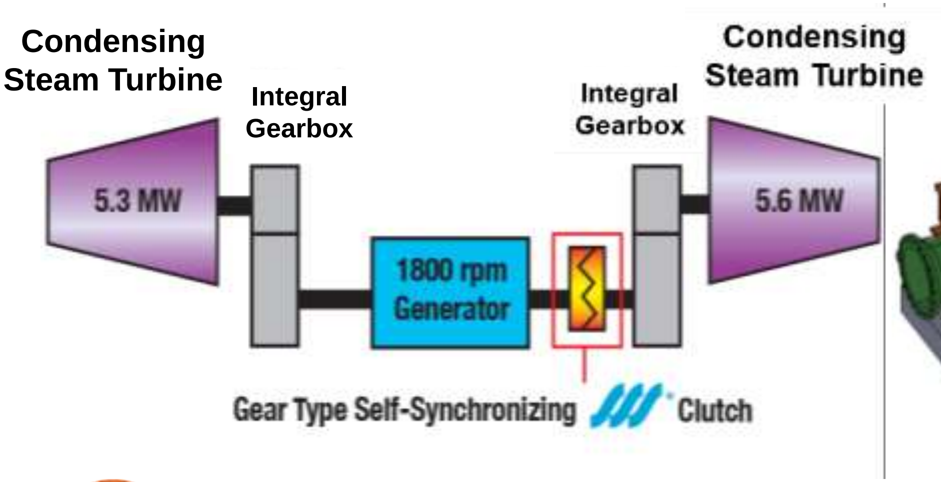
DISCLAIMER

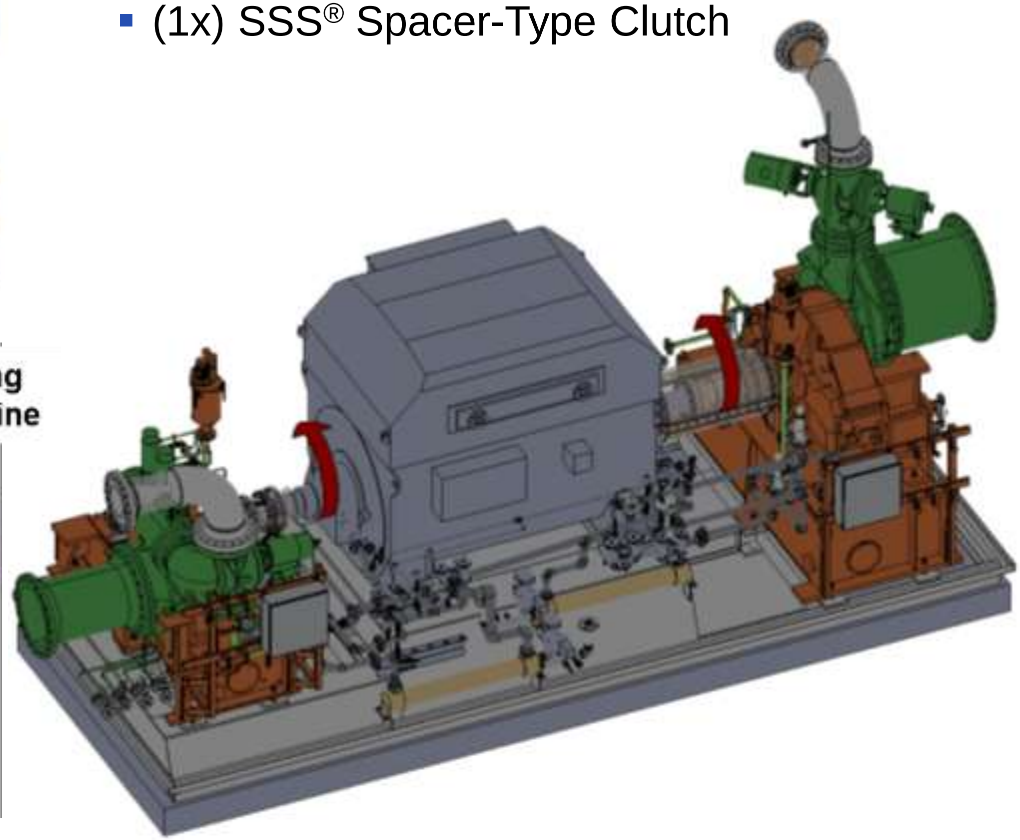
Please note the last five (5) slides in this PPT are place holders for small banners that we will be printing out.

Each small banner will have the titles included on its respective slide.

Case Study 1
University of Iowa's NEW 11 MW Combined Heat and Power Facility

University of Iowa CHP Plant:
- (1x) 11MW Double-Ended Generator
- (2x) Condensing Steam Turbines
- (1x) SSS® Spacer-Type Clutch





Case Study 1
University of Iowa 11 MW Combined Heat and Power Facility

This Combined Heat and Power Plant provides heat to the University of Iowa Campus and the University of Iowa Hospitals and Clinics while producing about one-third of the university's electric power needs.

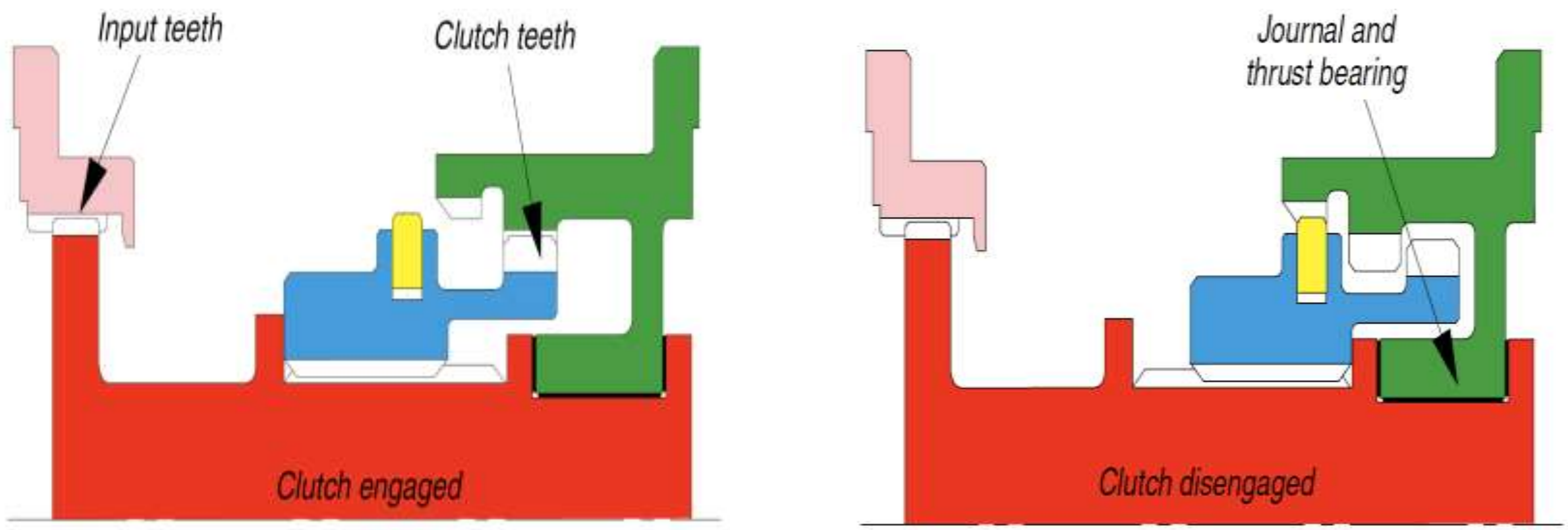
- The new addition includes two integral gear type steam turbines.
  - One high speed backpressure (HP) turbine driving into one gear
  - One low pressure condensing (LP) turbine integrated into a second gearbox
  - With both outputs driving a common generator.
- The HP turbine is a multivalve type providing high efficiency over a wide steam flow range.
- Heating steam is taken off between the HP and LP turbines.
- An overrunning clutch is installed between the output of the LP turbine gearbox and the generator to allow automatic disconnecting of the LP turbine when all steam is required for heating.
- The turbines, gearbox, generator, overrunning clutch, lube system and piping, steam sealing system and piping, and trip/throttle valves are all factory assembled on a common baseplate for convenient installation.

