

# **THE DPRK ENERGY SECTOR: CURRENT STATUS AND OPTIONS FOR THE FUTURE**

**East Asia Energy Futures (EAEF)/Asia Energy  
Security Project**

## **Energy Paths Analysis/Methods Training Workshop**

**4 to 7 November, 2003, Vancouver, BC, Canada**

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# OUTLINE OF PRESENTATION:

- Background to DPRK Energy Analyses
  - ◆ History and general analytical approach
- DPRK Energy Balance Update
  - ◆ Overall Approach
  - ◆ Overview of Results: Electricity Supply/Demand
  - ◆ Overview of Results: Other Fuels
- The Potential Role of Energy Efficiency in DPRK Energy Sector Development
  - ◆ Energy, Cost, Environmental Benefits
- Future Energy Paths for the DPRK
- Regional Options/Opportunities in Aiding in DPRK Energy Sector Development
- Analysis Application: Agricultural Sector Needs

# PREVIOUS AND ONGOING NAUTILUS INSTITUTE DPRK ENERGY WORK

- ❑ 1986-94: Nuclear Weapons/Proliferation Issues
- ❑ 1992-97: UN Energy-Environment Missions
- ❑ 1995: DPRK Energy Supply/Demand and Energy Efficiency Study
- ❑ 1996: KEDO-HFO Supply and Demand Study
- ❑ 1997: Supply and Demand for Electricity in the DPRK--1990, 1996, and Future Paths
- ❑ 1997: Spent Fuel Scenarios for East Asia
- ❑ 1997-02: DPRK Village Energy Project, Study Tours, and Proposal Collaboration
- ❑ 2002: Update to 2000 base yr (ongoing)

# PREVIOUS AND ONGOING NAUTILUS INSTITUTE DPRK ENERGY WORK

## □ OVERALL APPROACH TO DPRK ENERGY SECTOR ANALYTICAL WORK

- ◆ Obtain as much **information** as possible about the DPRK economy and energy sector from media sources, visitors to the DPRK, and other sources
- ◆ Use available information, comparative analysis, and judgment to **assemble a coherent and consistent picture** of the DPRK energy sector
- ◆ Think about **possible future paths** for DPRK energy sector and economy, what changes (national, regional, global) might bring those paths about, what changes might mean at end-use, infrastructure levels

# DPRK ENERGY BALANCE UPDATE: KEY CHANGES SINCE 1996

- ❑ A continuing decline in the supply of crude oil from China, reducing DPRK's refinery output
- ❑ Continuing degradation of electricity generation infrastructure due to:
  - ◆ Lack of spare parts, use of aggressive fuels (heavy fuel oil, shredded tires) in boilers designed for low-sulfur coal
- ❑ Continuing degradation of electricity T&D infrastructure
- ❑ Continuing degradation of industrial facilities

