VIII SIMPÓSIO DE ESPECIALISTAS EM PLANEJAMENTO
DA OPERAÇÃO E EXPANSÃO ELÉTRICA

VIII SYMPOSIUM OF SPECIALISTS IN ELECTRIC
OPERATIONAL AND EXPANSION PLANNING

19 a 23 de Maio de 2002
May – 19th to 23rd – 2000
BRASÍLIA (DF) – BRASIL

Preliminary Studies of Coordinated Voltage Control Applied to the Rio Area

Camilo B. Gomes
COPPE/UFRJ – CEPEL

Nelson Martins
CEPEL

Glauco N. Taranto
COPPE/UFRJ

Júlio C. R. Ferraz
COPPE/UFRJ – CEPEL

Marcelos G. Santos
ONS

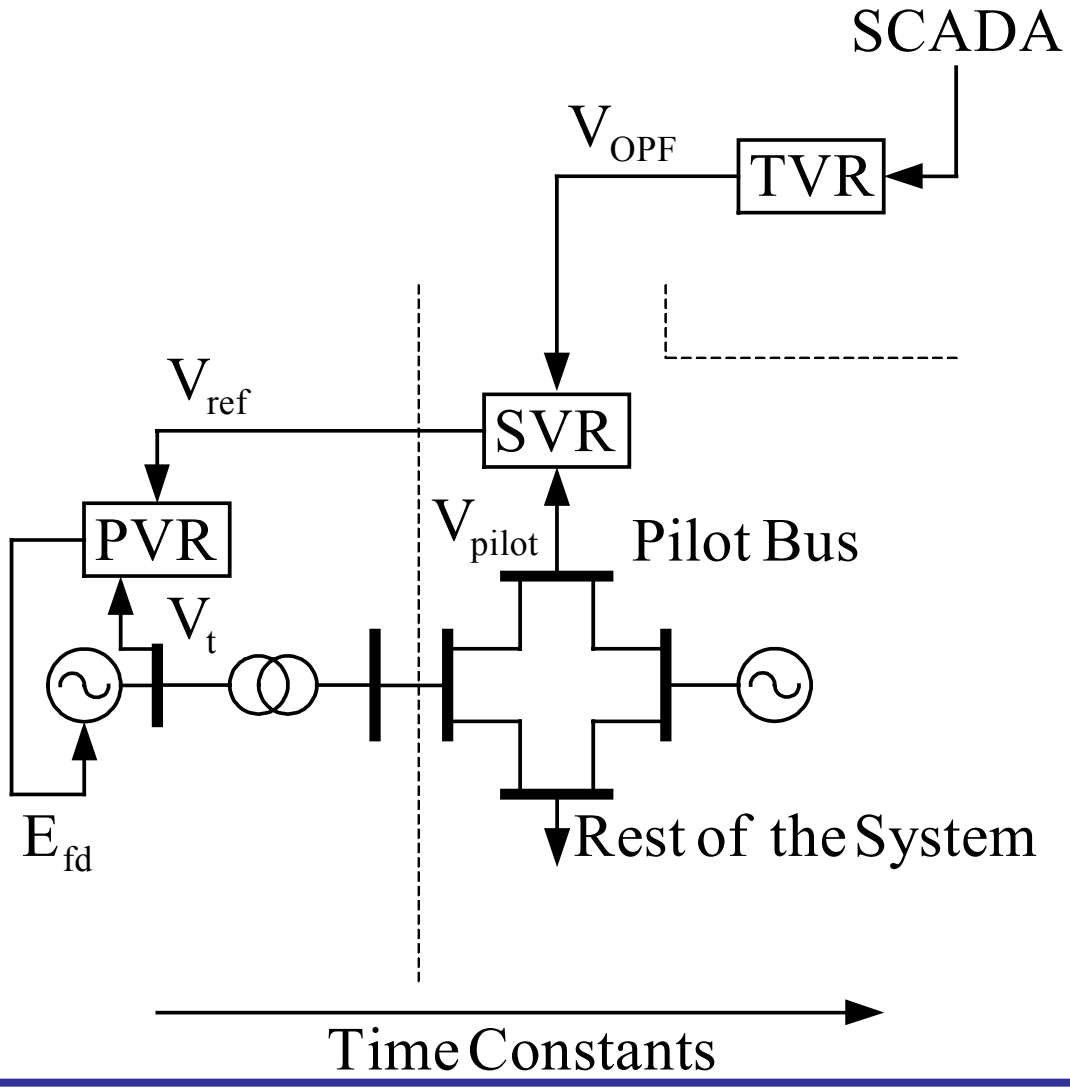
Introduction

- Description of Coordinated Voltage Control (CVC)
- Fast simulator based on “quasi-steady-state” concept
- Results for 24-hour load-curve in the Rio Area
- Fast simulations compared with load flow results
- Final Remarks

Coordinated Voltage Control (CVC)

- Primary voltage regulation (PVR)
  - Generator control (AVR)
  - Joint voltage control (JVC) ?
- Secondary voltage regulation (SVR)
  - Pilot node concept
  - Reference voltage changes in generator AVRs, etc.
- Tertiary voltage regulation (TVR)
  - Open loop control
  - Provides the voltage reference values to the SVR via an OPF program
  - Requires system data acquisition (SCADA)

Hierarchical Structure of Coordinated Voltage Control



Main Objectives of Secondary Voltage Regulation (SVR)

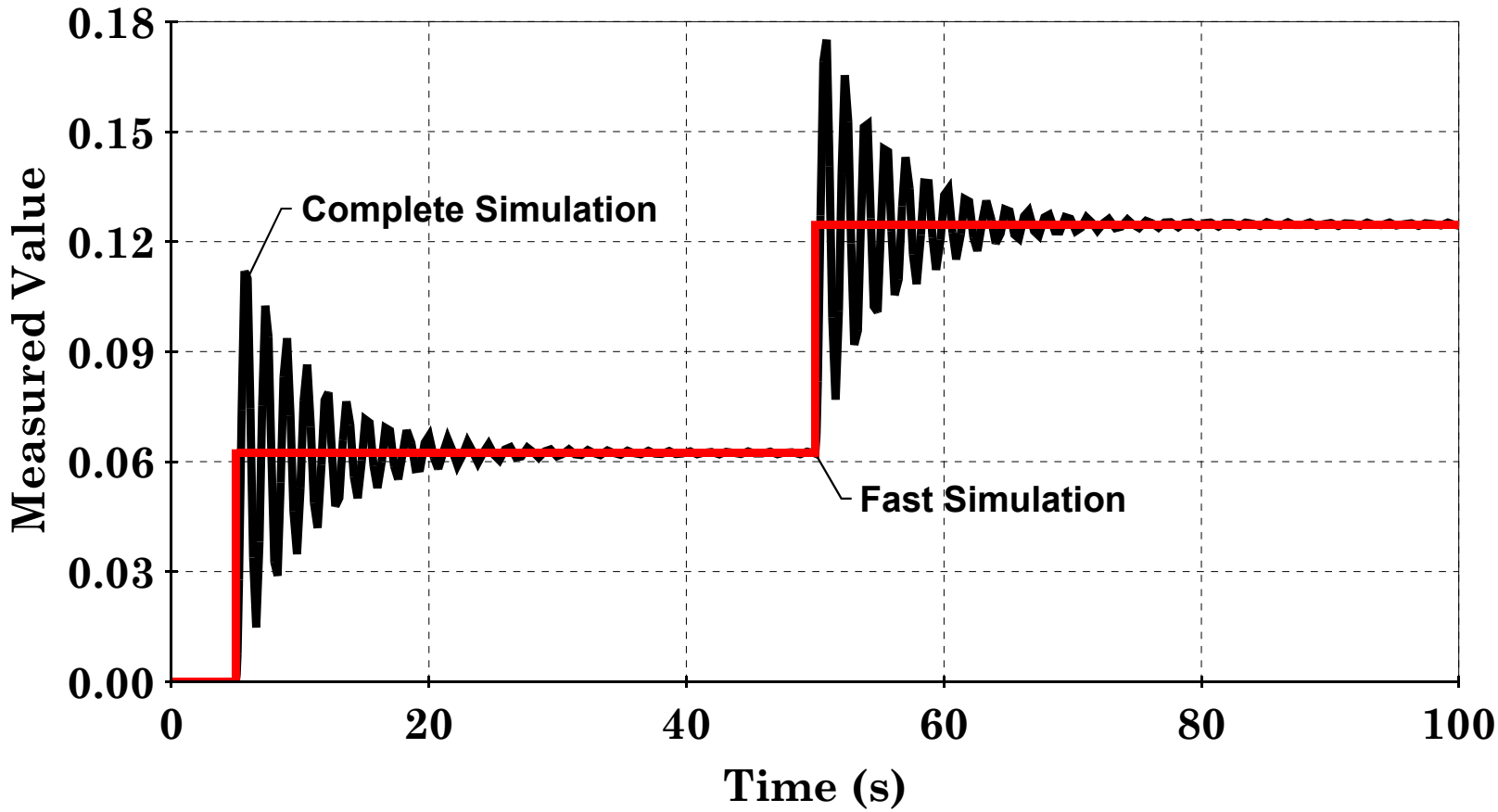
- Pilot bus voltage regulation
- Reactive power sharing among the participating power plants
- Better transmission voltage regulation
- Better voltage performance following contingencies or changes in topology or loading