Case Study 1

University of Iowa 11 MW Combined Heat and Power Facility

Size120FT SSS® Encased Spacer-Type Clutch:

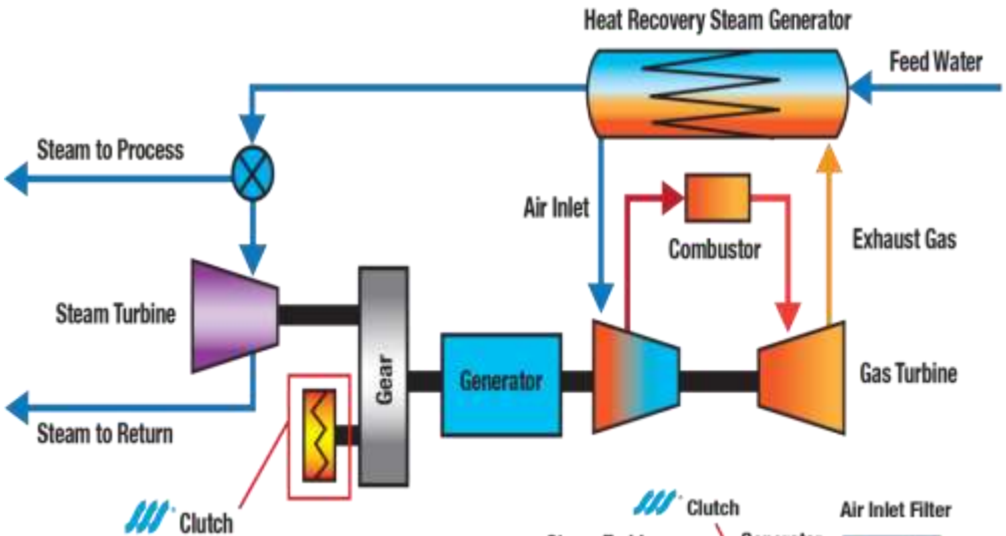
- Can accept axial expansion by sliding input teeth
- Can be fully shaft supported by internal bearing, or by an input and/or output pedestal bearing
- Acts as double element flexible coupling, accepting small angular and radial misalignment across teeth and internal bearing



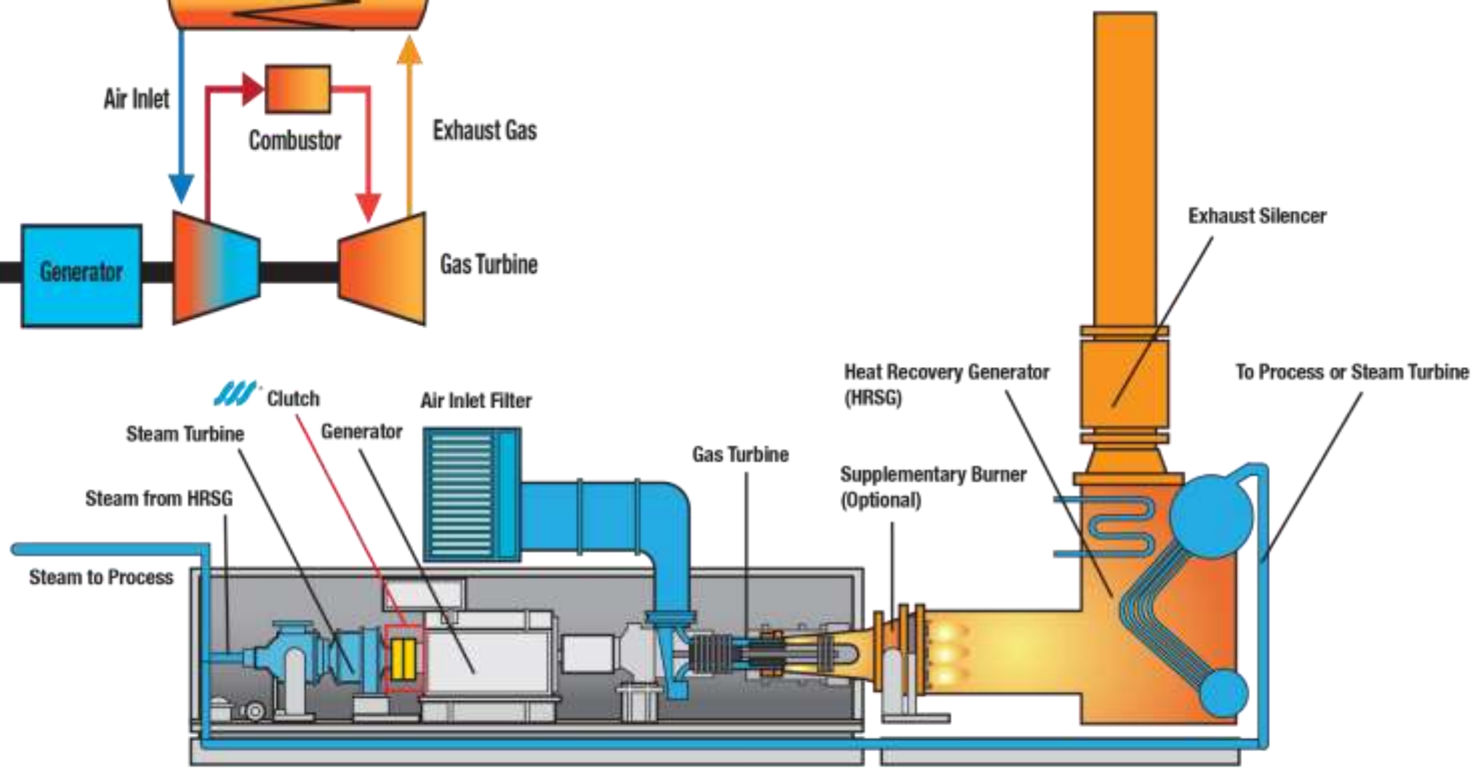
Case Study 2
Arizona State University 9 MW Combined Heat and Power Facility

Steam Turbine Assisted Cogeneration (STAC)

System Schematic



STAC System Installation



Case Study 2
Arizona State University 9 MW Combined Heat and Power Facility

1–9 MW Solar Turbines STAC System Single Shaft Combined Cycle Power Train (Single Skid Package) Including:

- 1-Solar Turbines Taurus 70 7.5 MW Gas Turbine
- 1-Dresser-Rand 2 MW steam turbine
- 1-SSS® gear type self-synchronizing overrunning clutch integrated into gearbox between steam turbine and generator
- 1-10 MW double end drive generator
- 1-Set of switchgear
- 1-Combined GT-ST control panel

Case Study 2
Arizona State University 9 MW Combined Heat and Power Facility

Areas of Capital Cost Savings

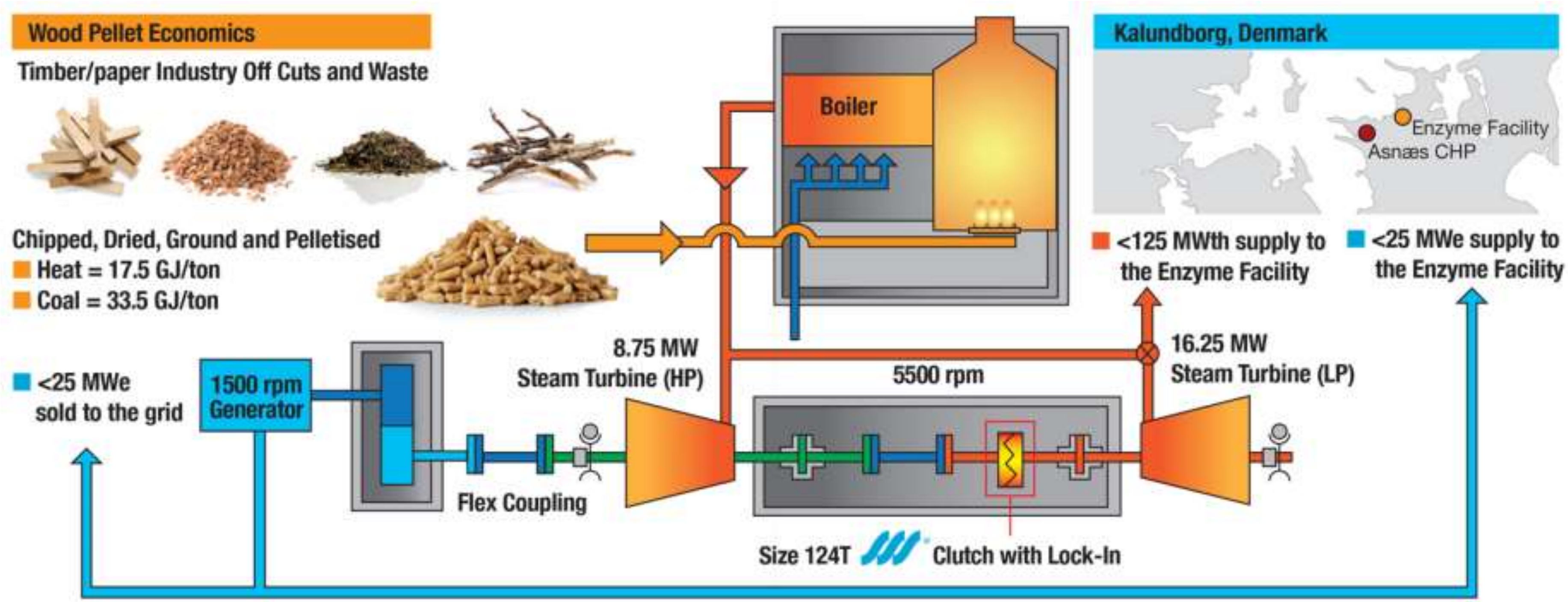
- One 10 MW double end drive generator approximately **80% the cost** of the two separate generators
- One set of switchgear versus two – about **40% savings** compared to one for the GT and one set for the ST
- **Single skidded package** to handle and install versus two separate skids
- One run of generator power cabling
- **One combined GT and ST control panel** to install versus two separate panels
- **Installation space savings:** approximately 150 Ft^2 in power room plus 24 Ft^2 in control/switchgear area