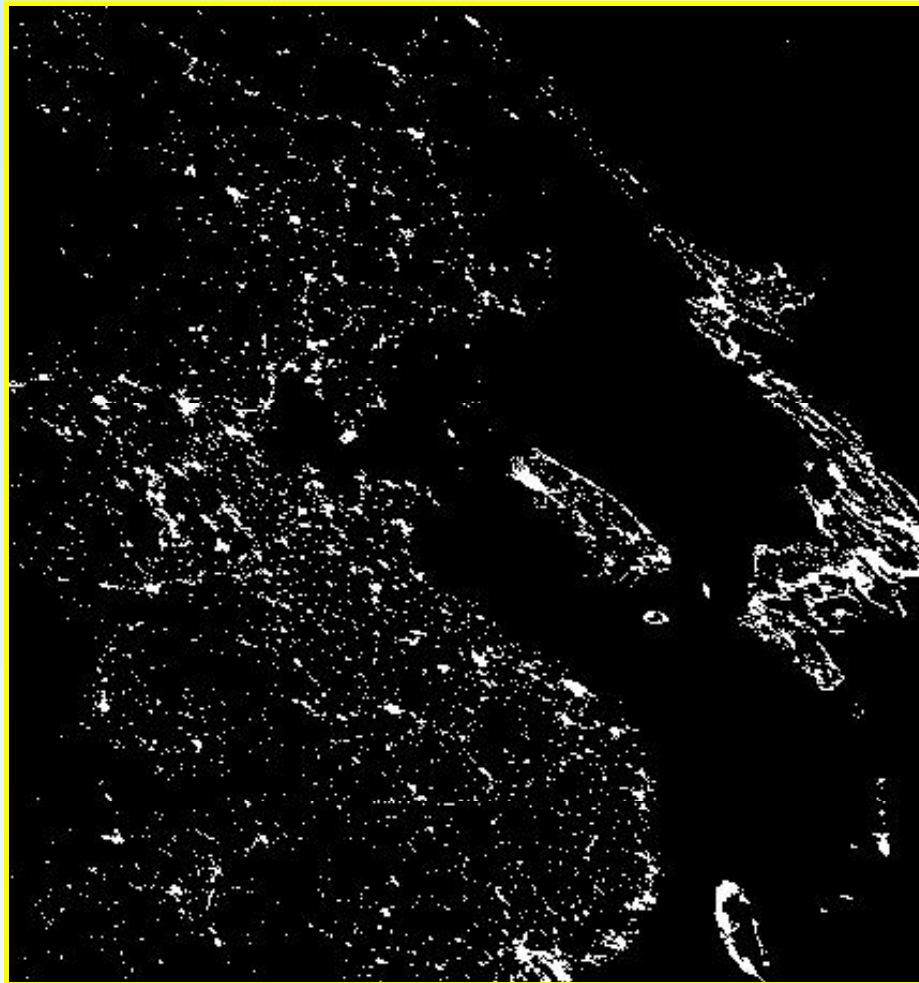
# **DPRK ENERGY BALANCE UPDATE: KEY CHANGES SINCE 1996**

- Continuing degradation of electricity T&D infrastructure
  - ◆ **Much reduced availability of electricity in most parts of the country away from Pyongyang**
- Continuing degradation of industrial facilities
  - ◆ **Eyewitness reports of industrial facilities being dismantled for scrap**
  - ◆ **Damage to operating industrial electric motors from poor quality electricity**

# DPRK ENERGY BALANCE UPDATE: KEY CHANGES SINCE 1996

- ❑ Some imports of used motor vehicles Continued decline in cement, steel production
- ❑ Evidence of significant international trade in magnesite (or magnesia)
- ❑ Continuing difficulties with transport of goods
- ❑ Difficulties in coal production
  - ◆ Lack of electricity, mine flooding (Anju region)
- ❑ Some economic revival, but..
  - ◆ Mostly associated with foreign aid and/or economic sectors--such as small markets and cottage industries--that are not energy intensive