Fast Simulator of SVR Dynamics

- SVR dynamic behavior is modeled by differential equations
- The fast dynamics are assumed instantaneous and stable
- System frequency dynamics is neglected
- Simulator only captures mid and long-term dynamics

Fast Simulator

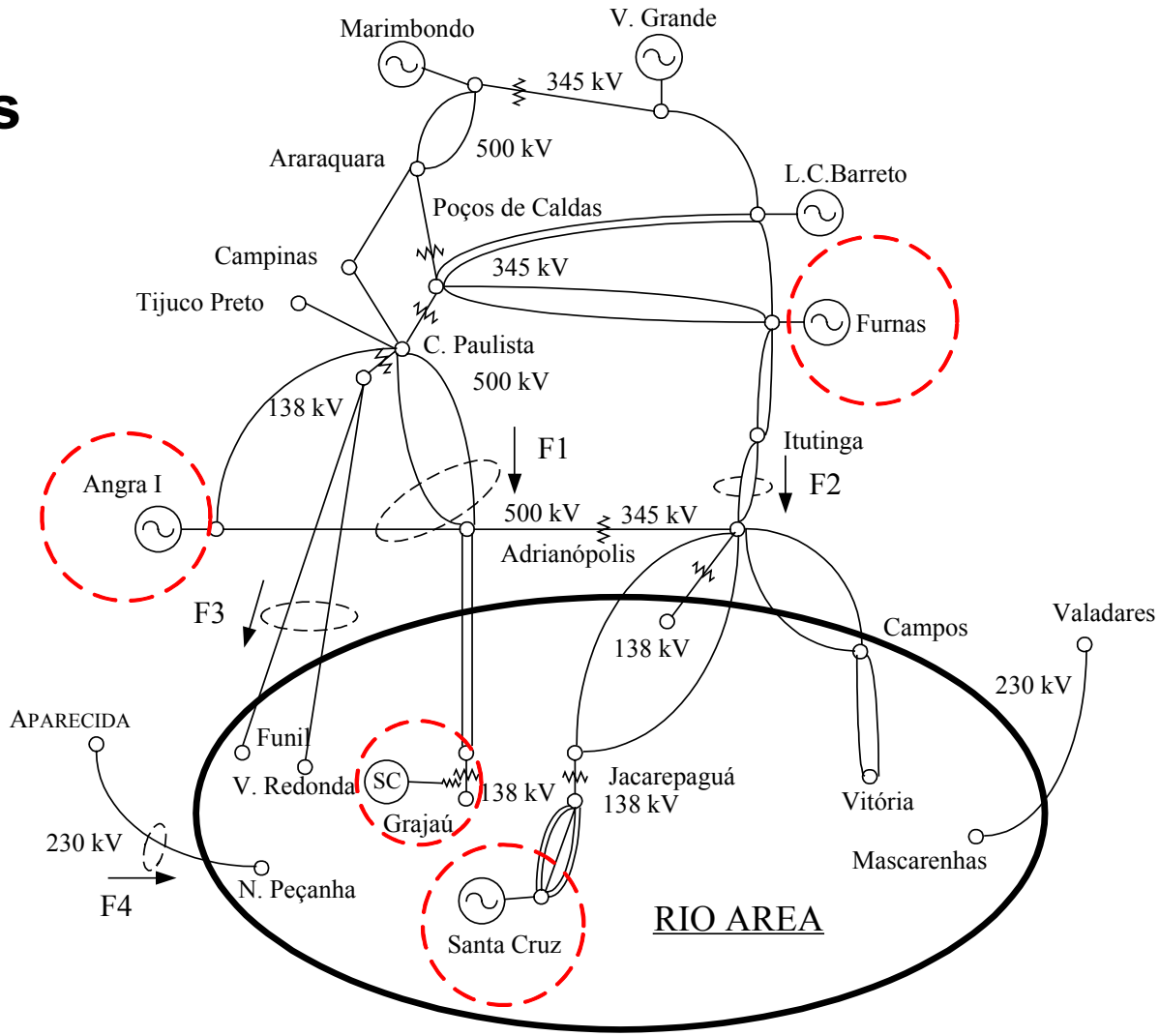
- Comparing results from a transient stability program and a fast simulation program



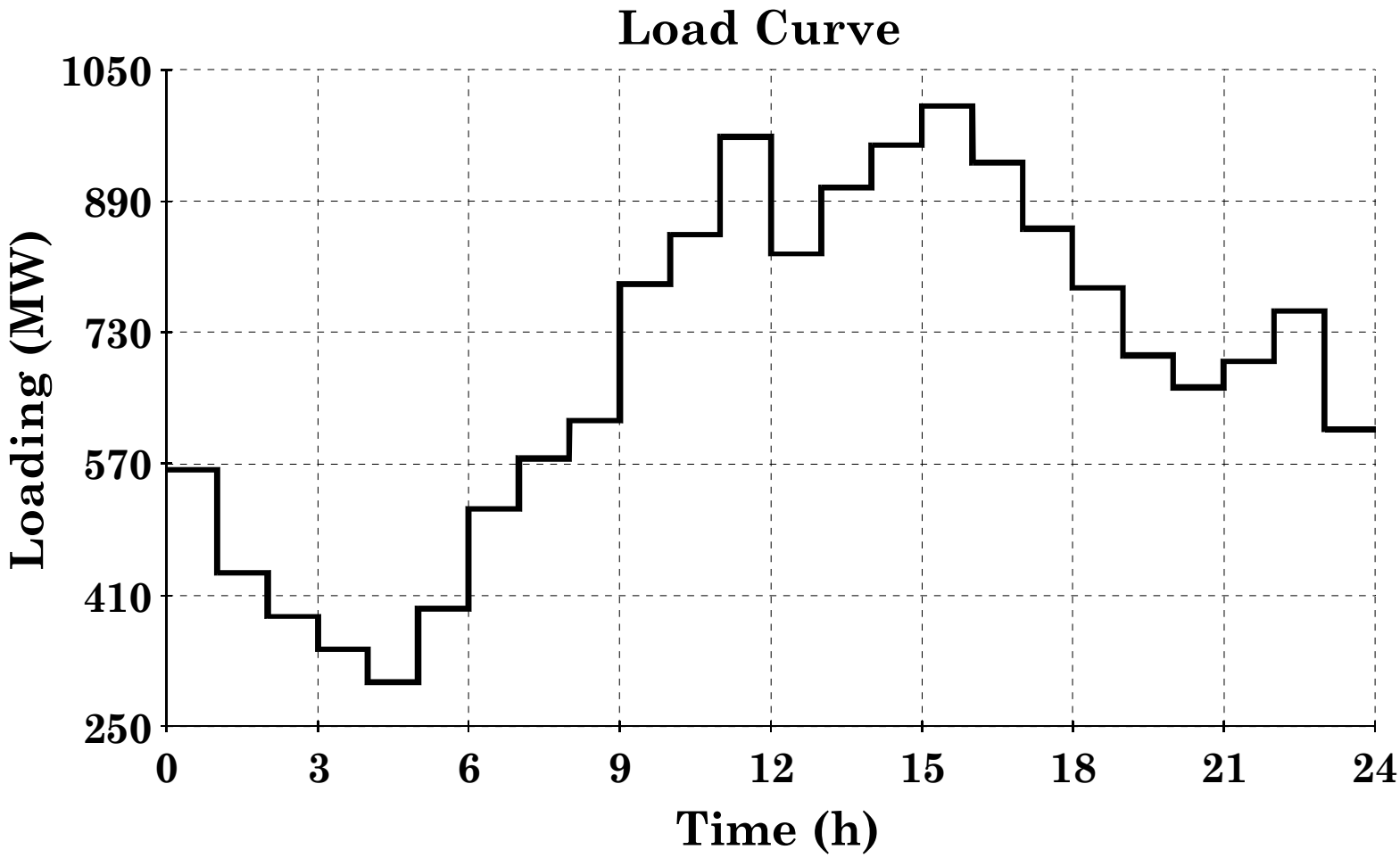
Results for 24-hour Load-curve in the Rio Area

