 (17.9)	513	12,312	369	4,494	15 (33.5)	1,096	26,304	789	9,601

## Specifications

Model Name	Airdolphin GTO
Model Number	Z-1000-250
Wind Turbine Type	Horizontal axis, up-wind
Rotor Diameter	1,800 mm (5'10"-7'8")
Mass	19.5 kg (42.9 lbs.)
Tower Diameter	48.6 mm (1-15/16")
Number of Blades	3
Blade Construction	Carbon fiber laminate over solid foam core
Blade Mass (per piece)	380 g (13 oz)
Blade Method	Interlock hub mounting
Body Material	Aluminum diecast
Body Construction	Screw-less joints (based on traditional Japanese craftsmanship)
Product Finish	Powder coating
Generator	Synchronous-type, three-phase power generator with permanent neodymium iron boron magnet
Control Systems	Built-in original Intelligent Power Management with: 1. Power Assist Function 2. Inverter Standby Function 3. Safety Control 4. Peak Power Management 5. Data Communication
Protection Circuit	Built-in
Data Logger	Built-in (Total energy production)
Yaw Control	Free yaw (360 degrees)
Direction Control	Original Swing-Rudder System
Start-up Wind Speed	0 m/s (Power Assist Function)
Cut-in Wind Speed	2.5 m/s, 5.6 mph
Peak Power	4.0 kW (20 m/s, 44.7 mph)
Maximum Rotor Speed	1,280 rpm (20 m/s, 44.7 mph)
Mass per Watt	17.7 g (0.6 oz)/W (at rated power)
Output Voltage	250V DC
Braking System	Regenerative electromagnetic braking system
Communication System (Signal Output)	RS-485

# AIRDOLPHIN PRO 48V

## AIRDOLPHIN Mark-Zero 24V

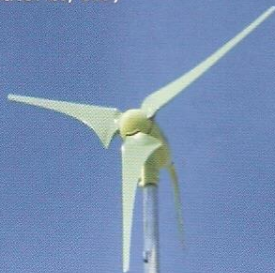
### Airdolphin Pro 48V

#### Off-Grid (Battery System)

- Mountainous areas
- Ocean areas and islands
- Repeater stations
- Remote monitoring sites (web cameras, GPS receivers, wireless applications)
- Street lights (no utility electricity required)
- Public facilities (dams, weather observatories, etc.)

#### Telecom System

- Communication base stations



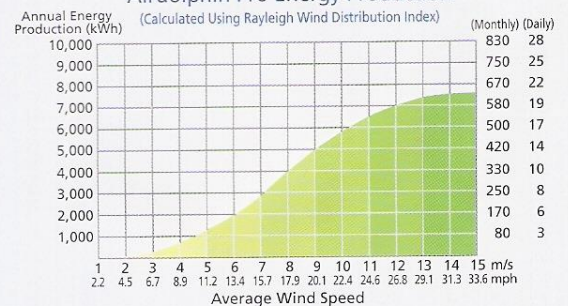
### Power Output Characteristics



### Intelligent Power Management System

A truly seamless power generation can be achieved from wind speeds ranging from 2.5 m/s (5.6 mph) and over, never cutting out. The system instantly responds to wind speed fluctuations for optimal power point production. At peak, Airdolphin Mark-Zero and Pro can deliver 2.3 kW output in 20 m/s (44.7 mph) winds, then shift to a gradual output as the wind intensifies.

### Airdolphin Pro Energy Production



Wind Speed (m/s)	Per Hour (Wh)	Per Day (Wh)	Per Month (kWh)	Per Year (kWh)	Wind Speed (m/s)	Per Hour (Wh)	Per Day (Wh)	Per Month (kWh)	Per Year (kWh)
2 (4.5)	6	144	4	53	9 (20.1)	566	13,584	408	4,958
3 (6.7)	28	672	20	245	10 (22.4)	662	15,888	477	5,799
4 (8.9)	73	1,752	53	639	11 (24.6)	738	17,712	531	6,465
5 (11.2)	140	3,360	101	1,226	12 (26.8)	795	19,080	572	6,964
6 (13.4)	231	5,544	166	2,024	13 (29.1)	834	20,016	600	7,306
7 (15.6)	339	8,136	244	2,970	14 (31.3)	858	20,592	618	7,516
8 (17.9)	455	10,920	328	3,986	15 (33.5)	871	20,904	627	7,630