# DPRK ENERGY BALANCE UPDATE: KEY CHANGES SINCE 1996





# DPRK ENERGY BALANCE UPDATE: ELECTRICITY SECTOR RESULTS

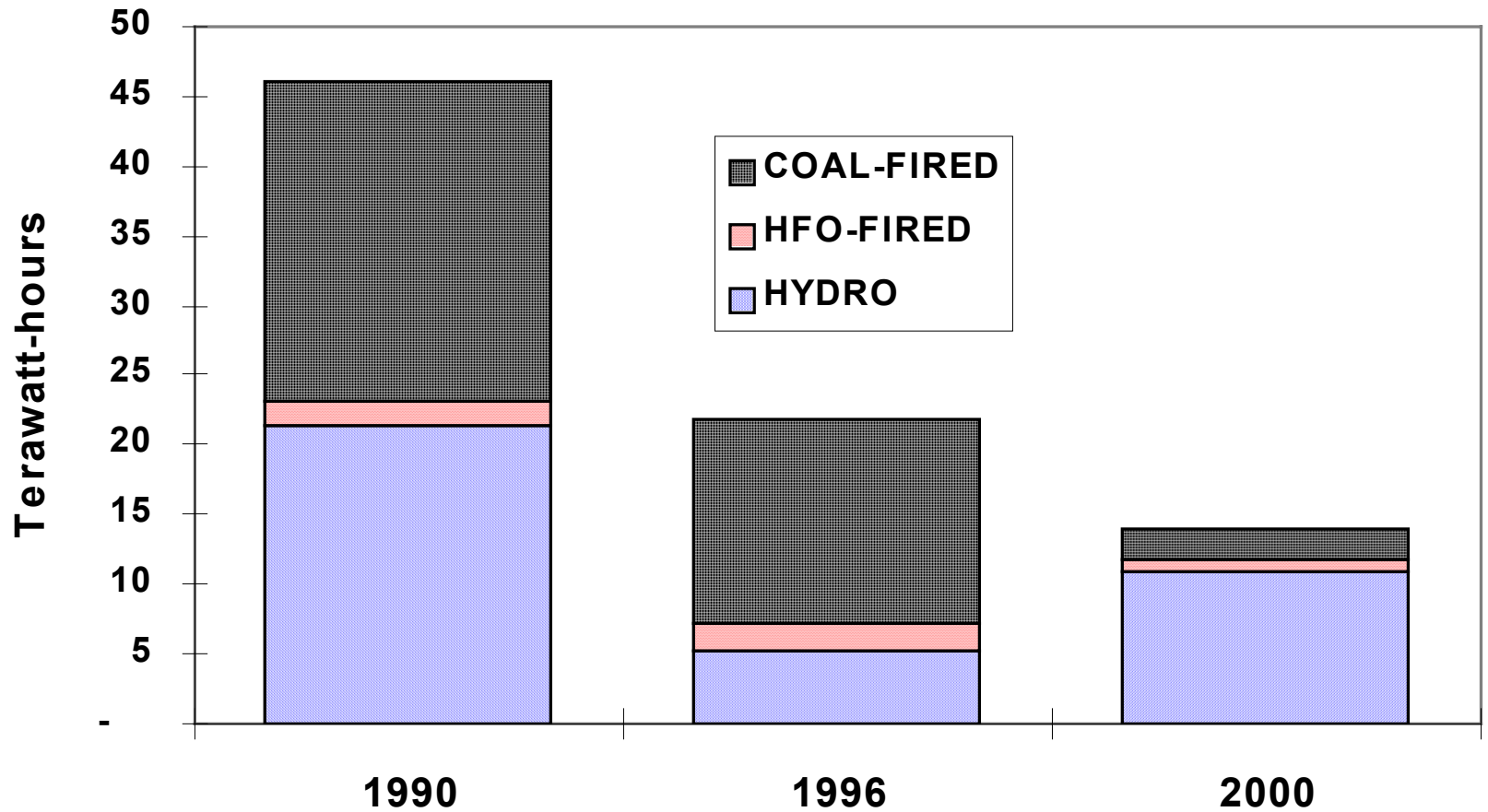
- Thermal generating system eroding rapidly
  - ◆ In most large power stations, only selected boilers and turbines if any, are operating
  - ◆ Problems with "air heaters", resulting in decrease in plant efficiency; problems with boiler tubes
- In total, we estimate less than 800 MW of thermal capacity was operable as of 2000
- Hydroelectric plants have shouldered much of burden of power generation in the DPRK, but...
  - ◆ Hydro availability is highly seasonal: far less power in the dry winter than at other times of the year

# DPRK ENERGY BALANCE UPDATE: ELECTRICITY SECTOR RESULTS

- We have assumed that of the ~4000 MW of other hydroelectric plants:
  - ◆ 80% of capacity is operable
  - ◆ Capacity factor in 2000 of about 38 percent
- Major "Youth Dam" including a tunnel system for carrying water has recently been completed, but generating capacity is unclear (200 MWe?).
- New Taedong dam for Southwest Coast irrigation?