Reactive power participation factors

- Furnas 30%
- Angra 5%
- Santa Cruz 10%
- Grajaú 55%

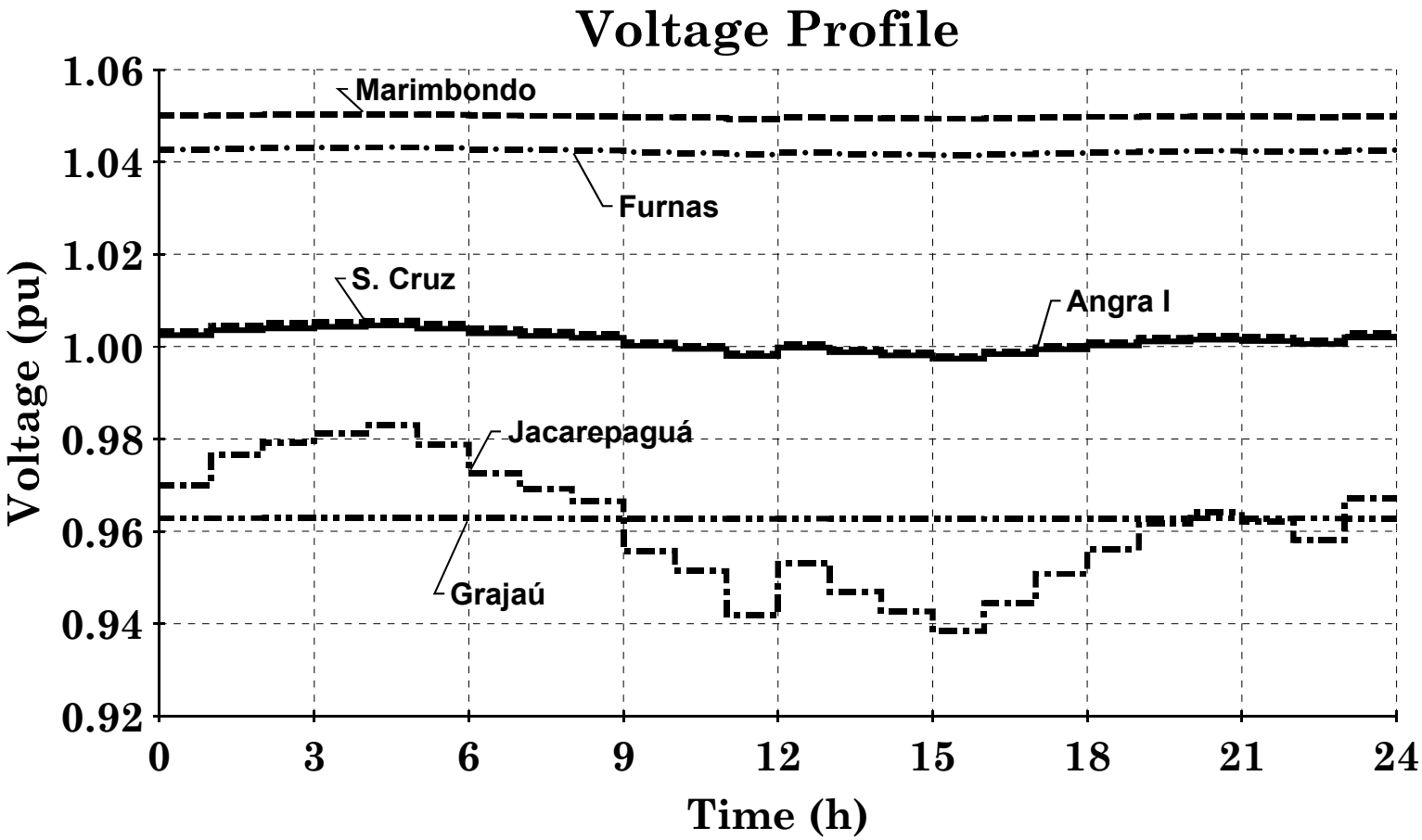


Results for 24-hour Load-curve in the Rio Area



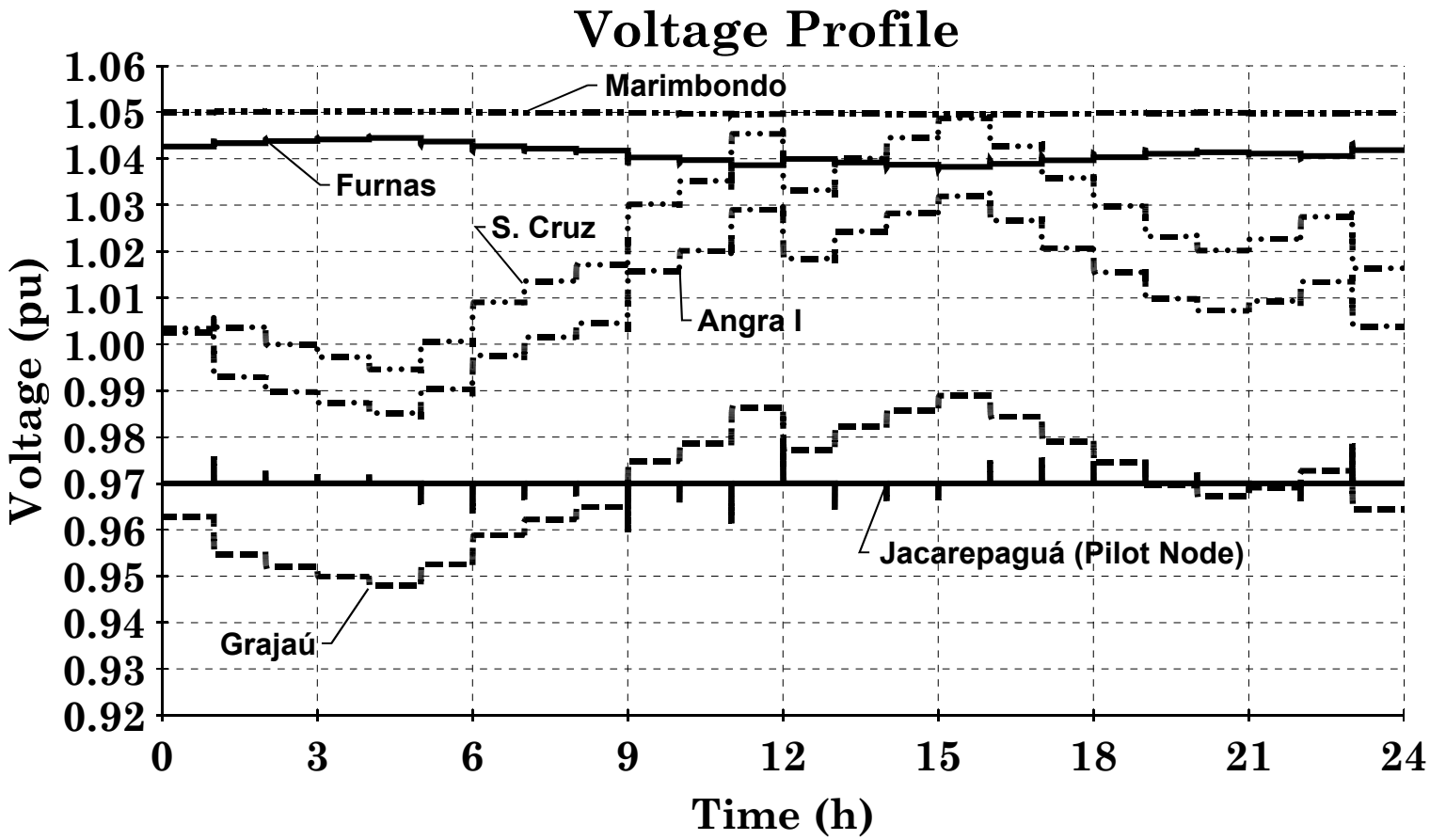
Results for 24-hour Load-curve in the Rio Area

