

Performance

International Power Technology's Series 7—Cogen system is a complete cogeneration package based on the patented Cheng Cycle. The system produces:

- 3.5 to 6.0 Mw of power at 27 to 39% generating efficiency
- 0 to 45 million Btu per hour of process thermal energy

Key advantages of the Series 7 are:

- An outstanding ability to track varying loads economically
- High electrical capacity and generating efficiency
- Mechanical simplicity and reliability
- Superior NOx control
- Sophisticated controls to maximize economic returns

Application

Cheng Cycle operating flexibility means the Series 7—Cogen can be applied to installations with a wide range of total energy requirements. The Series 7—Cogen is particularly attractive for installations with fluctuating thermal loads. Since process thermal loads vary on a seasonal, daily or shorter term basis, conventional cogeneration system economics are often degraded as these fluctuations cause thermal load to drop below rated output of the system. In contrast, Cheng Cycle operating flexibility turns periods of low thermal load into opportunities to produce more electricity more efficiently.

Cheng Cycle

The patented Cheng Cycle is central to the operational flexibility and mechanical simplicity of the Series 7—Cogen. The Cheng Cycle is an advanced heat engine cycle which combines and optimizes the Brayton (gas turbine) and Rankine (steam turbine) cycles. In the Series 7—Cogen these two cycles are combined using a single Allison (Division of General Motors) 501 gas turbine which is modified for Cheng Cycle operation.

Cheng Cycle provides unequalled load following flexibility because thermal energy not needed for process is used to boost electrical power output and thermal efficiency. Exhaust heat from the gas turbine is used to produce steam in a matched heat recovery steam generator (HRSG). Steam produced in the HRSG can be used either for injection into the turbine or for process. Steam is injected when process thermal loads are low or when it is economically desirable to maximize power output.

Product Description

The Series 7—Cogen unites state-of-the-art power generation technology with state-of-the-art controls. Major components are:

- Allison 501 gas turbine generating set designed for Cheng Cycle operation
- Matched heat recovery steam generator
- Real time computer-based cycle and economic controls

Generating Set

Prime mover of the Series 7—Cogen is a modified Allison 501 gas turbine. The turbine is manufactured and modified for Cheng Cycle operation by the Allison Division of General Motors. The 501 has established a reputation for performance and reliability, with nearly 14,000 in aircraft and industrial service worldwide. The 501 was chosen by International Power Technology based upon its reliability and ideal performance characteristics under Cheng Cycle operations. Each turbine used in the Cheng Cycle Series 7—Cogen receives Allison's full warranty and service support. Genset packaging is performed by licensed Allison distributors according to International Power Technology's specification.

Heat Recovery Steam Generator

The HRSG is an integral part of the Series 7—Cogen. Design of the HRSG involves carefully matching its characteristics with those of the 501KH turbine. Production of the HRSG is done by major boiler manufacturers under subcontract to International Power Technology. Provisions for burning additional fuel in the HRSG (secondary combustion) are included since this significantly increases system operating flexibility.