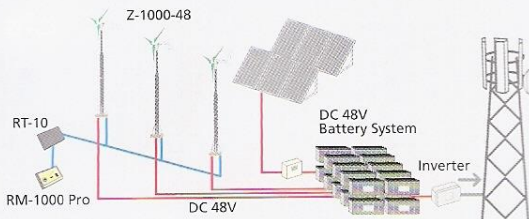
### Specifications

Model Name	Airdolphin Pro / Airdolphin Mark-Zero
Model Number	Z-1000-48 / Z-1000-24
Wind Turbine Type	Horizontal axis, up-wind
Rotor Diameter	1,800 mm (5'10-7/8")
Mass	17.5 kg (38.5 lbs)
Tower Diameter	48.6 mm (1-15/16")
Number of Blades	3
Blade Construction	Carbon fiber laminate over solid foam core
Blade Mass (per piece)	380 g (13 oz)
Blade Method	Interlock hub mounting
Body Material	Aluminum diecast
Body Construction	Screw-less joints (based on traditional Japanese craftsmanship)
Product Finish	Anti-corrosion Teflon-based paint
Generator	Synchronous-type, three-phase power generator with permanent neodymium iron boron magnet
Control Systems	Built-in original Intelligent Power Management with: 1. Power Assist Function 2. Seamless Power Control Functions 3. Safety Control 4. Battery Charge Management 5. Data Communication
Protection Circuit	Built-in
Data Logger	Built-in (Total energy production)
Yaw Control	Free yaw (360 degrees)
Direction Control	Original Swing-Rudder System
Start-up Wind Speed	0 m/s (Power Assist Function)
Cut-in Wind Speed	2.5 m/s, 5.6 mph
Peak Power	2.3 kW (20 m/s, 44.7 mph)
Maximum Rotor Speed	1,000 rpm (20 m/s, 44.7 mph)
Mass per Watt	17.5 g (0.6 oz)/W (at rated power)
Output Voltage	50V DC (Z-1000-48) / 25V DC (Z-1000-24)
Braking System	Regenerative electromagnetic braking system
Communication System (Signal Output)	RS-485
Recommended Battery Capacity	Deep cycle lead acid battery 500 Ah or more Off-grid: Deep cycle lead acid battery, 500 Ah or more

**Typical Off-Grid / Stand-Alone System**

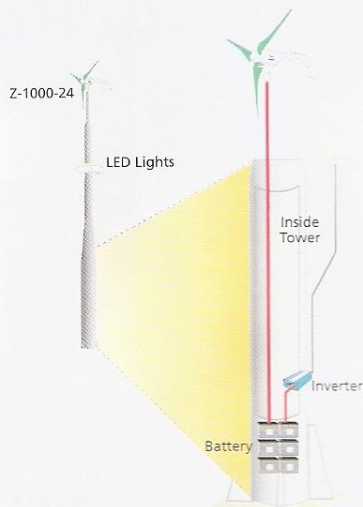
**Telecom System (48V)**

Airdolphin Pro can be installed on a 48V battery system at communication base stations and other locations. You can also attach Airdolphin Pro to an existing solar power system connected to a 48V battery system. The overvoltage-protection threshold can be set to match battery characteristics.



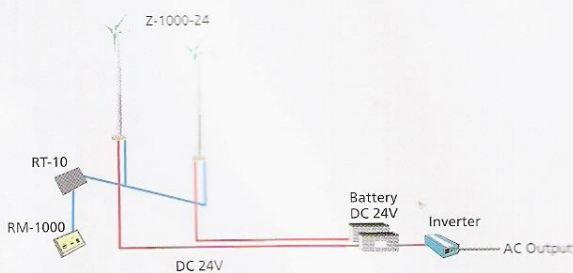
**Street Light System (48V/24V)**

In the all-in-one street light system powered by Airdolphin, a battery is housed in the pole, and LED lighting is integrated into a single unit. The system provides light to areas without electricity, such as along highways, on bridges, and preserved land.



**Small Off-Grid System (24V)**

This system is ideal for ensuring electrical supply in times of disaster and for camping vehicles, fishing boats and other leisure vehicles.