- **Voltage profile without SVR**



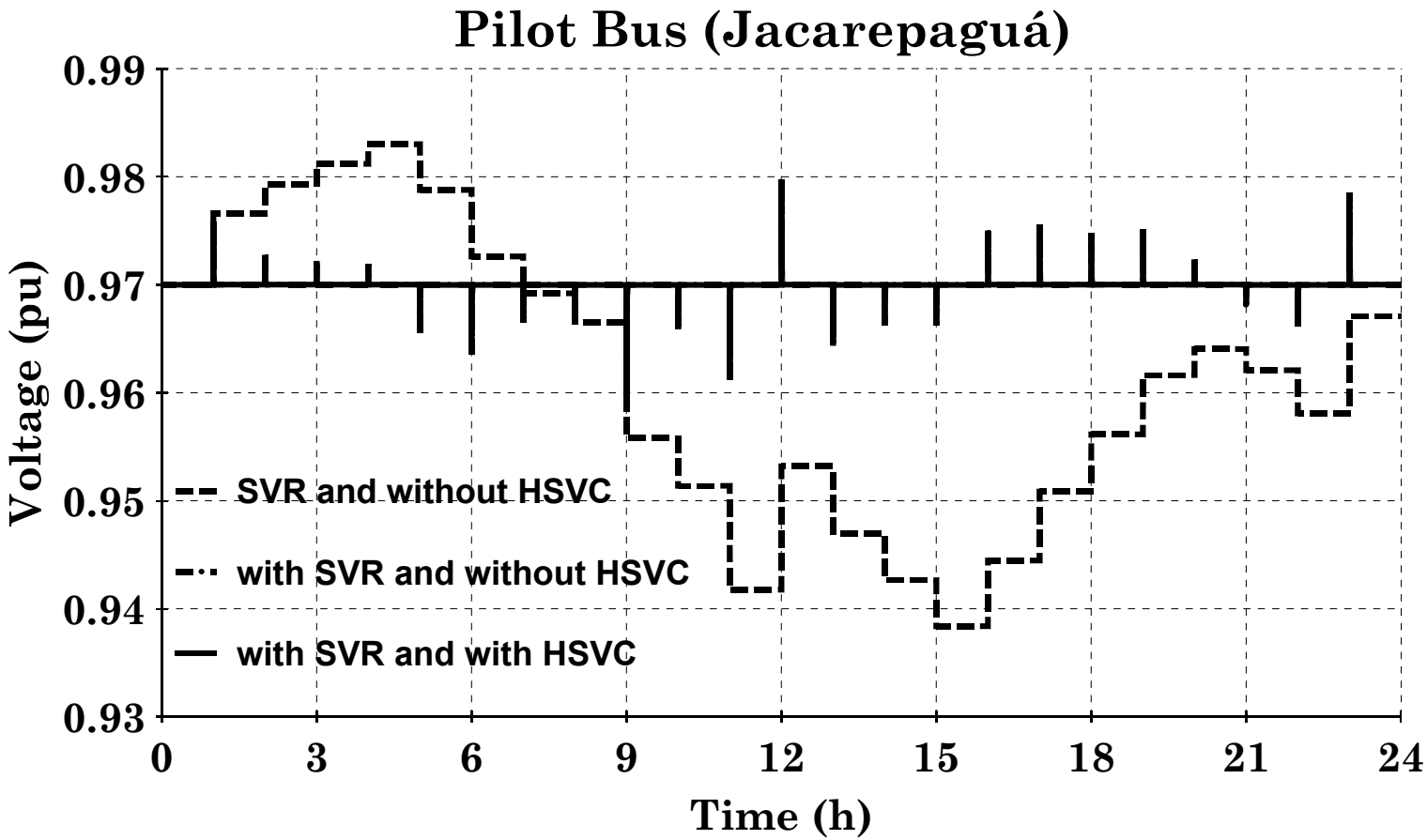
Results for 24-hour Load-curve in the Rio Area

- **Voltage profile with SVR**



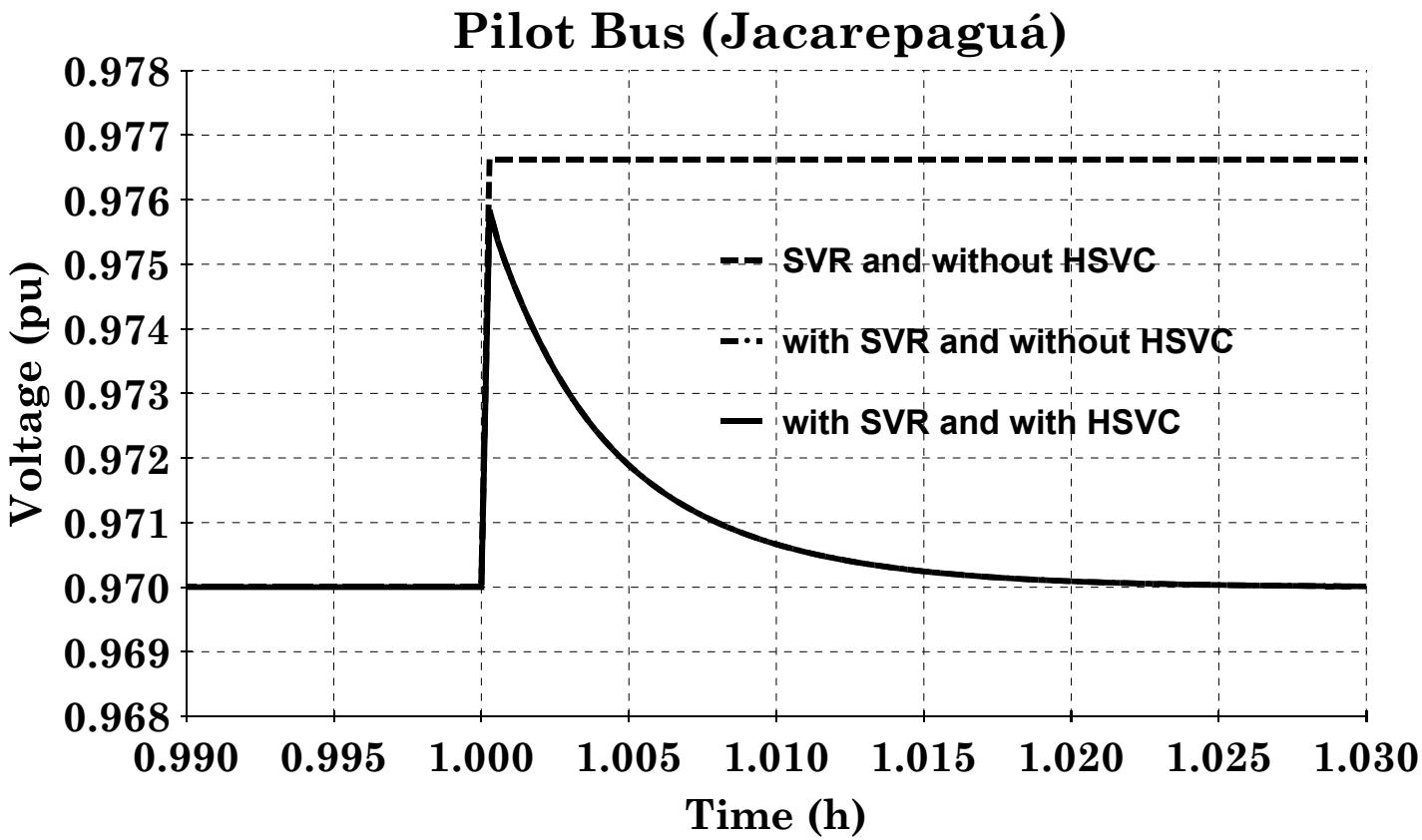
Results for 24-hour Load-curve in the Rio Area