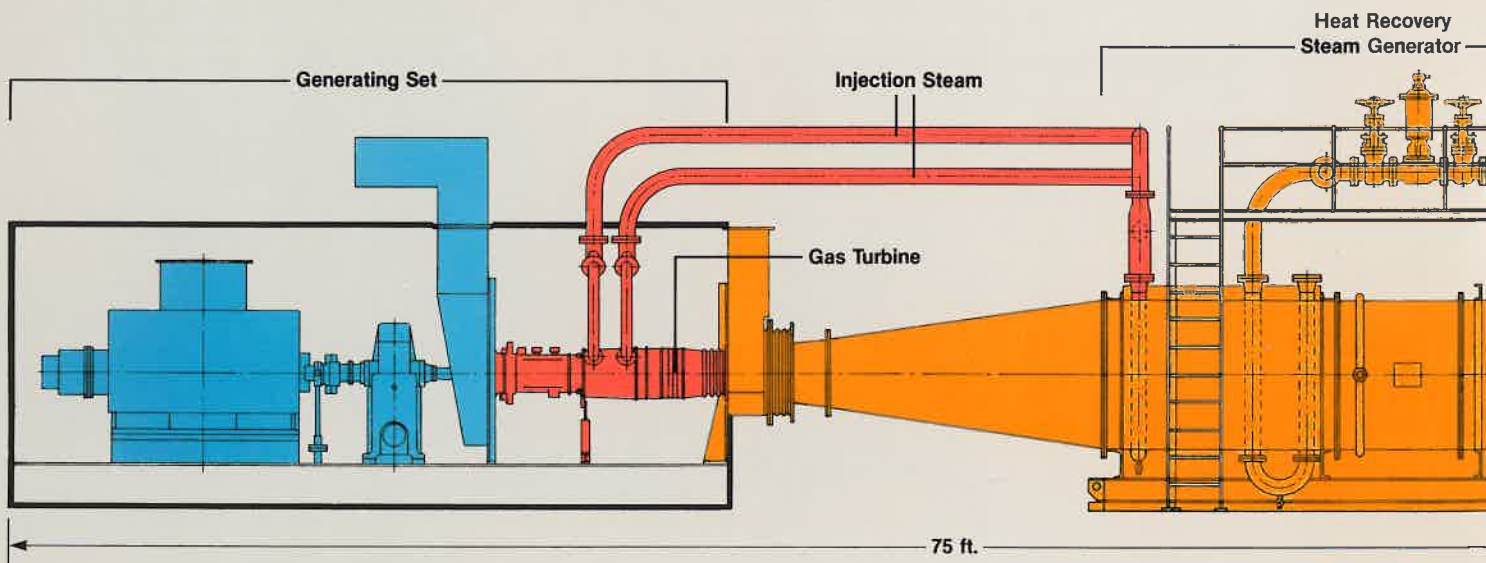


Figure 1. Cheng Cycle Series 7—Cogen System

Computer Based Controls

The Series 7—Cogen includes a sophisticated computer based control system which is designed to ensure that the cogeneration plant operates in the most reliable and economic manner. The control system operates on two levels: 1) a functional level which controls cycle parameters to maximize efficiency and ensure reliability, and 2) a supervisory level which governs overall system operations to ensure economic optimization.

1) The functional level governs the physical parameters of the system (i.e. fuel flow, steam flow, etc.). It implements the operating strategy chosen by the supervisory level, and ensures that process requirements are met at all times.

2) The primary function of the supervisory level is to optimize system economics on a real time basis. In addition, the supervisory level performs many recordkeeping tasks relating to system performance (both economic and technical) and regulatory compliance.

The control system is designed and manufactured by International Power Technology. Reliability is ensured through the use of proven components and backup systems.

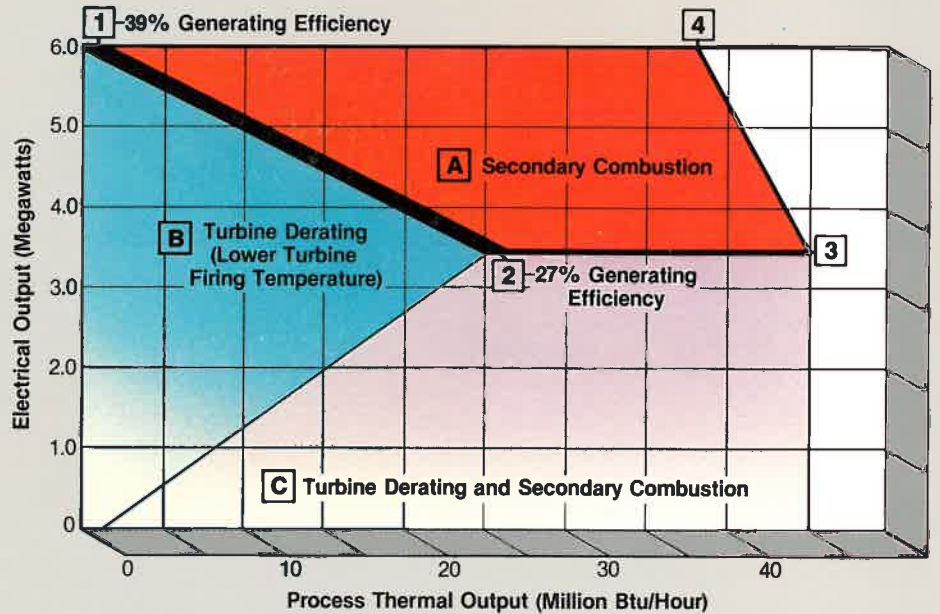


Figure 2. Series 7—Cogen Operating Regime

Operational Characteristics

The Series 7—Cogen represents a significant advance in cogeneration technology. Key advantages of this new technology are a broad operating regime and the ability to select operational mode on an economic basis.

