

Your idea – our drive.

For us, everything revolves around you.



Framo Morat is your partner for customized drive solutions. In the areas of gearwheel technology, worm gear sets and drive systems we supply a comprehensive range of products that cover a wide spectrum of applications. In addition to our complete range of catalogue products, we also design and implement customer-specific drive solutions. Framo Morat is your reliable partner for worm, spur or planetary gears; complete gear motors; and complex drive systems – and for your drive concept too!

GEARVALLEY

With us you profit from the experience and expertise of two centuries of Black Forest industrial culture.
www.gearvalley.com

Spur gears

Rotor shafts, gearwheels with internal or external tooth systems, pinions and chain pulleys according to individual customer requirements.

Worm gear sets

Framo Morat is one of the world's leading suppliers, having produced over 60 million worm gear sets, many of which were customer-specific.

Drive technology

Innovative standard drives such as the Compacta slip-on gear drive motor, as well as complete customer-specific drive solutions, are in use in numerous applications.

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Following the sun.

Customized drive solutions for the solar industry.

 **FramoMorat**
Your Idea - Our Drive





The driving force...

Capture the sun...

Every day, the sun sends immeasurable amounts of energy to the earth, though we have to 'capture' this energy first in order to be able to use it. Drive systems from Framo Morat ensure that this is achieved as effectively as possible.

With both photovoltaic modules and solar thermal energy systems, the aim of achieving maximum energy exploitation through the course of the day requires precise alignment to the sun. Solar tracking systems place photovoltaic modules or reflectors in the optimum position at all times of day. In this way, the effectiveness of PV systems can be increased by between 20 and 45 per cent compared to fixed-mounted systems, depending on the technology and the geographical location. All components in our drives have been specially designed for use in all weathers to allow reliable long-term operation with minimum maintenance

and servicing effort. Thus with drive solutions from Framo Morat, at the end of the day both the energy balance and the cost balance are right.

Technologies for solar energy generation

- **Photovoltaic (PV):** In PV systems solar radiation is directly converted to electrical current with the help of special semiconductors (solar cells). The most important PV technologies are silicon, thin-film and concentrator cells.
- **Concentrated Solar Power (CSP):** In CSP power stations, mirrors focus the sunlight on a liquid (water or special oils) so that it evaporates. A power generator is driven using the hot vapour. The most important CSP technologies are heliostatic, parabolic channel and Fresnel collectors.



...for your success. ...with drives from Framo Morat.

Framo Morat is the right partner for the successful capture of sunlight. Our drive solutions for the solar industry include all necessary components, from the drive and its gears, through positioning systems, to control electronics.

As the leading European supplier of gearing technology, worm gear sets and complete drives, we not only have high technical competence and state-of-the-art production plants, but also decades' long experience from numerous implemented drive solutions. This knowledge is of immediate benefit to our customers in the solar industry because the components used are already employed in numerous applications and sectors, and have proved themselves a thousand times over.

Our drive solutions are developed and produced in-house according to customer-specific requirements – allowing optimum fulfilment of customer needs. Whether for photovoltaic or solar thermal systems, drives from Framo Morat guarantee you maximum efficiency and cost-effectiveness.

GEARVALLEY

Made in GearValley

Framo Morat's Head Office was founded in Eisenbach in the Black Forest in 1863. Numerous producers of precision mechanics, precision turned parts and drives are now located in the flourishing watch-making centre of old, so that one also speaks of the Black Forest "GearValley".

A turn for the better.

Stay on the sunny side
with our 1- and 2-axis PV tracking systems.