- **Pilot node voltage profile**



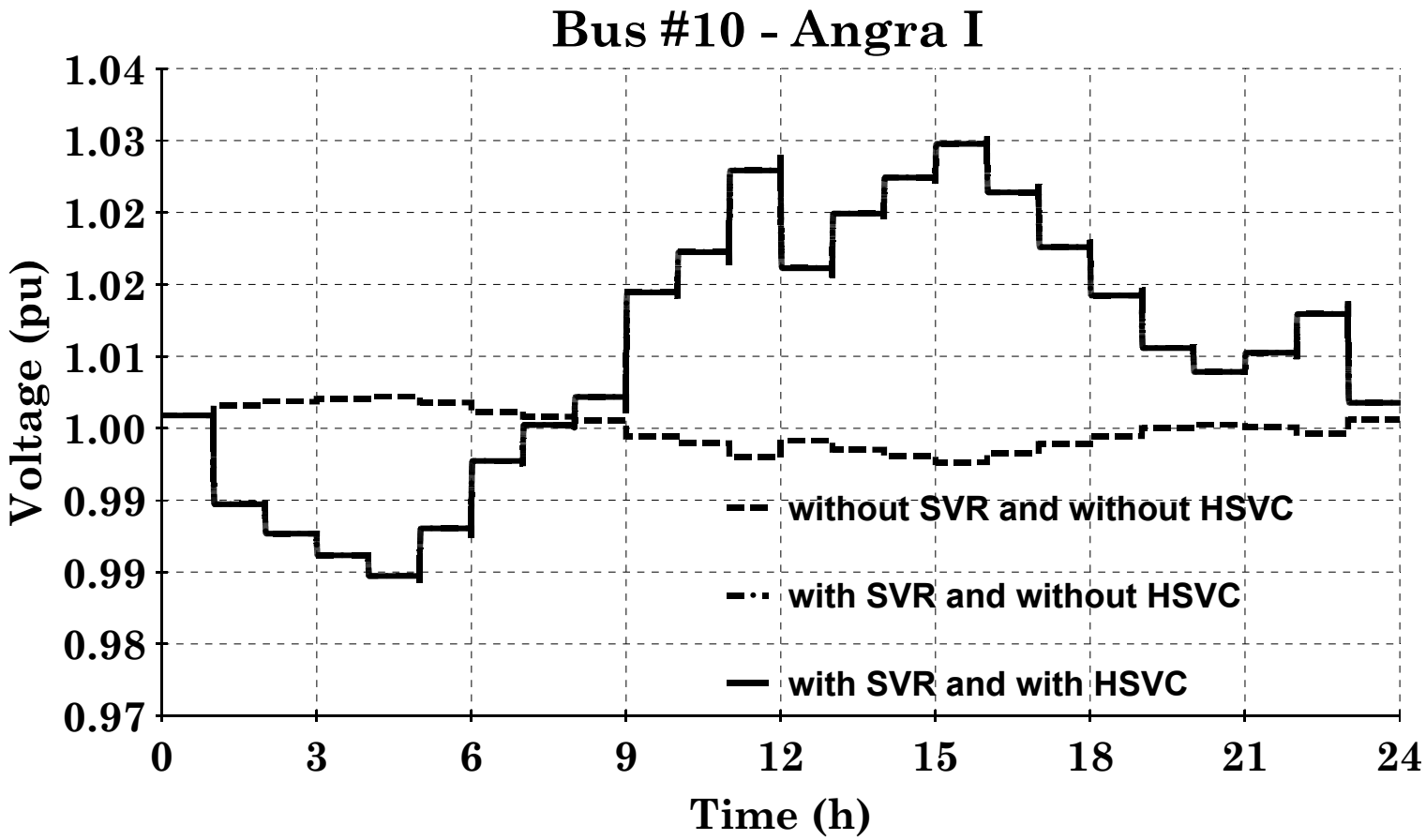
Results for 24-hour Load-curve in the Rio Area

- Enlarged view of pilot bus voltage after a load decrease



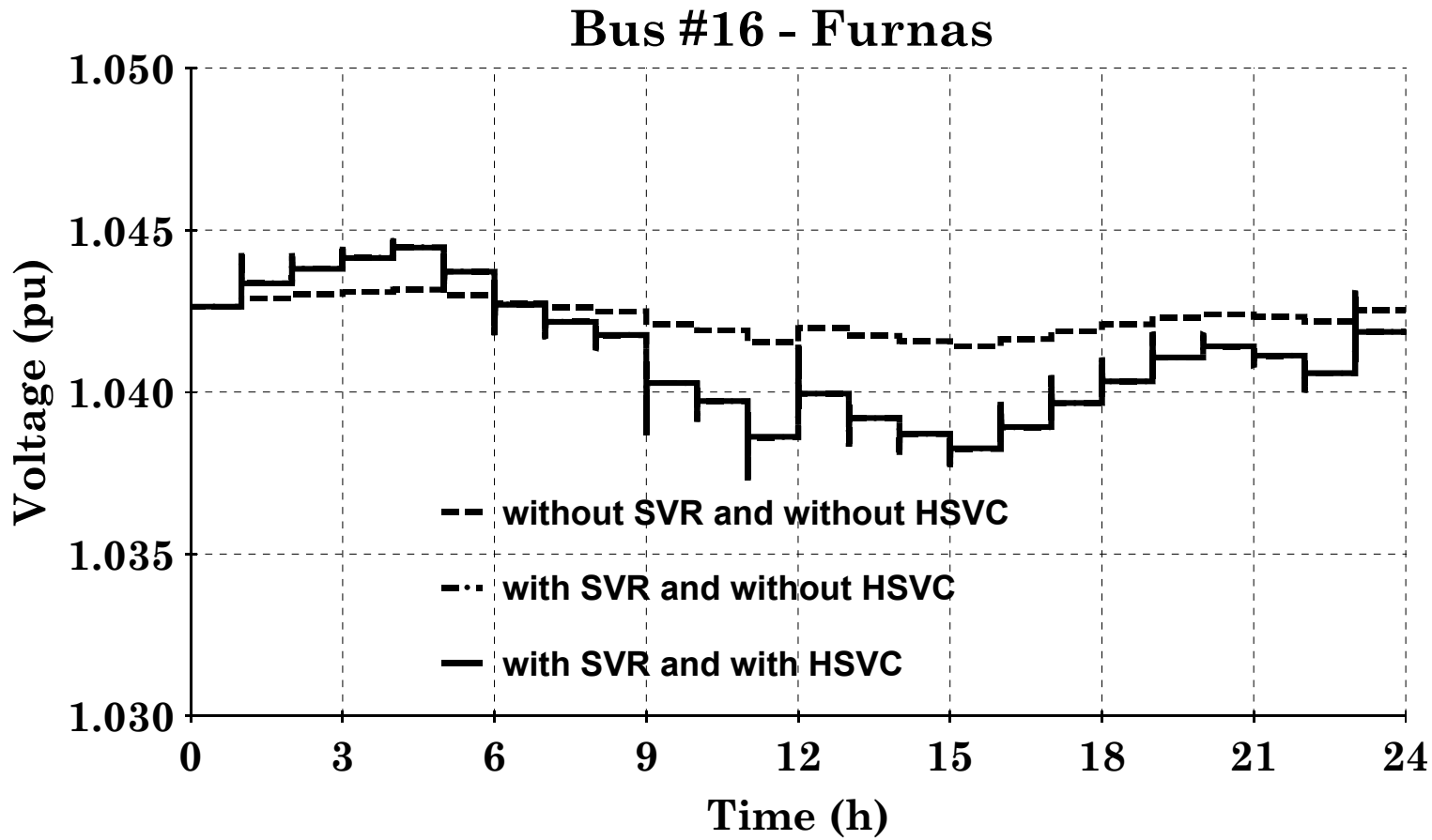
Results for 24-hour Load-curve in the Rio Area

- **Angra I voltage profile**



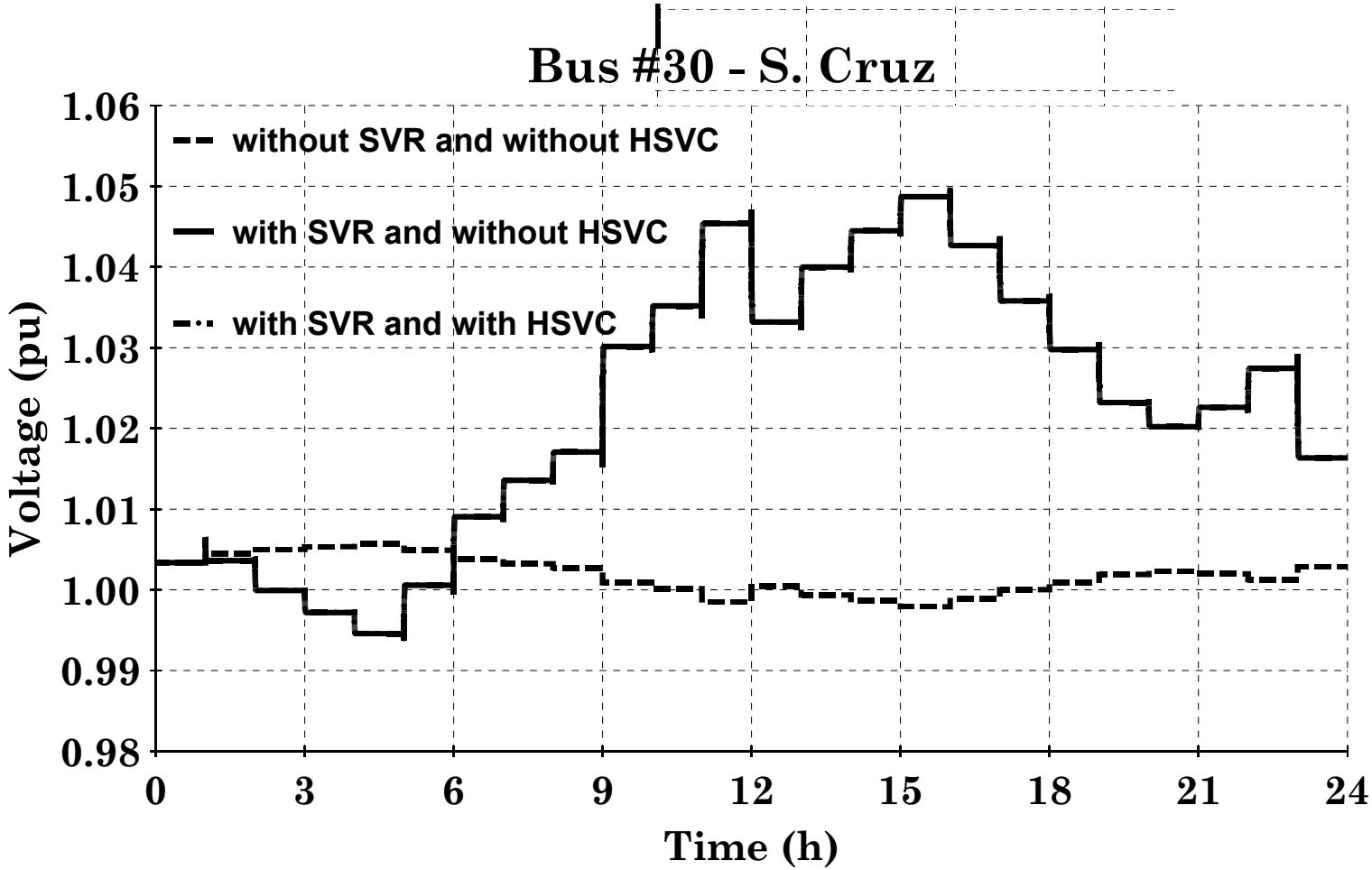
Results for 24-hour Load-curve in the Rio Area