Operating Savings

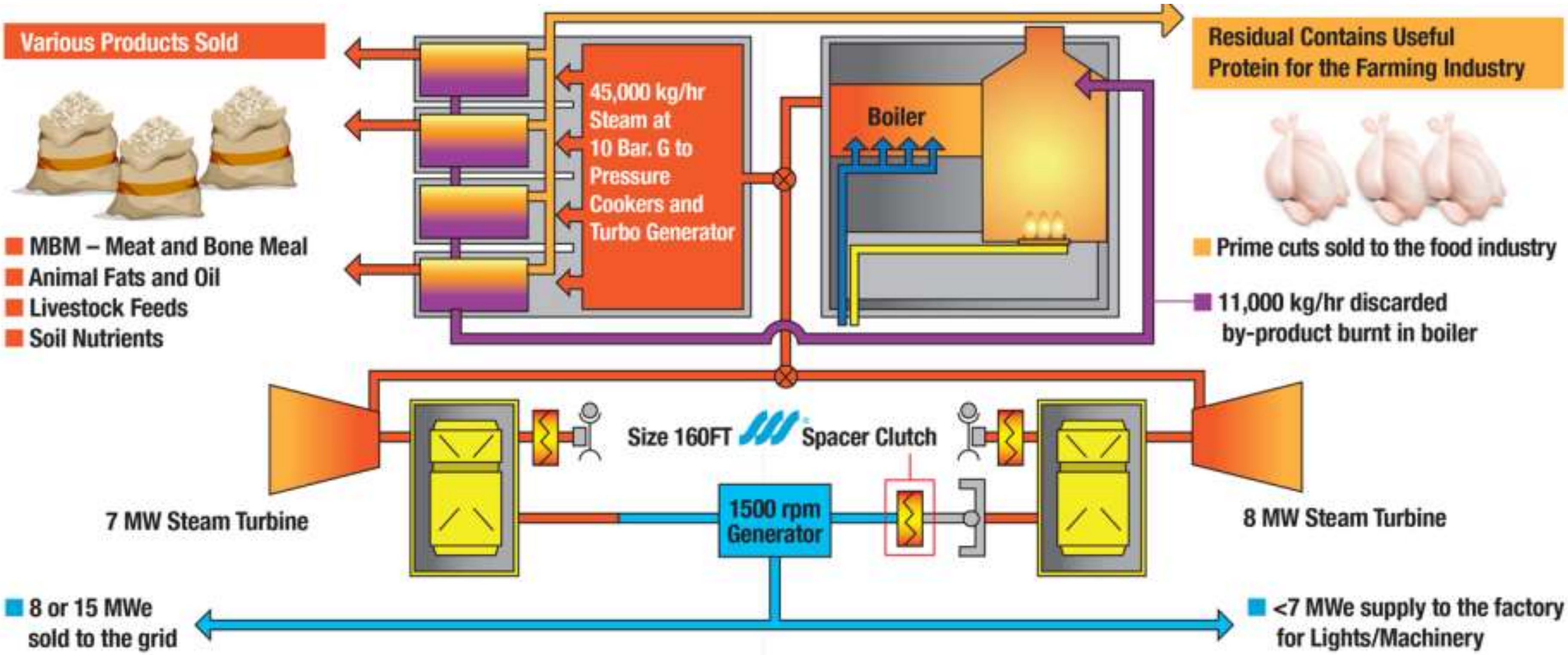
- When all steam needed for heating turbine can be automatically disengaged and shutdown saving cost of producing minimum steam flow required to prevent damage to the turbine (see plot of savings)

18 of the STAC packages with SSS® Overrunning Clutches installed worldwide, some with encased clutches mounted between the steam turbine and generator and others with the clutch integrated in the gearbox.

Case Study 3 – Biomass
Agricultural Waste – 25 MW, Denmark



Case Study 3 – Biomass
Meat Processing – 15 MW, United Kingdom



Case Study 4
>1.5MW Clutches for CHP Plants - Plauen, Germany

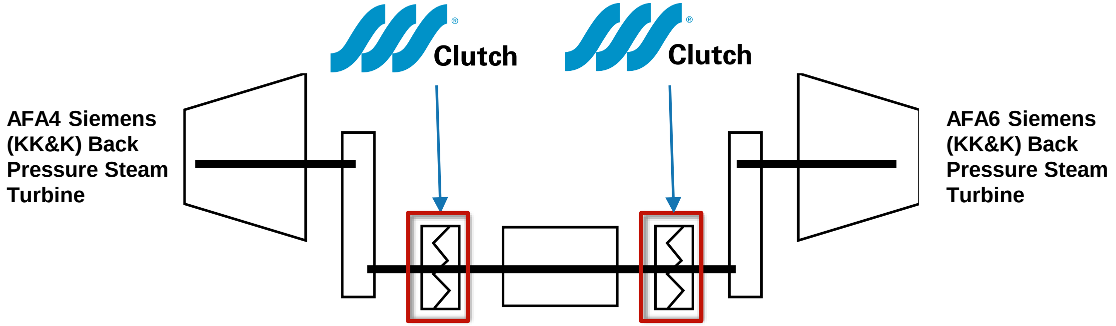
Steam
- 60 tonnes/hour grid
- 5.7 Bar pressure to grid
- 240 ° C temp to grid

Electricity
- 1.0 MWe back pressure turbine
- 0.32 MWe back pressure turbine
- 1,500 rpm generator

SSS® Clutches
- 36 + 30 SSS® Clutch Couplings
- No oil supply required
- Includes flexible couplings
- Size 30 includes electrical insulation


Siemens (KK&K) Dual Driven Steam Turbine Generator


SSS Clutch Coupling



Case Study 4

>1.5MW Clutches for CHP Plants - Plauen, Germany

Two standard single valve turbines with automated hand valves both geared to a single double end drive generator through standard SSS® Clutch Couplings.

- One turbine designed for 100,000 lbs/hr and the other for 33,000 lbs/hr
- Overall cost lower than the two turbines driving separate generators each with their own switchgear
- Generator stays synchronized with the grid continuously
- Fits within the available space

Case Study 4
>1.5MW Clutches for CHP Plants - Plauen, Germany

Using One Large and One Small Back Pressure Turbine:

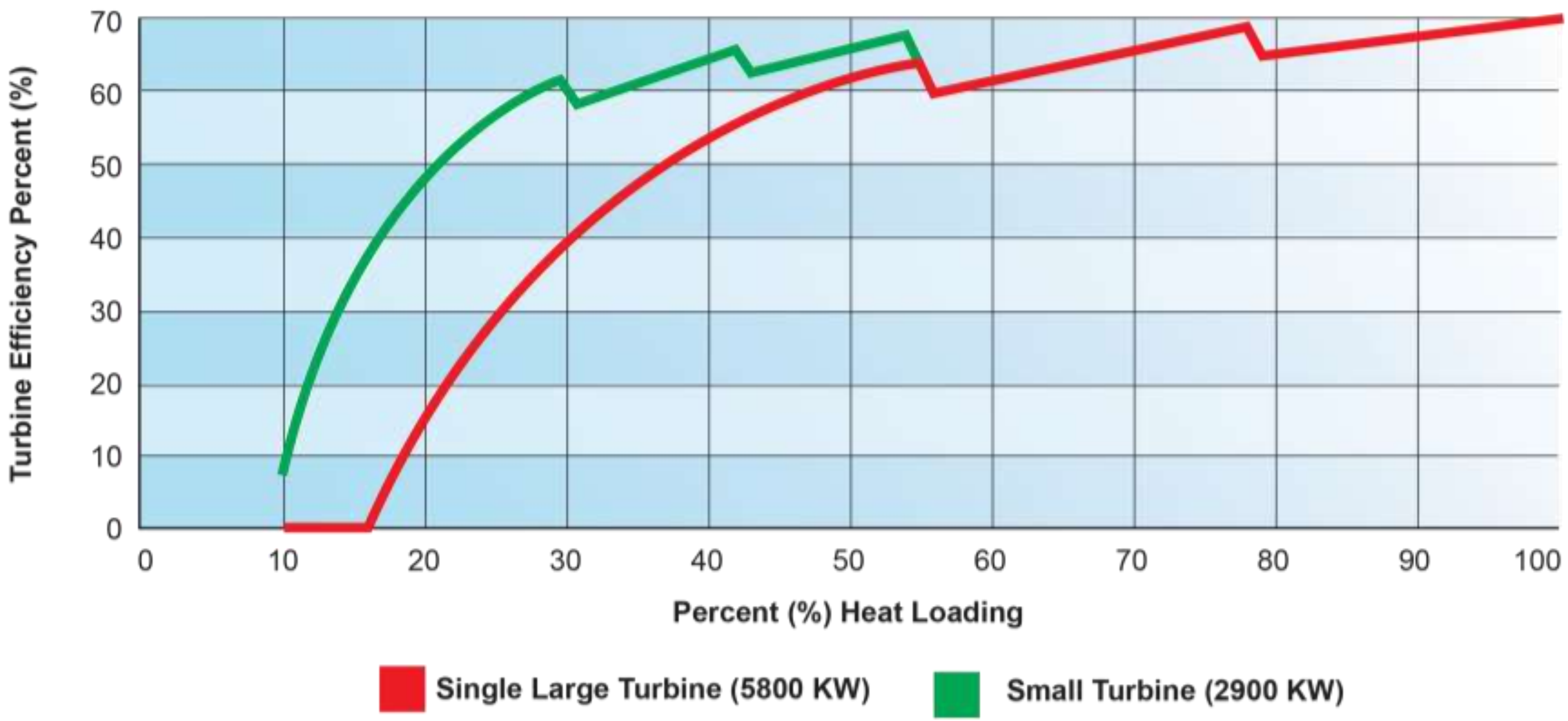
- Significantly Improves Efficiency and Operating Income When operating at Reduced Heating System Demand

Combining the Two Turbines on One Generator with Overrunning Clutches:

- Saves the cost of a second generator and switchgear
- Reduces space and foundation size
- Turbines can be engaged without re-synchronizing generator
- If no heating demand generator can be used for power factor improvement with both turbines shutdown and clutches disengaged

Turbine Efficiency:
Comparing Large Turbine Only to Large and Small Back Pressure Turbines

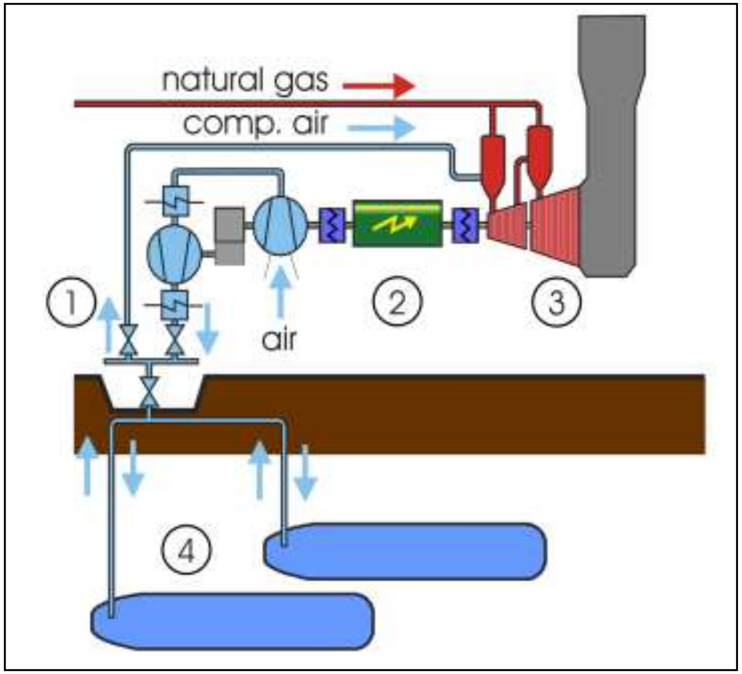
Based on a Design Heating System Load of 125 MMBTU/HR



Compressed Air Energy Storage (CAES)
One Generator, Two Clutches, Three Modes

Overrunning Clutches Provide Triple Use of Generator

1. Generator
2. Motor for Compressing Air
3. Synchronous Condenser for Grid Stabilization



Huntorf, Germany
330 MW CAES Plant

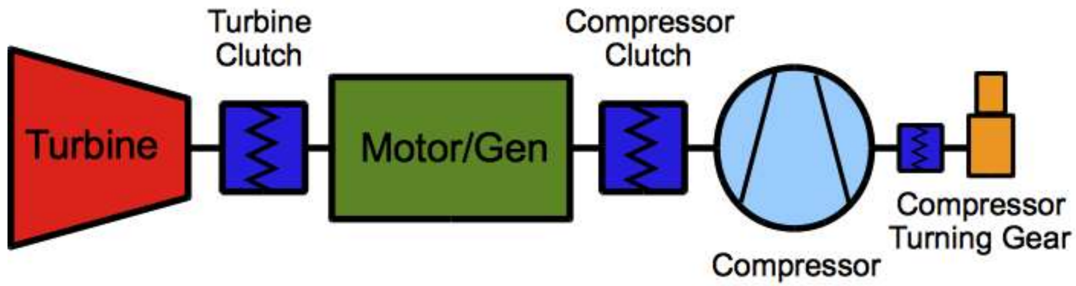
330 MW CAES Plant in Huntorf, Germany

World's first high power CAES plant. Designed and built by ABB for NWK, Huntorf, Germany and commenced operation in 1977. The plant operated continuously for over 20 years until its first major overhaul.

Also very robust, the SSS Clutches have required no maintenance since commissioning even with daily starts and stops for the first 20 years.

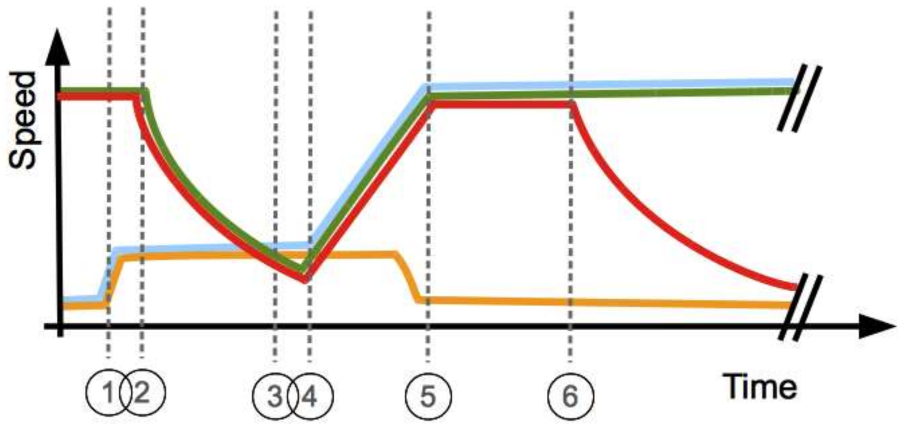
The specs:

- **Over 13,000 starts and 110,000 hours of total generation.**
- **The turbine clutch transmits 330MW at 3,000rpm .**
- **The compressor clutch transmits 110MW at 3,000rpm.**