Operating Regime

The operating regime of the Series 7—Cogen is shown in Figure 2. Except under unusual circumstances, such as a utility outage, the system will operate along line 1-2-3 or within region A. Line 1-2 indicates power and thermal output for rated turbine inlet temperature and varying levels of steam injection. At point 2, no steam is injected, and power and thermal output are equal to that of a simple cycle Allison 501-KB5 based cogeneration plant. At point 1, all available thermal energy is used to produce injection steam, and power output and generating efficiency are maximized.

Region A represents the addition of secondary combustion in the HRSG. This feature allows the system to produce any combination of electrical and thermal outputs within this region.

It is important to note that along line 1-2-3 and within region A the turbine is operating at one firing temperature. The turbine does not undergo thermal

cycling while load following. This can significantly improve turbine life and reduce maintenance costs.

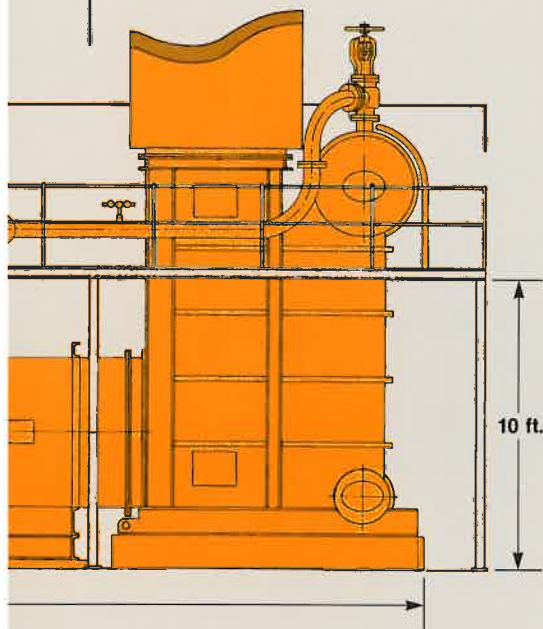
Operating Modes

The Series 7—Cogen control system selects the economically optimal mode of operation at all times. The choice is based on site requirements and prevailing economic conditions.

Normally, the Series 7—Cogen will operate in one of three modes. The most typical mode consists of operating along line 1-2-3. The specific operating point is determined by process steam demand, and electrical power output varies inversely to process steam load.

The second common mode of operation occurs during periods of high electrical rates. Under these conditions, operating economics dictate that electrical output be maximized. The system will operate along line 1-4-3, with secondary combustion allowing the system to simultaneously track thermal load and maximize power output.

A third mode of operation will occur under conditions such as a utility outage or very low electricity buyback rates. In this mode, thermal and electrical output are matched simultaneously to the requirements of the site. The operating point in this mode could be anywhere in the Series 7—Cogen operating regime (regions A, B, and C).