- **Furnas voltage profile**



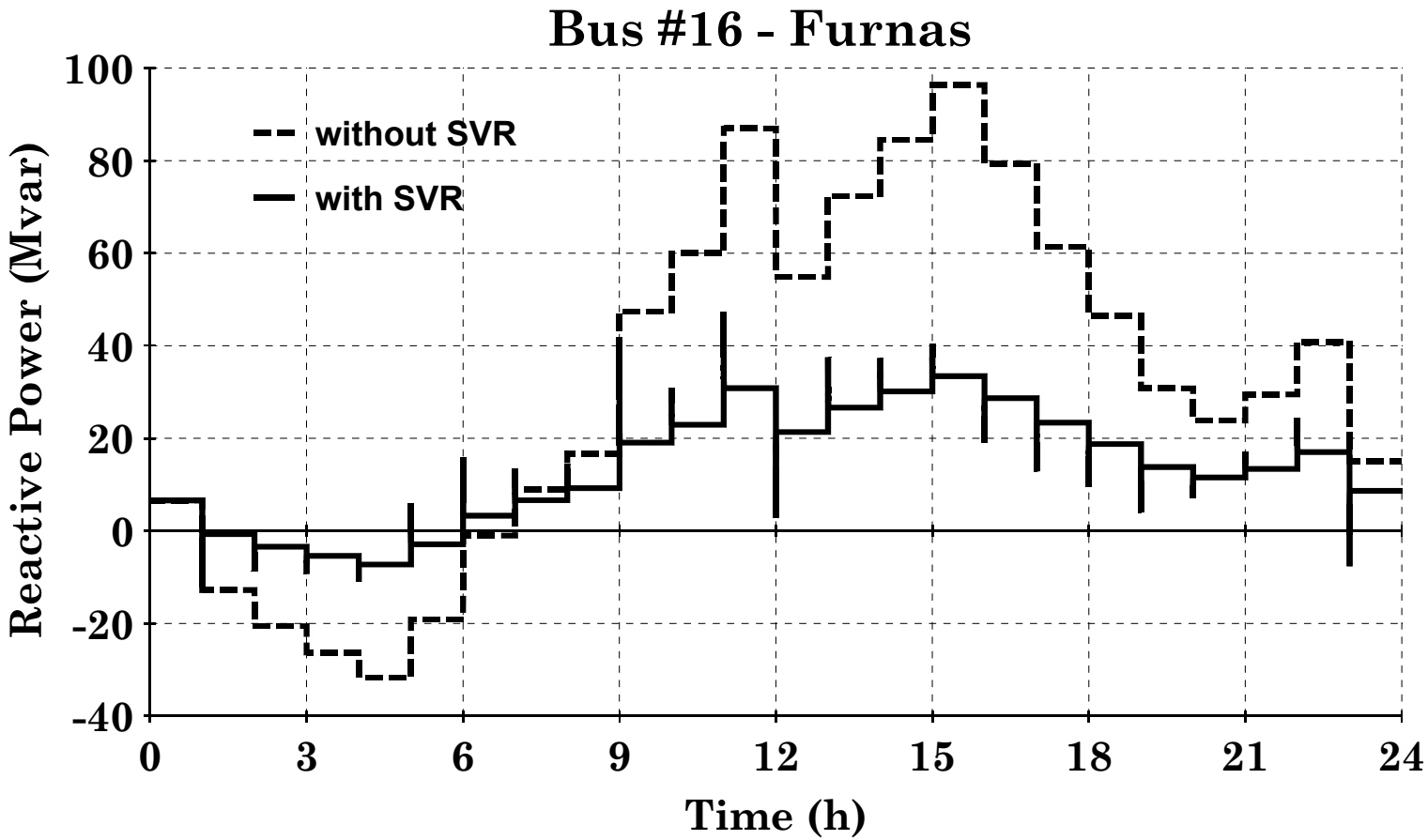
Results for 24-hour Load-curve in the Rio Area

- **Santa Cruz voltage profile**



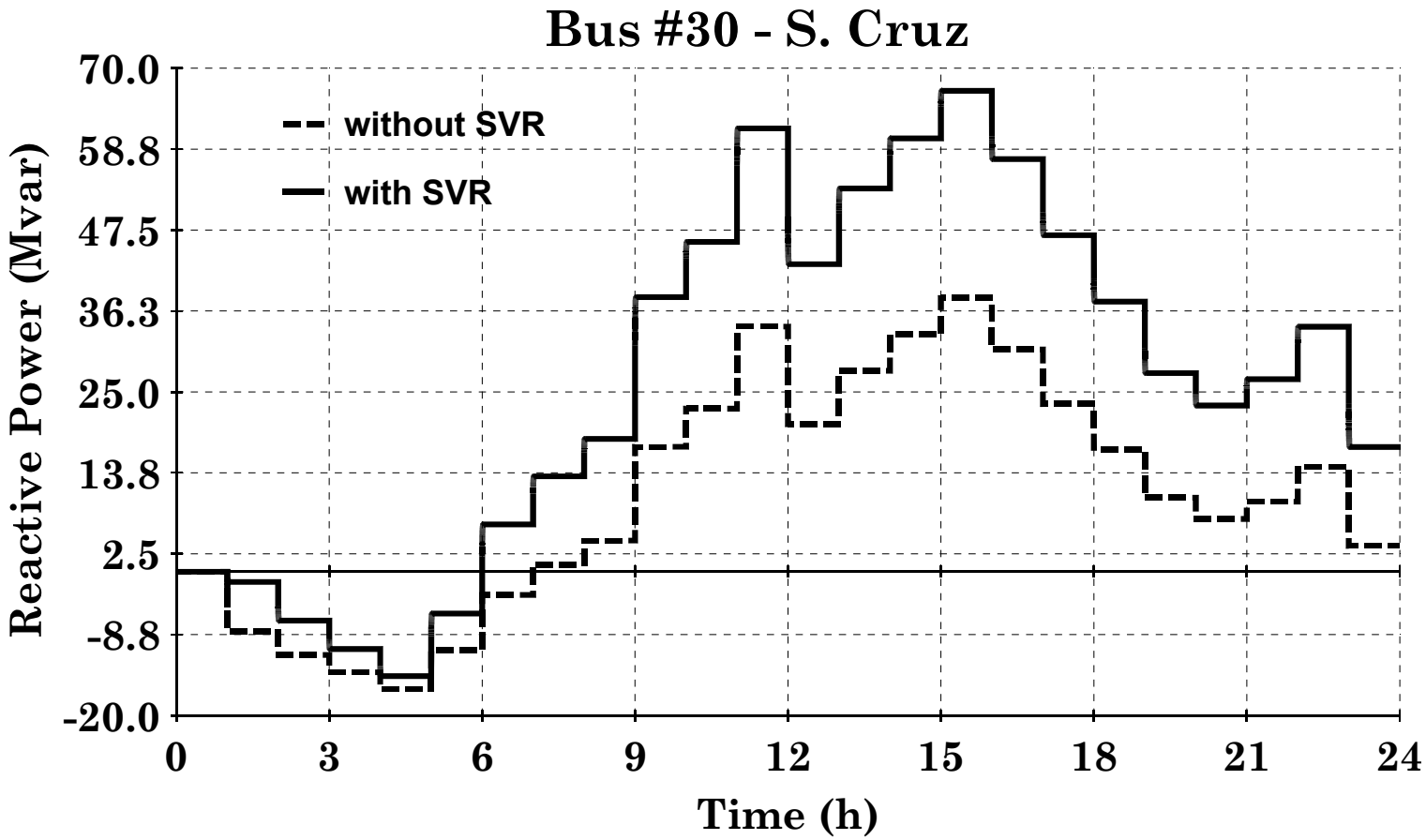
Results for 24-hour Load-curve in the Rio Area