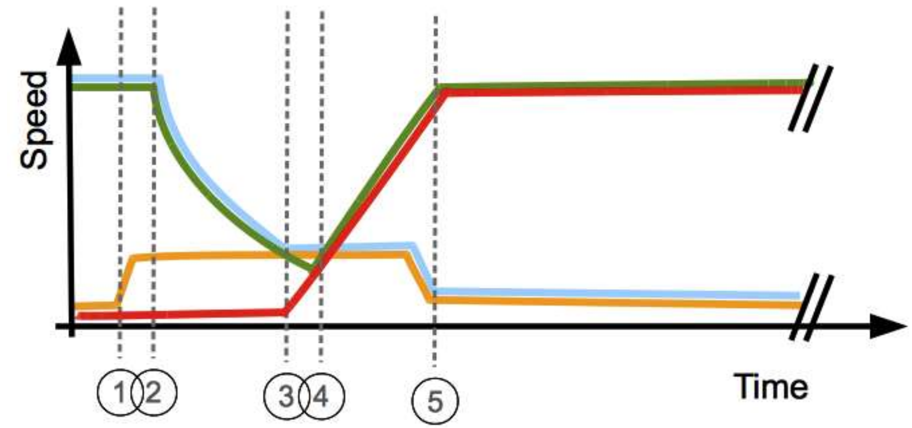
CAES
Operation Procedure

Generation to Compression



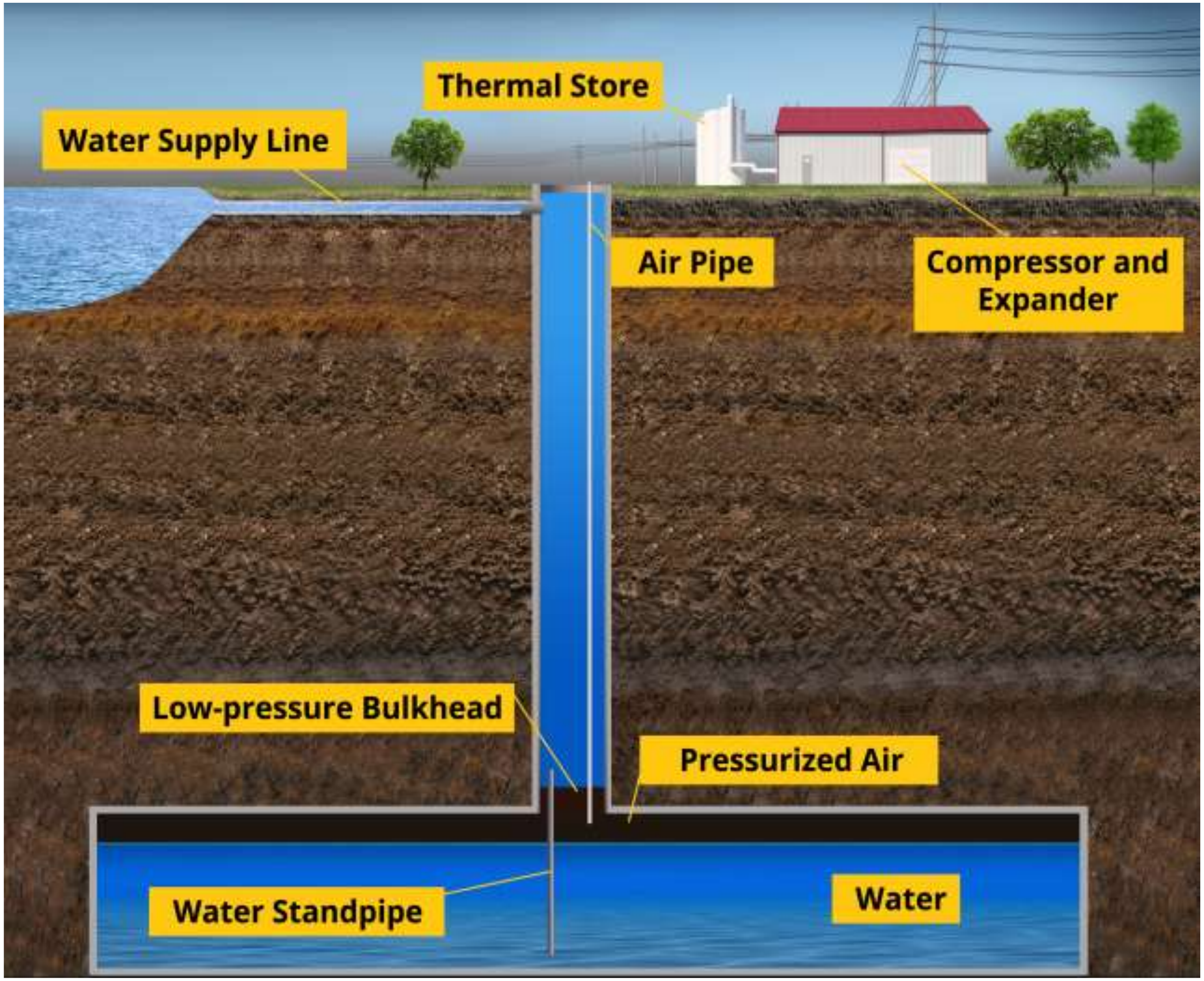
1. Start Compressor TG
2. Shutdown Turbine/Generator (Turbine clutch remains engaged if ‘Locked-In’)
3. When Generator rpm<Compressor rpm shift Compressor Clutch to Ratchetting
4. Start Turbine => Turbine & Compressor Clutches automatically engages
5. Accelerate & synchronize motor/generator
6. Shutdown Turbine => Turbine Clutch automatically disengages

Compression to Generation



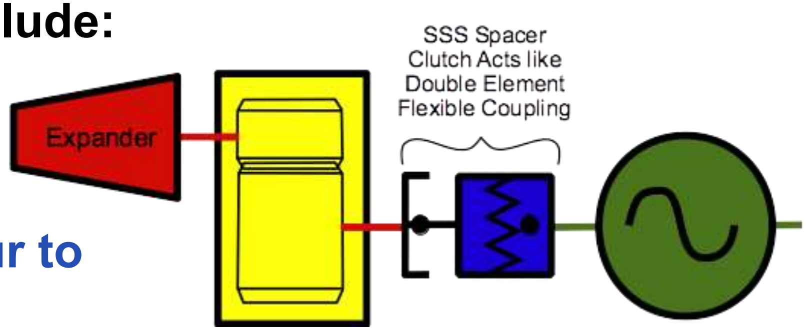
1. Start Compressor TG
2. Shutdown Generator/Compressor
3. Compressor TG engages and Generator rpm<Compressor rpm shift Compressor Clutch to ‘Locked-Out’
4. Start Turbine => Turbine Clutch automatically engages
5. Accelerate & synchronize motor/generator

Hydrostor Terra™ A-CAES – Small to Medium Constant Pressure CAES



Hydrostor Terra™ – 5MW to 500MW
NOT Site Specific

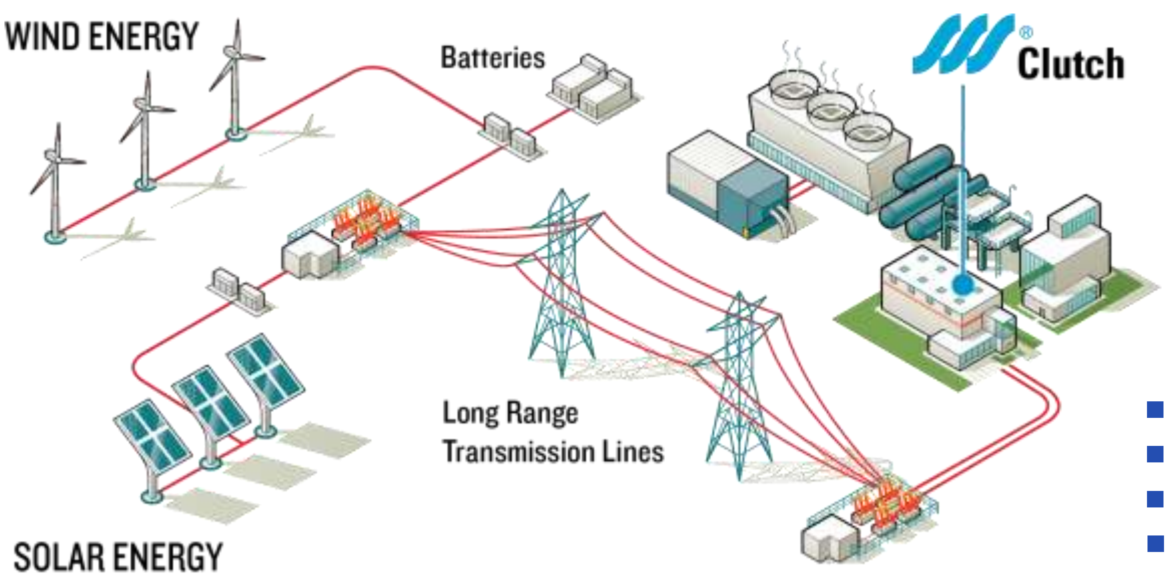
Applications for the Hydrostor Terra™ include:



- Renewable power on demand
- Fossil-fuel-free peaking capacity and flexible generation
- Bulk storage up to 100's of MW, 4 hour to multiple-day duration
- Repurpose aging fossil-fuel power plants
- Ancillary grid services located exactly where needed
- Emission free A-CAES can be installed in dense urban areas where fossil fuel plants are not allowed
- Increased distributed renewable generation with energy storage resource
- Lower electricity rates through replacement of diesel generation
- Load shifting to reduce transmission and distribution system congestion
- Capitalize on electricity price volatility

Maximizing the Contribution of Renewable Sources of Energy

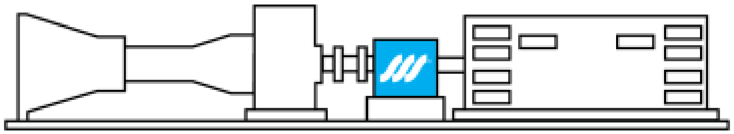
First SSS® Clutch supplied for Synchronous Condensing approximately 45 years ago



<u>LOAD CENTER:</u> Peaking gas turbines with SSS® Clutches provide quick start real power as well as synchronous condensing for intermittent renewable resources of energy. SSS® Clutches enable generator inertia and reactive power for grid support.