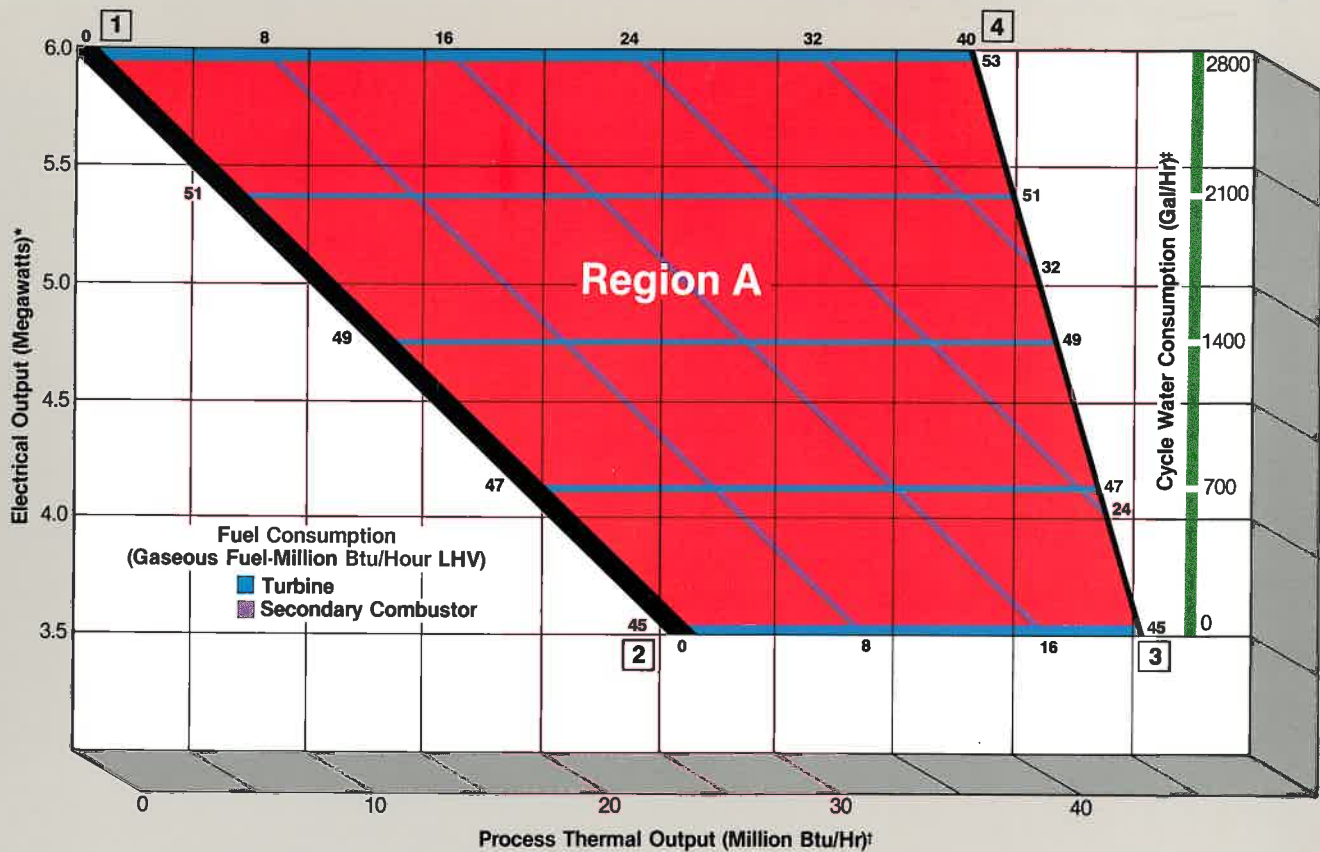


Figure 3. Series 7—Cogen System Performance

Space Requirements

The Series 7—Cogen, including balance of plant, requires a space of approximately 45 x 100 feet. In situations where space is a limiting factor, the system can be configured to meet specific needs.

Pollution Control

NO_x control is an inherent feature of Cheng Cycle operation. Steam injection is capable of greater NO_x reduction than water injection, the most commonly used control technology.

Product Availability

The Series 7—Cogen is available only through International Power Technology. The Cheng Cycle is covered by numerous U.S. and foreign patents on both hardware and cycle parameters.

Project Evaluation Services

International Power Technology offers potential customers technical and economic feasibility studies of their specific applications. These studies include sizing the system, modeling site loads and cogeneration plant operations, and performing investment analyses of the cogeneration project.

NOTES: ISO Conditions

* Net of Generator, Gearbox, Inlet & Outlet Duct Losses

† Saturated Steam Produced at 205 psig

‡ Injection Steam Only, Process Condensate Losses Not Included

Cheng Cycle Systems are covered by some or all of the following patents:

4,297,841
4,248,039
4,128,994
4,072,182
3,978,661

Pending:

477,693
476,885
476,456
273,269
175,283