- **Furnas reactive power**



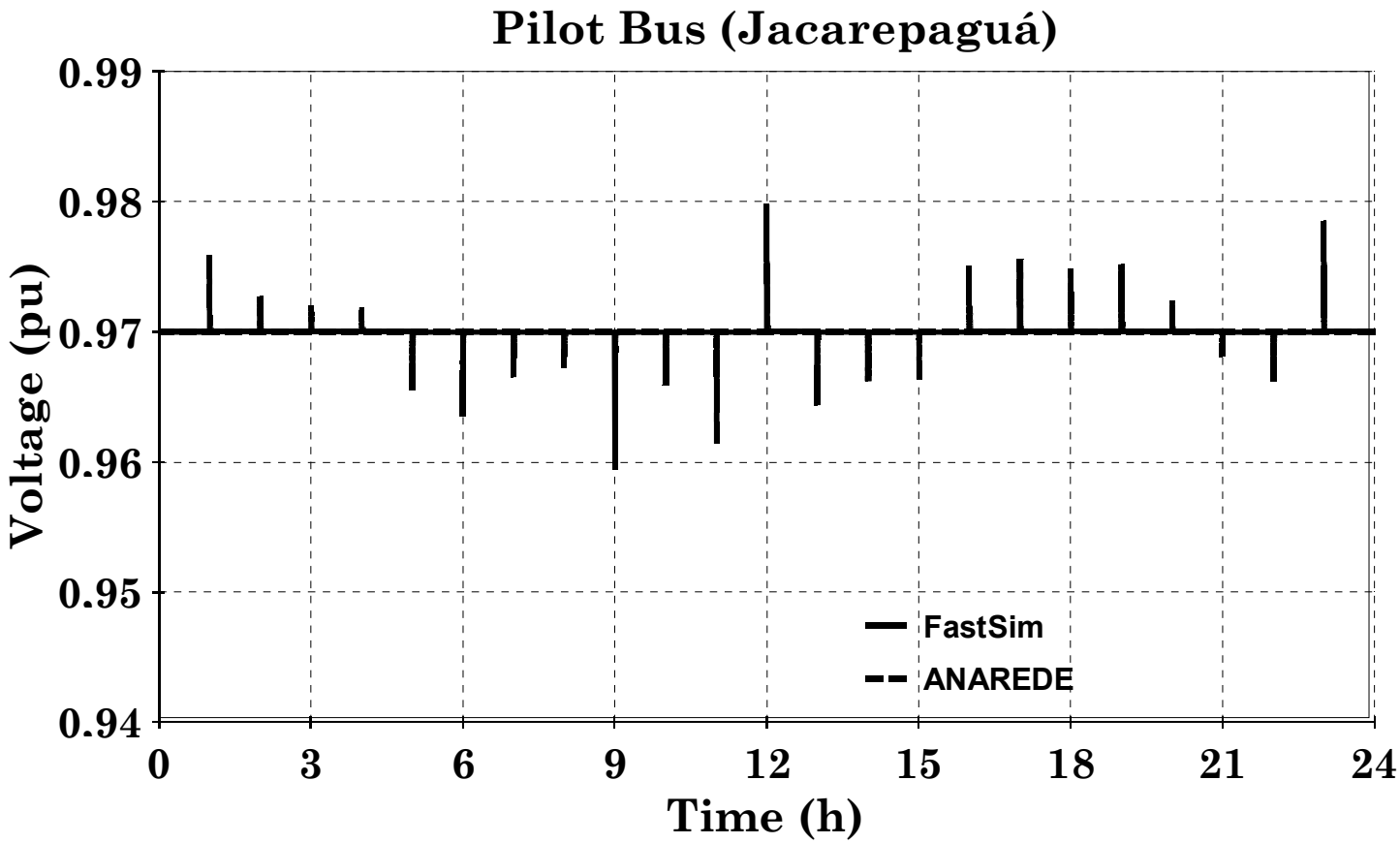
Results for 24-hour Load-curve in the Rio Area

- **S. Cruz reactive power**



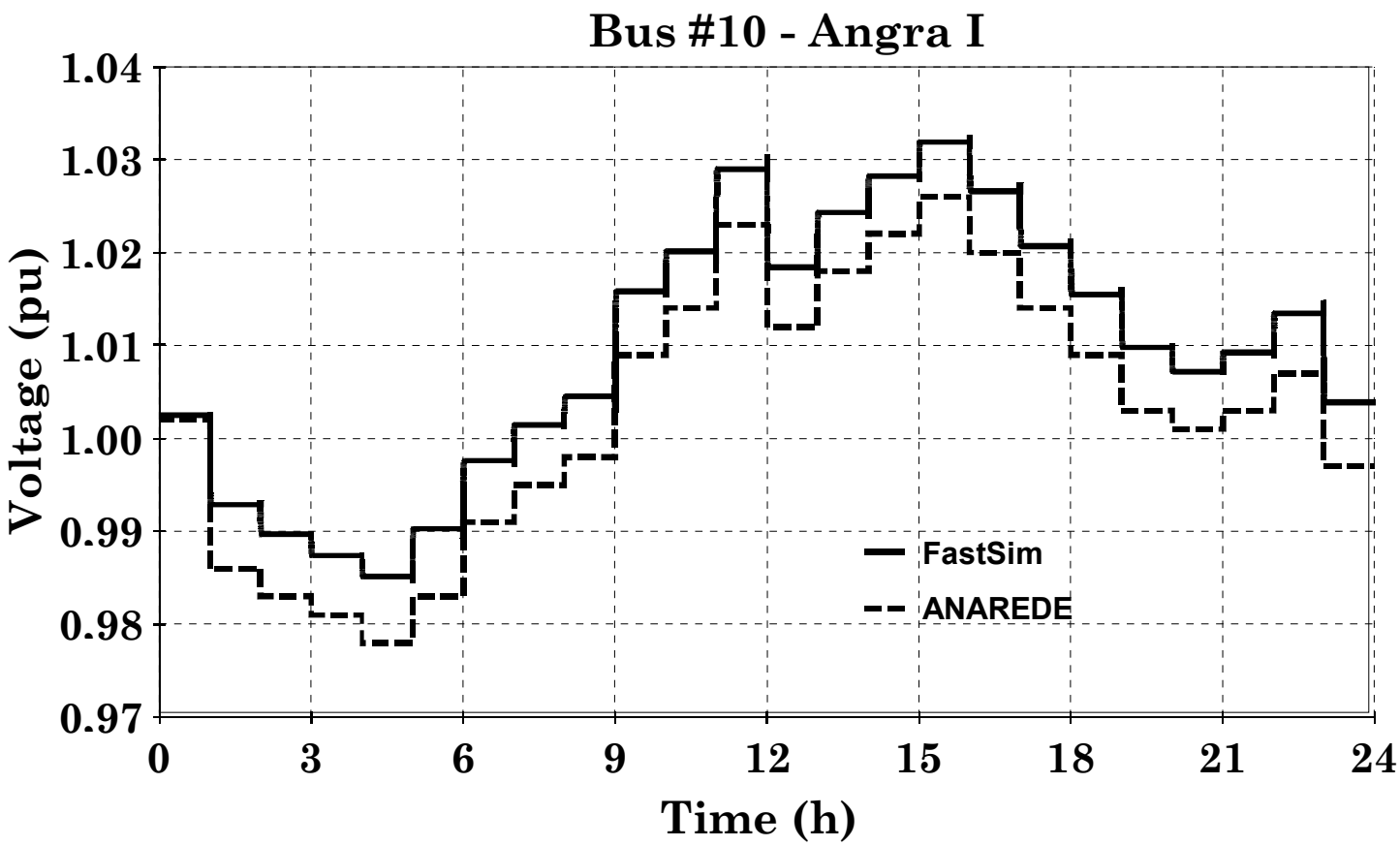
Fast simulation program × load flow program

- Pilot Node voltage is regulated at 0.97 p.u.