Azimuth and elevation adjustment

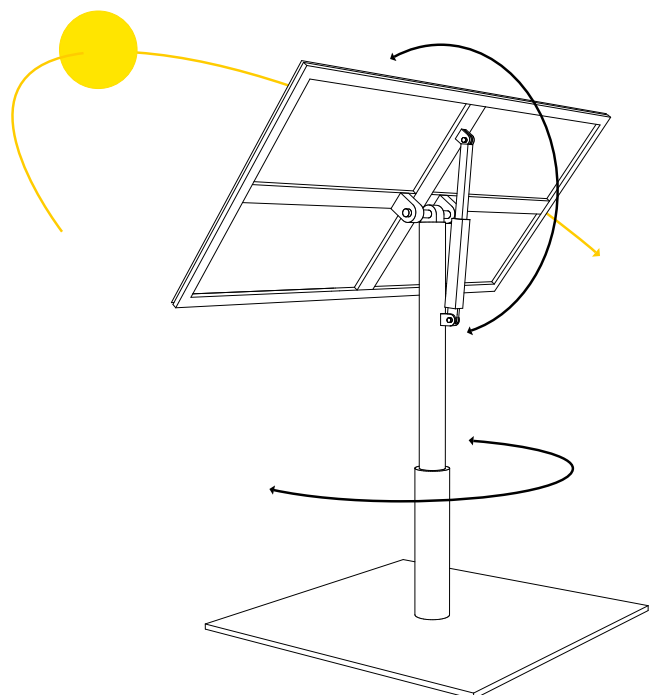
Solar cells work most effectively with vertical light incidence, so the module's energy yield can be optimized with 2-axis adjustment. Whereby east-west alignment, following the path of the sun, is described as the azimuth adjustment, and the vertical alignment according to the position of the sun above the horizon is called the elevation adjustment.

Azimuth adjustment

- Up to 20,000 Nm
- From 0.01 r.p.m.
- Rotational clearance from 2 angular minutes

Elevation adjustment

- Lifting power up to 10 tons
- Speed up to 25 mm/sec
- Accuracy from 0.1 mm/1,000 mm



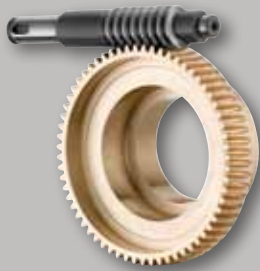
1- or 2-axis tracking systems are used to increase the effectiveness of photovoltaic plants. They align the PV module horizontally and vertically to the sun (azimuth and elevation adjustment). Framo Morat has developed special drive systems for this purpose – in which all components, from the drive housing to the cable, have been specifically designed for harsh outdoor operation.

Tracking drive for PV plants

- 1- or 2-axis tracking
- Azimuth adjustment through self-locking worm gears
- Elevation adjustment through electromechanical linear actuators
- Low power requirement for tracking drive
- Robust drives, highly immune to wind loads, humidity and temperature variations
- Drive control, positioning and communication (fieldbus) can be integrated in the drive

Worm gear sets and worm gears

- Dynamic torques of up to 9,000 Nm
- Static torques of up to 20,000 Nm
- Use of high-quality bronze, brass or cast steel materials



Application example:

spindle-type linear actuators for elevation adjustment

- Dynamic loads of up to 50 kN
- Static loads of up to 210 kN
- Trapezoidal thread or ball screw drives with or without integrated limit switches
- Intermediate gears, optionally as worm, spur or planetary gears
- Three-phase, AC or DC current motors as well as brushless DC and servo motors

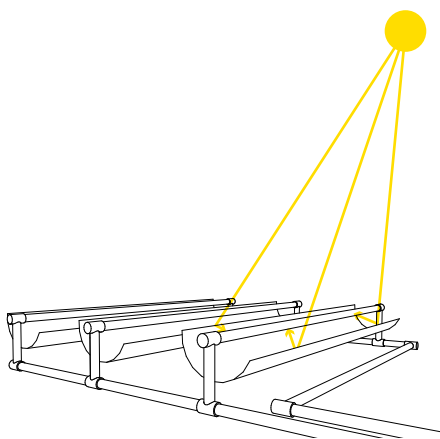
Application example: decentralized drive for single-axis tracking of thin-layer modules

- Economical tracking
- 3-stage DC gear motor (permanent magnet) with 120 Nm drive torque
- Integrated motor control, absolute value encoder and CAN-Bus interface
- Tracking of more than 200 m² module area through up to 40 secondary gears
- Simple timed control for stand-alone systems
- Central astronomical control for drives in solar parks