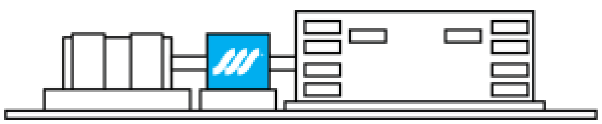
Number of clutches installed	**650+**
Number of countries	**55**
AERO-type gas turbines	**250+**
Industrial gas turbines	**400+**
Clutches over 100 MW	**50+**

Gas or Steam Turbine Generators



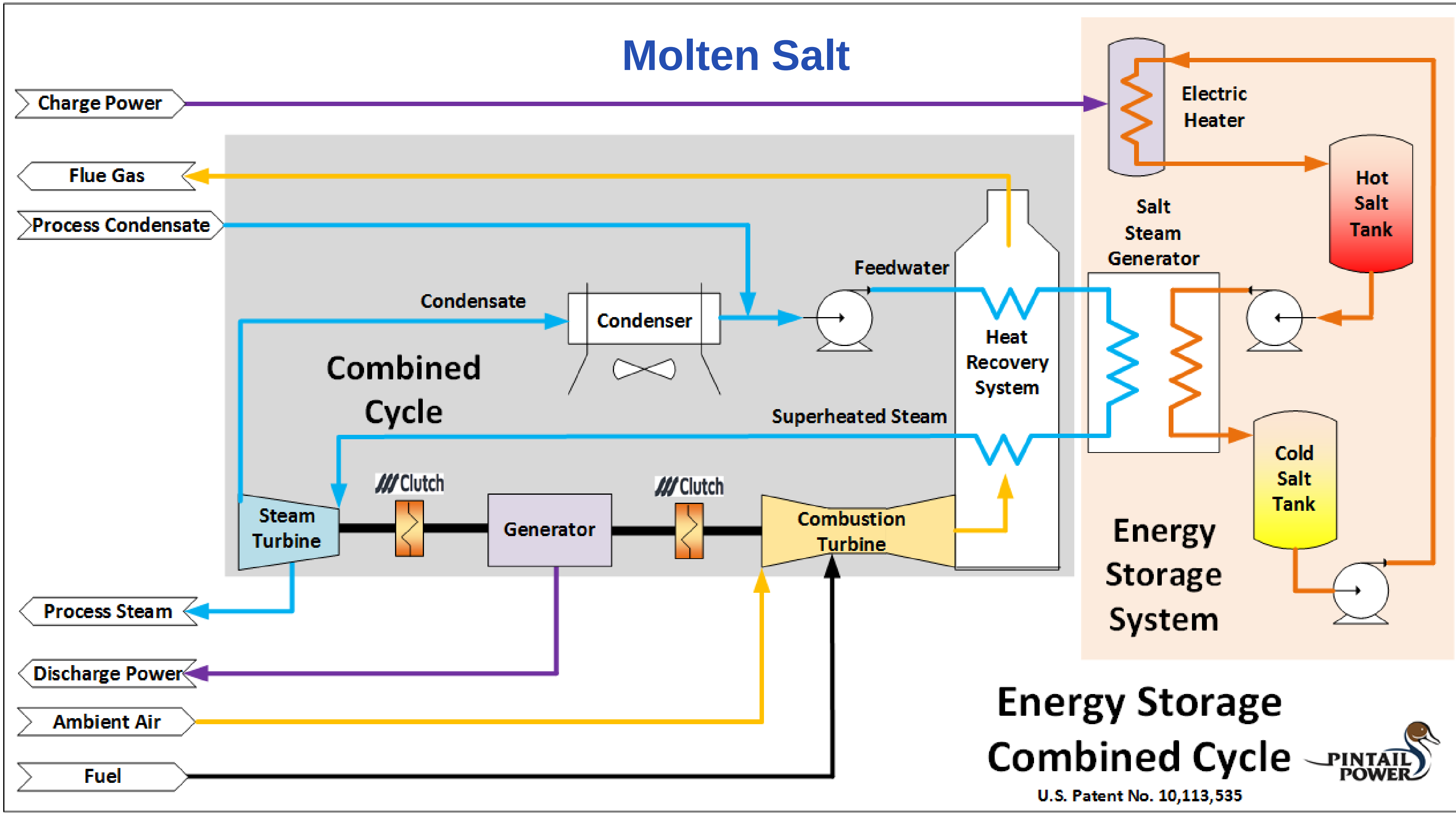
Gas Turbine Generator

Acceleration Systems



Electric Motor Generator

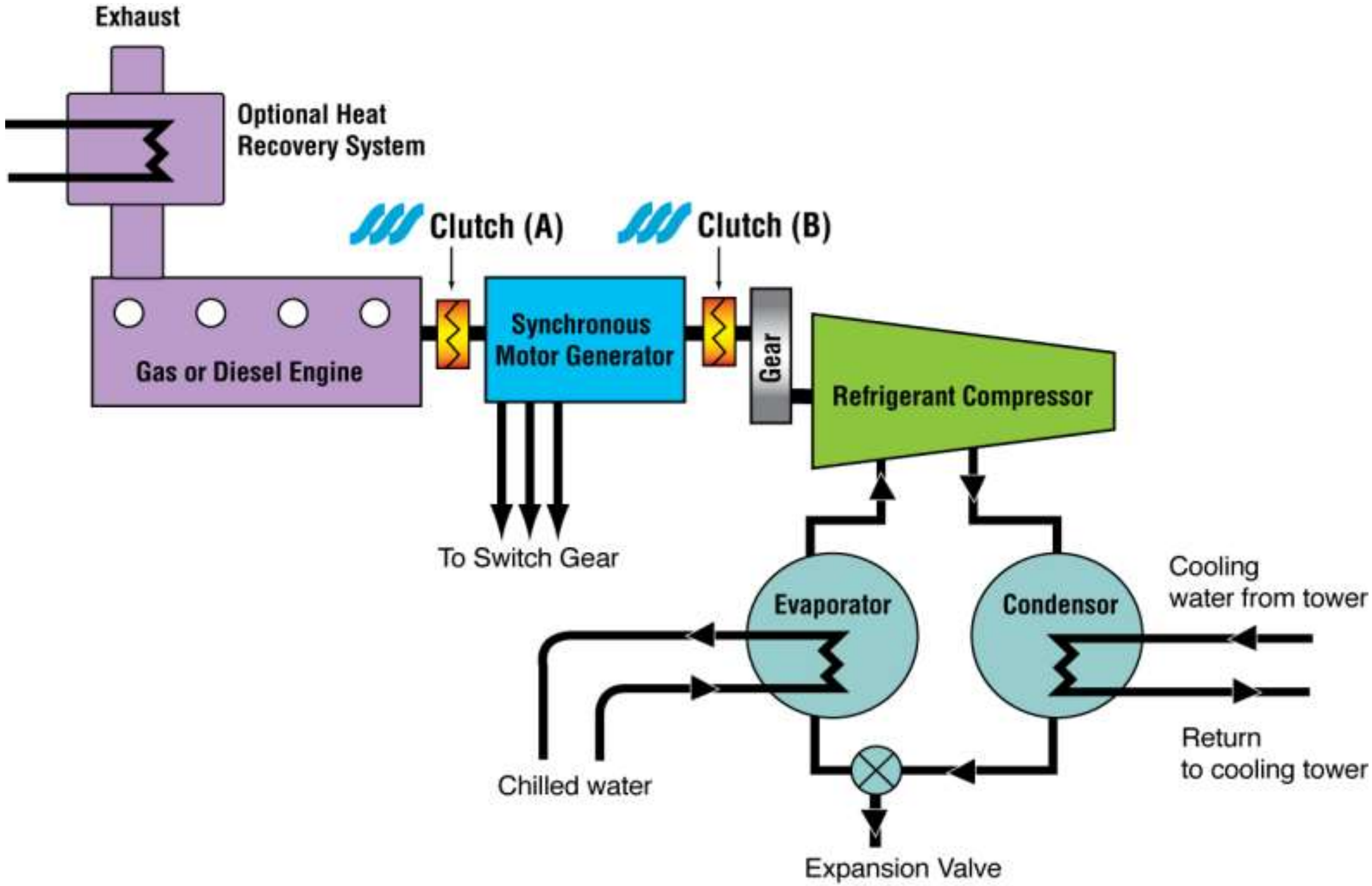
Combined Cycle Energy Storage



Benefits of Combined Cycle Energy Storage

- Lower cost storage. Thermal storage costs a fraction of batteries, is proven, compact and economical.
- Flexible charging. Unlike batteries, the molten salt can be cycled without limit or degradation. The molten salt has a proven service life of multiple decades. Also, fast charging captures more electricity at low prices.
- Simplicity. A single pressure steam system; reheaters and duct burners are eliminated.
- Faster startup. Combustion and steam turbines reach full power quickly by pre-heating the steam cycle using stored energy.
- Higher efficiency. Optimally integrating stored energy with exhaust heat, MSCC maximizes output to deliver record-setting fuel Heat Rate.
- Lower Marginal Cost. Low cost electricity is stored to displace fuel cost.
- Lower emissions.
- Ancillary services. Frequency regulation and demand response can be instantly varied by adjusting the charging power, while reactive support is delivered by a synchronous condenser using a SSS® clutch to decouple generator from the turbines.
- Clutches allow combustion turbine to be used for peaking if required after stored energy is consumed.