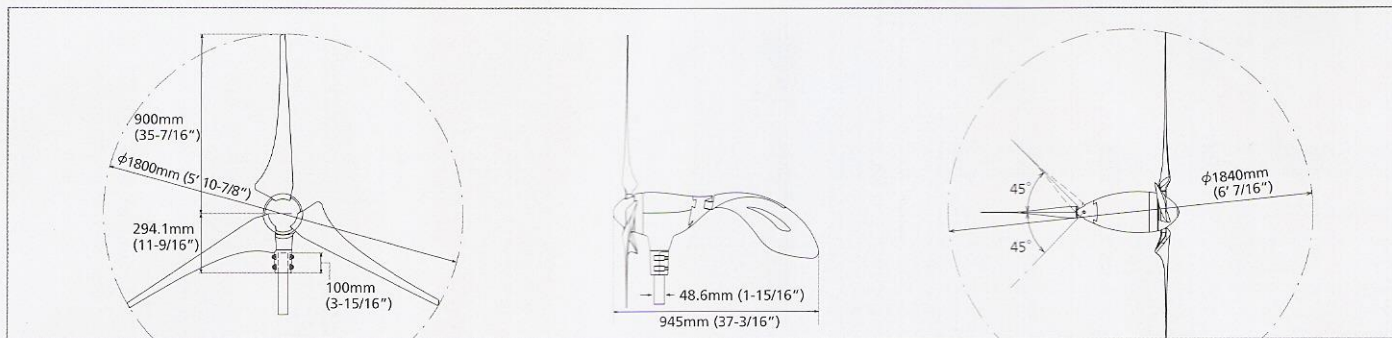
**Airdolphin Mark-Zero 24V**

**Off-Grid (Battery System)**

- Residences in remote areas
- Remote monitoring sites (web cameras, GPS receivers, wireless applications)
- Street lights (no utility electricity required)
- Public facilities (dams, weather observatories, etc.)



# Outer Dimensions



Front, Side, and Top Views

## Airdolphins in Action Around the World



U.K.

Germany

Spain

Turkey

Mongolia

Austria

Japan

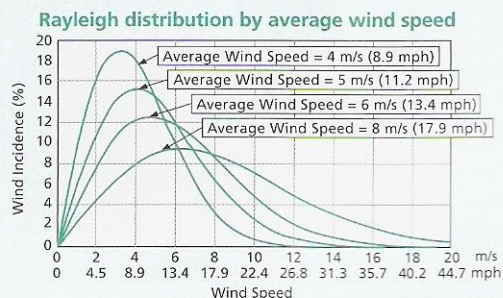
## Airdolphin FAQ

### Q1 How much energy does it produce?

**A1** A graph shows power generation calculation for each product. This is a simulation result for average wind speed setting based on Rayleigh Distribution. The actual wind distribution will differ by location. The figures in the graph represent DC power from Airdolphin. Therefore, the efficiency of grid-tie inverter for on-grid systems, the battery charge/discharge loss for off-grid systems, and inverter efficiency for stand-alone systems also need to be considered.

### Q2 What is Rayleigh Wind Distribution?

**A2** It is a distribution form generally used to illustrate wind distribution. For example, if the average wind speed is defined at 5 m/s (11.2 mph), the distribution form will be determined accordingly.



### Q3 What happens in strong wind conditions like typhoons?

**A3** Airdolphin automatically lowers rotational speed during strong winds, and safely continues power generation. Unlike furling (passive control) on other companies' wind turbines, Airdolphin uses active control. With automatic slowdown, the wind load is rapidly reduced to a safe condition, so there's no need for the user to stop turbine operation. Airdolphin's survival wind speed is over 65 m/s (145 mph).

### Q4 Would the blades freeze and/or break in snowy areas?

**A4** In snowy areas, the Power Assist Function has proved effective for preventing ice buildup. Even if the blades freeze, they will operate normally after removing the snow and ice.

### Q5 How is it evaluated?

**A5** Airdolphin's reliability evaluation is based on hundreds of vehicle-mounted tests at a circuit course, which can realize strong winds of 35 m/s (78 mph). Also, field tests have been carried out in severe climates around the world, for continuous improvement of the product's reliability.

- Government-sponsored performance test in south France
- Performance test in areas below -35 degrees centigrade (-31 Fahrenheit) in Canada
- Performance test in Japan's remote areas with over 50 m/s (112 mph) wind speed, salt damage, or heavy snow.

### Q6 How do you stop the wind turbine?

**A6** With the optional RM-1000 remote monitor, you can safely stop turbine operation anytime for maintenance, etc. You can also monitor the operation or control stop/run of the unit from a remote location via the internet.

### Q7 Why do you need the Power Assist Function? What's the daily consumption?

**A7** Airdolphin generates high power with ultra-efficient blade design and a generator with the world's strongest magnet. The only disadvantage is that large amount of torque is needed for rotor start-up, so the Power Assist Function was developed to bring out the best from the blades and the generator. Airdolphin starts up with the help of Power Assist Function. When the wind is sufficient, the Power Assist Function automatically turns off. Even if there is zero wind throughout the day, the power consumption is merely 30 Wh/day.

### Q8 Where can I purchase a tower?

**A8** Dedicated towers are available for separate purchase. Up to 5 m (16 ft) rooftop towers and up to 30.5 m (100 ft) ground towers are available. Please consult Zephyr or our dealers.

### Q9 How do I choose a grid-tie inverter? Are there any recommended manufacturers? Where can I buy them?

**A9** You can use the commonly available PV inverters, as long as they satisfy the following minimum specifications and settings.

- Specifications:
- Maximum input voltage: over 400V DC
  - Minimum input voltage: under 250V
- Settings:
- Power operating mode: Constant voltage mode (CV Mode)
  - CV setting voltage: 270-280V DC (adjustable)

We have tested and recommend the Sunny Boy Series by SMA Solar Technology AG, Germany.



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