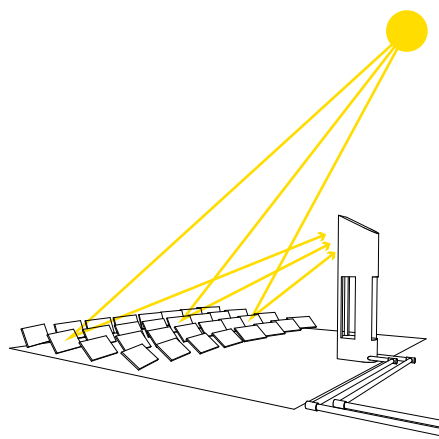
Precise – to the minute.

Our highly accurate CSP mirror adjustments provide you with a rich crop of sunshine.



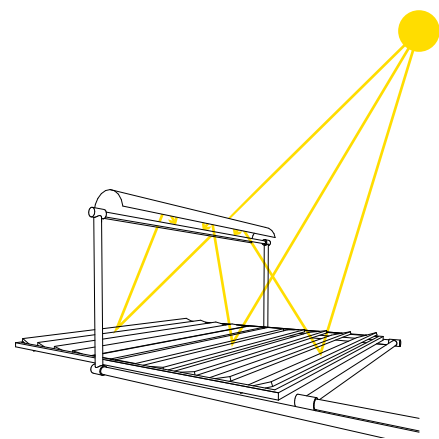
Parabolic channel collectors

In parabolic channel collectors the incidental sunlight is directed towards a fixed absorption tube (through which a thermo-oil is flowing) via a parabolic curved mirror. The oil that evaporates as a result of the consolidated energy runs a current generator. A single-axis tracking mechanism is used to adjust the parabolic channel collectors (arranged in a north-south alignment) from east to west.



Solar tower plant with heliostats

In solar tower power stations the incidental sunlight is focused onto a central absorber at the top of the tower using large mirrors, so-called heliostats. Water evaporates as a result of the concentrated energy and drives the downstream generator for electricity production. In order to hit the focal point at all times, the heliostats must track the sun through two axes.



Fresnel collectors

The functional method of the Fresnel collector is similar to that of the parabolic channel collector though it does not consist of one unit, but of flat reflector panels whose slope is adjusted towards the sun by means of a single-axis tracking mechanism. Fresnel collectors have a simple design and are thus cheaper to implement, though they involve more complicated tracking.

In the case of solar thermal energy generation, the tracking task involves aligning reflectors towards the sun in such a way that the sun's beams are precisely focused on a focal point (in solar tower plants) or a focal line (in parabolic trough and Fresnel collectors). Even minor deviations of a few angular minutes can impair the solar energy yield so that particularly precise and reliable tracking systems are required for CSP applications. The position of Fresnel reflectors must be adjusted several thousand times a day in order to be able follow the course of the sun.

In addition to high precision, CSP tracking systems also require a high level of immunity against climatic extremes. This is because most CSP plants are located in parts of the earth that receive a lot of sunshine, where major fluctuations in temperature (from -10°C to $+60^{\circ}\text{C}$) and air humidity (from 10% to 100%), as well as severe friction caused by dust and sand storms are to be expected. All components in our drives are appropriately designed, from corrosion-resistant motor and drive housings with high tightness levels, through UV-stable cables and seals, to the use of particularly high-quality lubricants.

Tracking drives for CSP plants

- Single-axis tracking with Fresnel or parabolic trough drives
- 2-axis tracking for heliostat drives
- Self-locking precision worm gears with extremely low circumferential backlash (up to < 2 angular minutes, depending on the size)
- Low power consumption for tracking drive
- Drive control, positioning and communication (fieldbus) can be integrated in the drive

Application example: Reflector drive for Fresnel collectors

- 5-level brushless DC motor with a gear ratio of 38,000:1
- Backlash of max. 5 angular minutes
- Dynamic torques of up to 120 Nm
- Static torques of up to 250 Nm
- Integrated motor control with 17-bit absolute value encoder and CAN-Bus interface
- Customer-specific mounting equipment for simple integration in the power station's steel structure
- One drive swivels a mirror area of 60 m^2