Dual Driven Chillers
Reciprocating Engine and Synchronous Motor/Generator

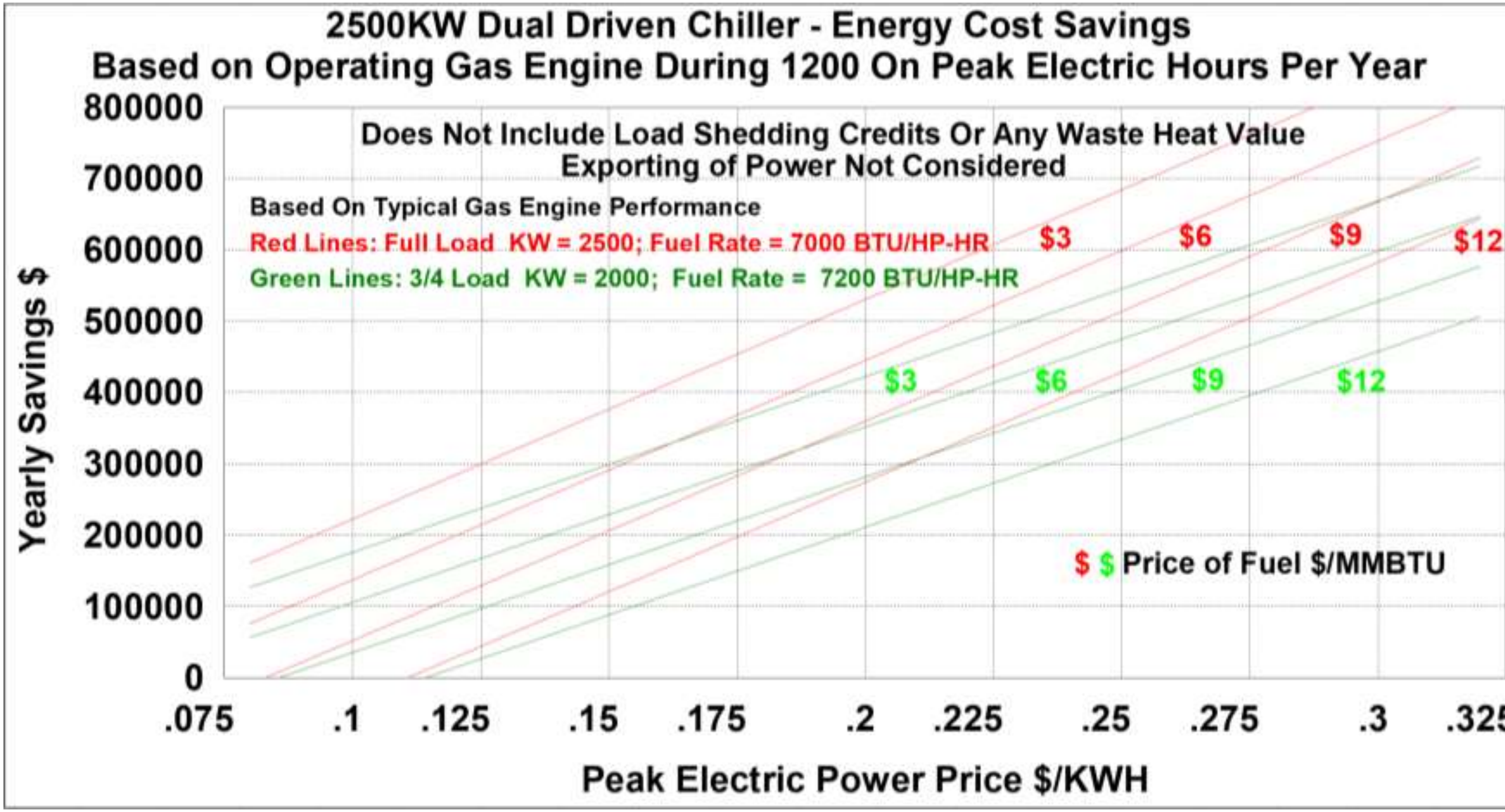


Benefits of a Dual Driven Chillers

Connect two drivers to a single chiller compressor, getting double duty from your standby generator engine. New to central plant chiller systems, this concept has been used successfully with natural-gas pipeline compressors for years, allowing operation with natural gas or electricity, depending on the cost.

- Energy source selection based on real time costs
- Demand side management revenue
- Peak time power sales revenue
- Demand peak management
- Provides chilling during electric power outage
- Provides standby power during electric power outage
- Cost savings compared to separate standby generator and motor driven chiller
- Engine exhaust and jacket water can provide valuable heat

Finances Behind a Dual Driven Chiller



Basic SSS Clutch - How Does it Work?

It can be called…

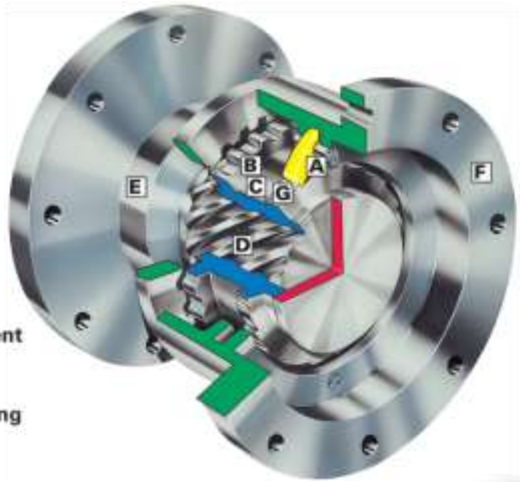
- Freewheel
- Overrunning Clutch
- One Way Clutch