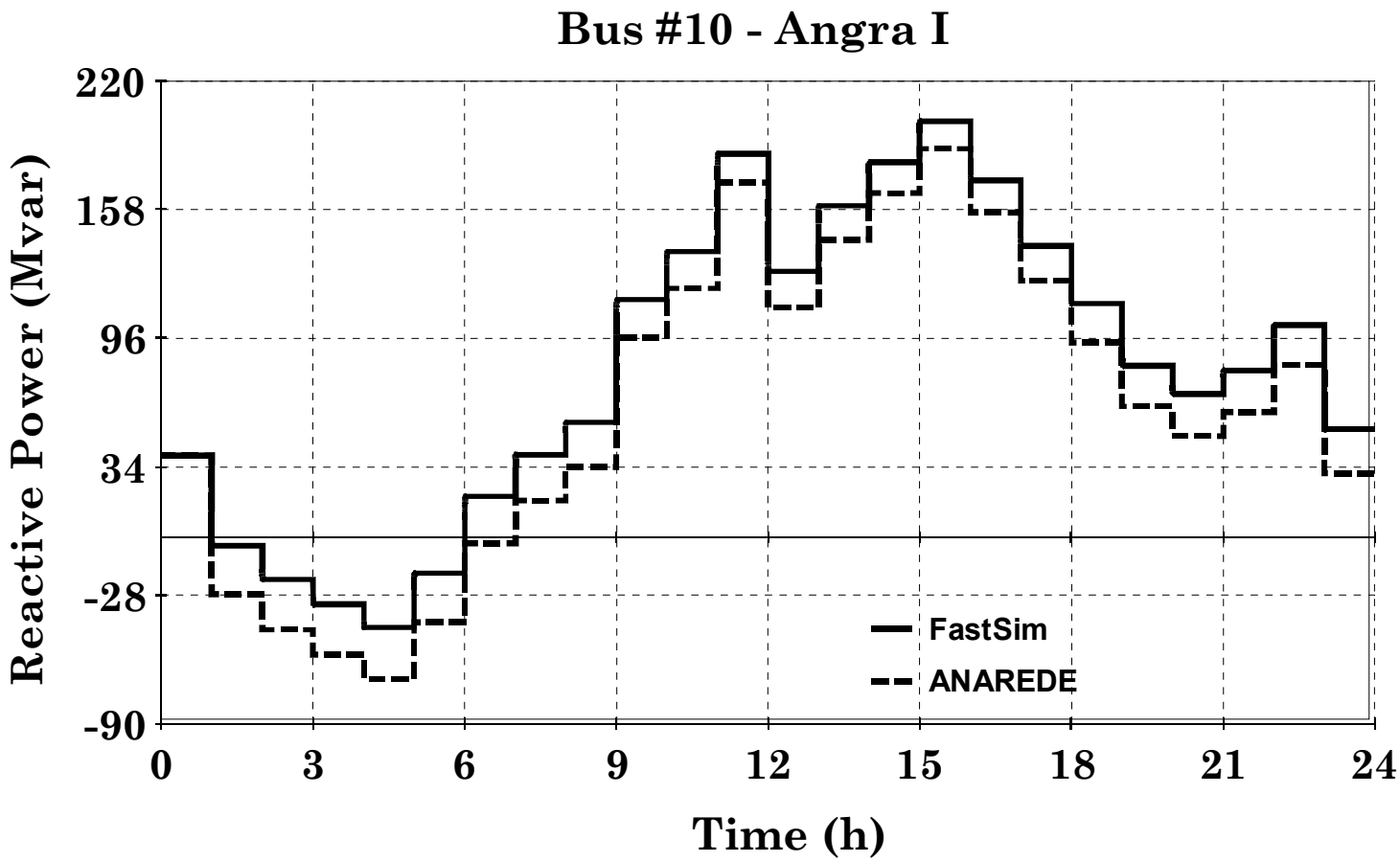
Fast simulation program × load flow program

- **Angra I Terminal Voltage**



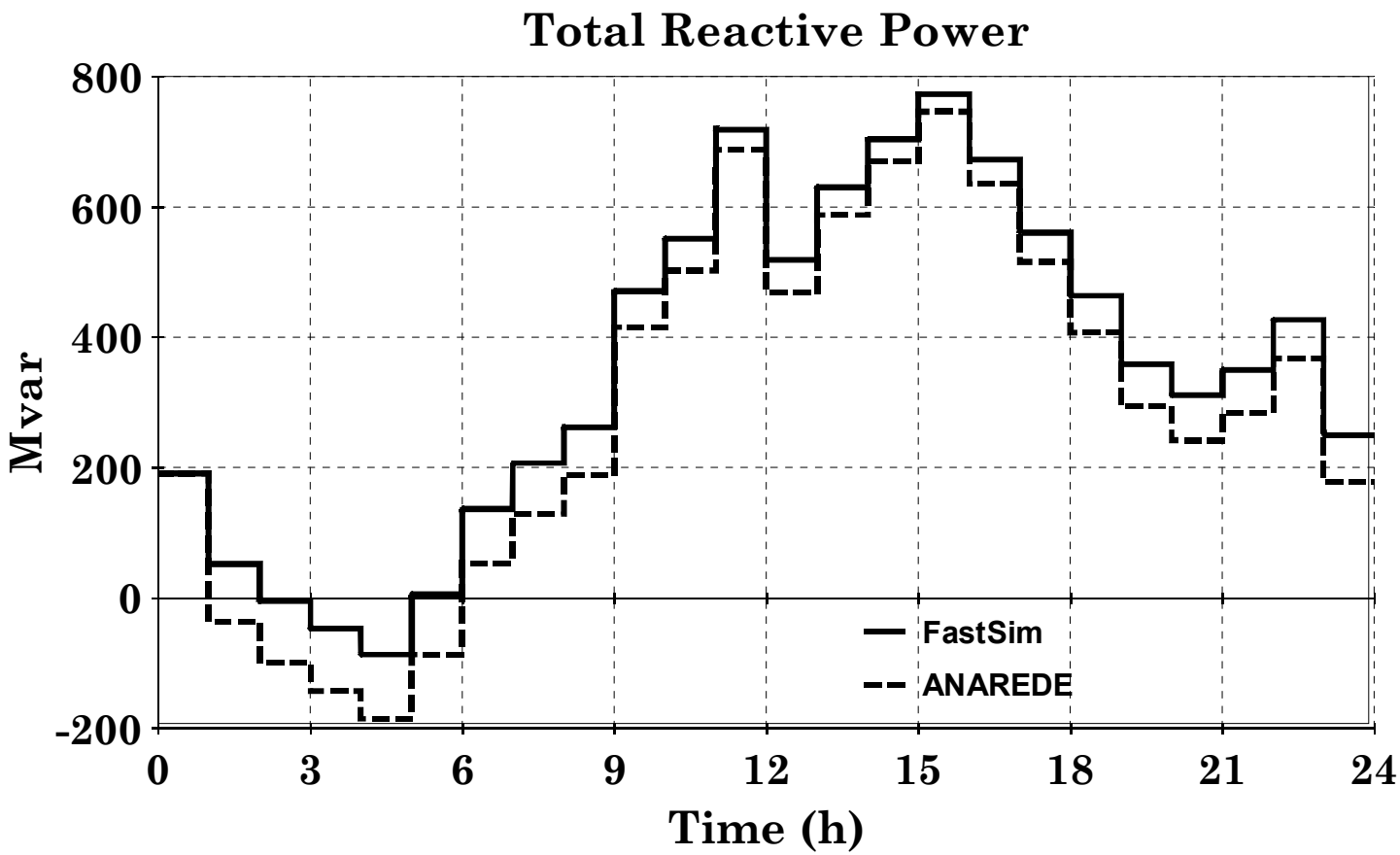
Fast simulation program × load flow program

- **Angra I reactive power**



Fast simulation program × load flow program

- **Total Reactive Power**



Validation of Fast Simulation Results

- Small differences in results are due to different bus representations in the two programs:
  - Power flow (Anarede): buses represented as Vθ, PV and PQ
  - Fast simulator (FastSim): all buses have a PQ model and generator voltage regulators modeled by their algebraic equations
- Proper PV bus representation in FastSim is desirable

Final Remarks

- This coordinated voltage control structure is similar to those used in first European schemes
- Coordinated Voltage Control schemes improve the overall system performance
  - ➔ Improved transmission voltage profile
  - ➔ Better utilization of reactive power resources
  - ➔ Proper VAr Sharing among generating plants
  - ➔ Lower number of equipment switchings (tap changers and shunt banks)