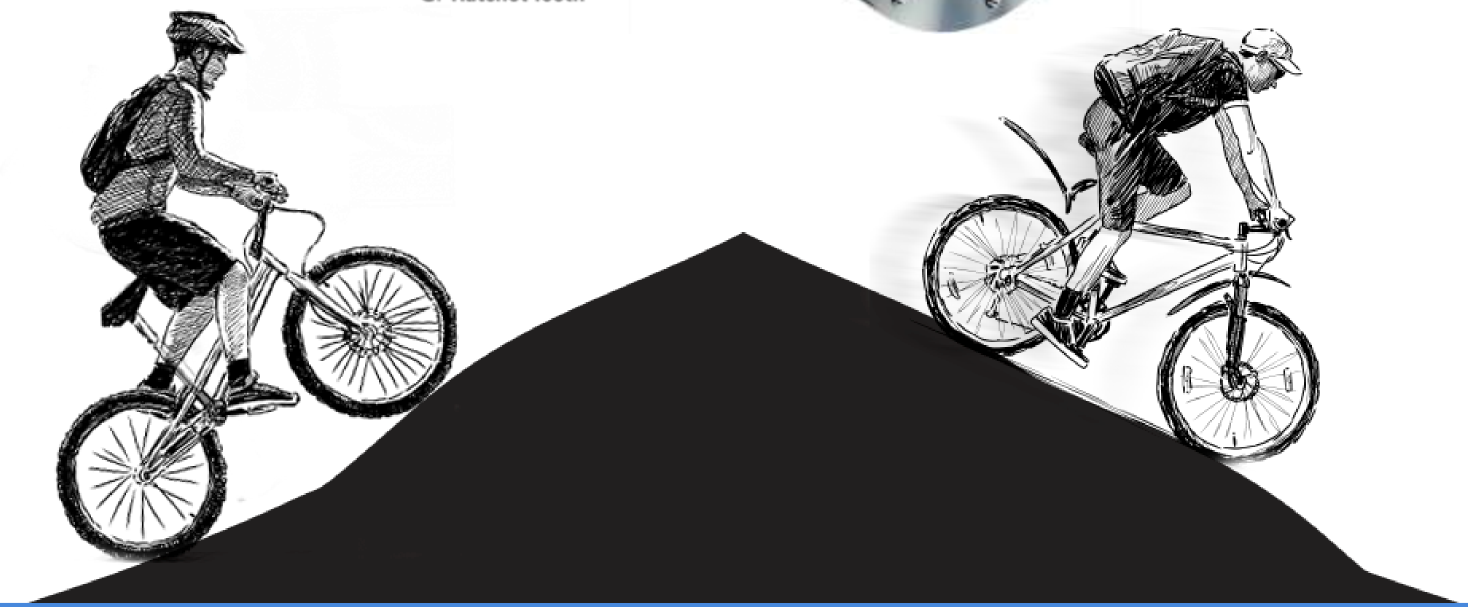
It is…

- Mechanical
- Automatic

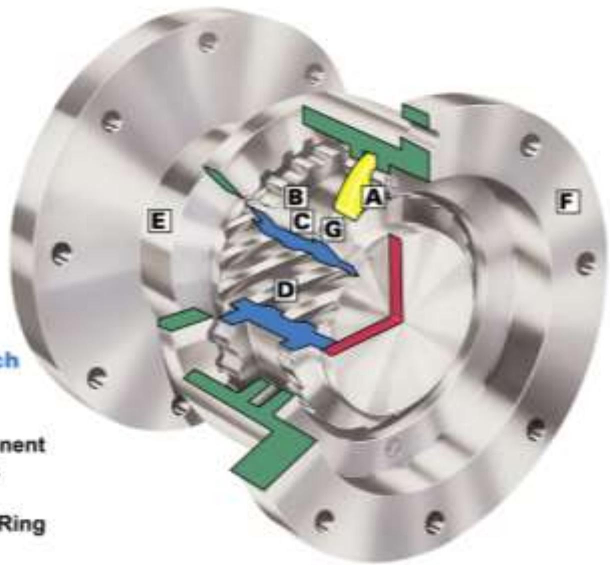
Elements of Basic SSS Clutch

A. Pawl
B. Clutch Teeth
C. Sliding Component
D. Helical Splines
E. Input Shaft
F. Output Clutch Ring
G. Ratchet Teeth





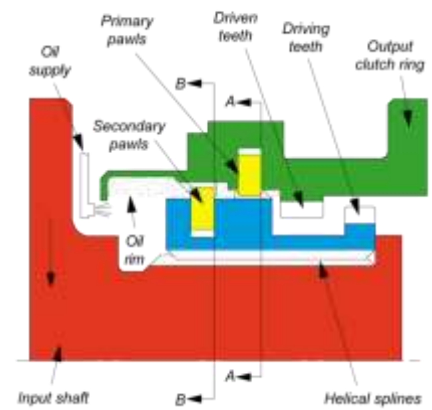
High Power Critical Duty Automatic Overrunning Clutches Drive Through Gear Teeth

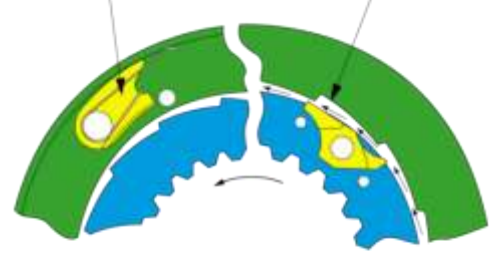


Elements of Basic SSS Clutch

- A Pawl
- B Clutch Teeth
- C Sliding Component
- D Helical Splines
- E Input Shaft
- F Output Clutch Ring
- G Ratchet Teeth

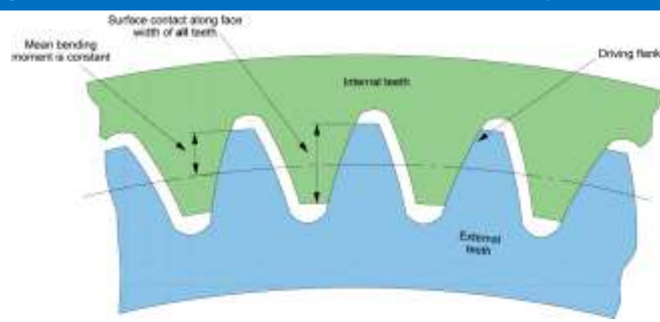
Overrunning Clutch Details





Condition with output at high speed and input stopped

Overrunning Clutch & Diagram
Showing Surface Area Contact of Involute Shaped Teeth When Engaged

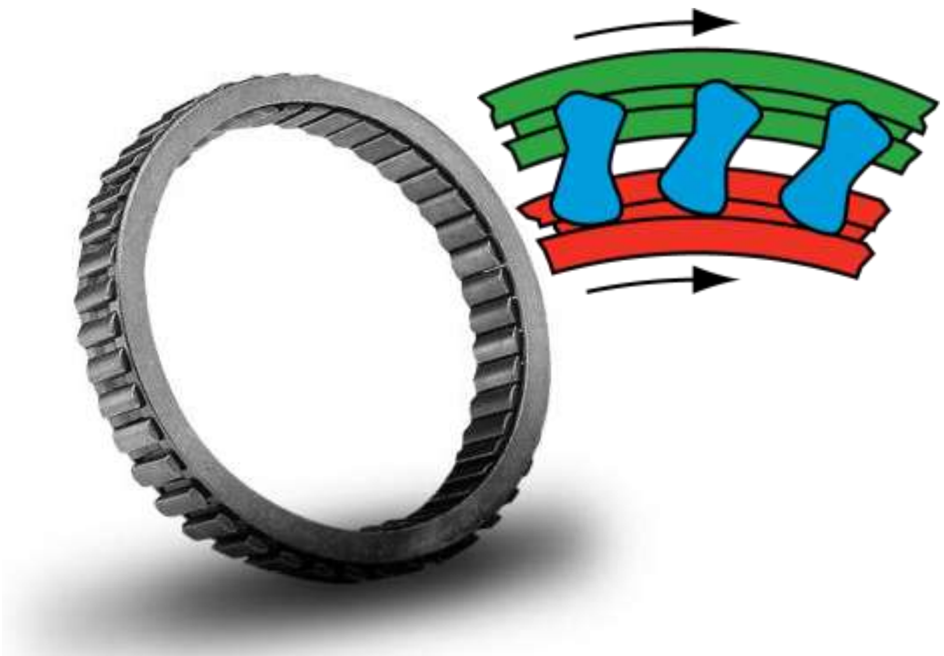


Clutches For High Power Critical Service Applications

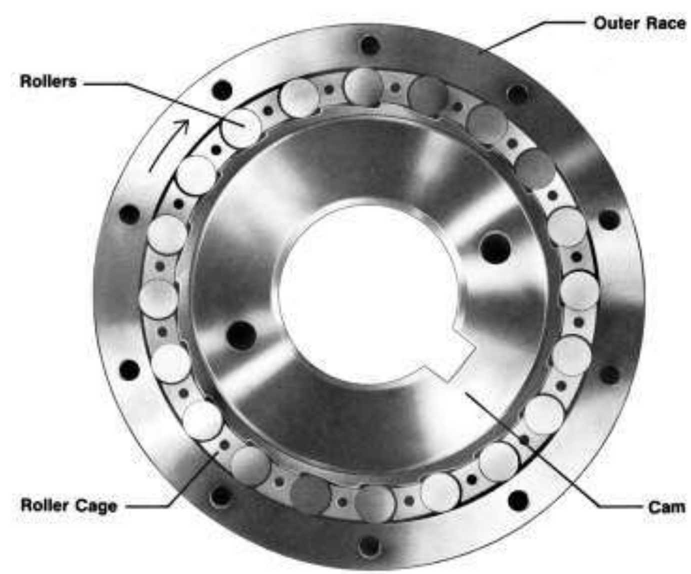
Synchro-Self-Shifting (SSS) Overrunning Clutch

- Drive through multiple concentric gear teeth (large drive area)
- Pawls and ratchets used to align and shift axially the concentric gears into engagement along helical splines
- The pawls and ratchets are inactive except during the short engagement process
- Teeth engaged automatically when shaft speeds are synchronized at any speed from rest to full operating speed
- Include internal oil dashpot to cushion engagement
- See diagram

Low Power non-Critical Duty Automatic Overrunning Clutches Typically Drive Through Line Contact



Sprag Type Clutch



Ramp and Roller Clutch

Two Drivers -
Better Than One

Clutch Company, Inc.

Overrunning Clutches

Clutch Company, Inc.

CHP Case Studies

Clutch Company, Inc.

Energy Storage

Clutch Company, Inc.

District Chilling

Clutch Company, Inc.