# DPRK ENERGY BALANCE UPDATE: ELECTRICITY SECTOR RESULTS

Gross Generation in the DPRK, 1990, 1996, and 2000



# DPRK ENERGY BALANCE UPDATE: OTHER SUPPLY DATA/RESULTS

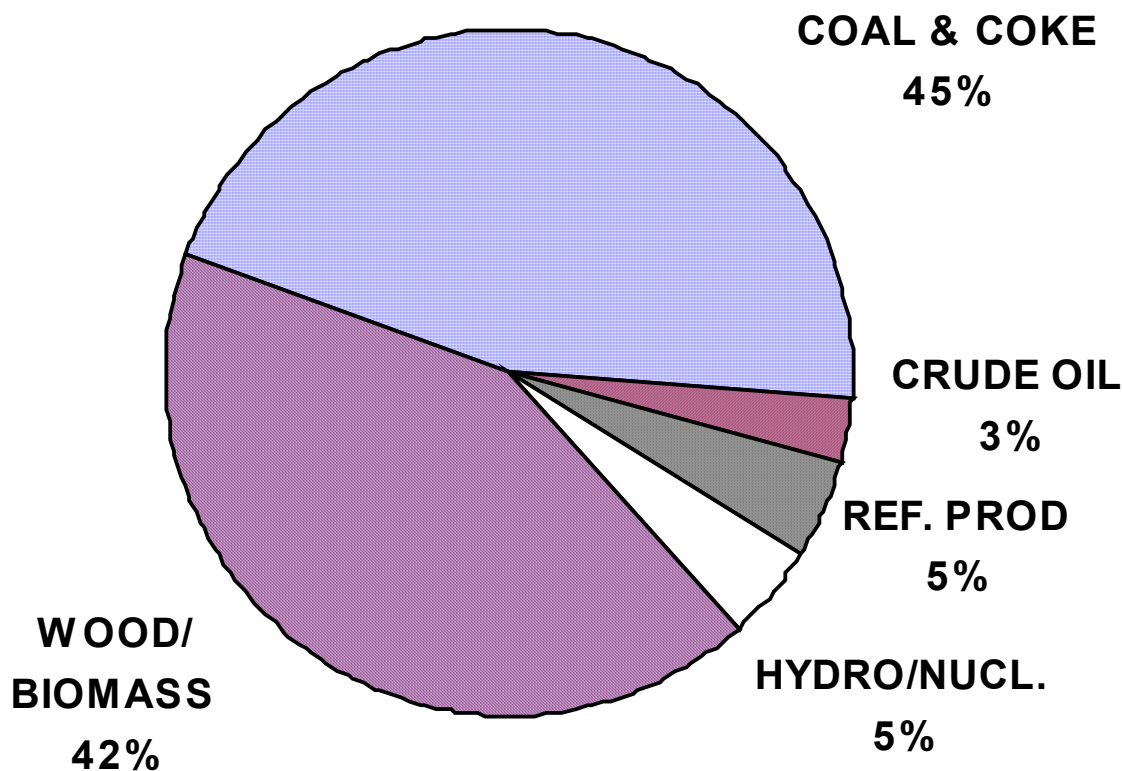
- Coal, biomass resources sufficient for level of production sustained by DPRK infrastructure
- Coal imports: China, 226 kte, Australia, 31kte
- Coal exports (at least) China (8.1 kte), Japan (351 kte)
- Crude oil imports in 2000: 389 kte from China, est. 190 kte from other sources
- Refined products imports to the DPRK from:
  - ◆ ROK, Singapore, Japan, China, Russia, KEDO
  - ◆ Chinese refinery on border (~300 kte)

# DPRK ENERGY BALANCE UPDATE: OTHER SUPPLY DATA/RESULTS

- DPRK crude oil production off Sukchon County reported, but it seems likely that any output, if it did occur, was minimal
- Estimated 25,000 tonnes of used tires from Japan, Taiwan for use as boiler fuel (cargoes from Europe reportedly also requested)

# DPRK ENERGY BALANCE UPDATE: OTHER SUPPLY DATA/RESULTS

**ESTIMATED DPRK ENERGY SUPPLY BY  
TYPE: 2000**



# DPRK ENERGY BALANCE UPDATE: ENERGY DEMAND DATA/RESULTS

## □ Industry:

- ◆ Output 18% of 1990 except cement/building materials/other minerals (29%), fertilizers (11%)
- ◆ Average energy intensity 115% 1990 levels

## □ Transport:

- ◆ Road freight scales with industrial output
- ◆ Diesel rail freight is assumed to be 30% of 1990 levels, electric rail freight 24% of 1990

# DPRK ENERGY BALANCE UPDATE: ENERGY DEMAND DATA/RESULTS

## □ Residential:

- ◆ Residential coal use ~50% of 1990 levels
- ◆ Based on power availability, electricity use per household about 29% of 1990

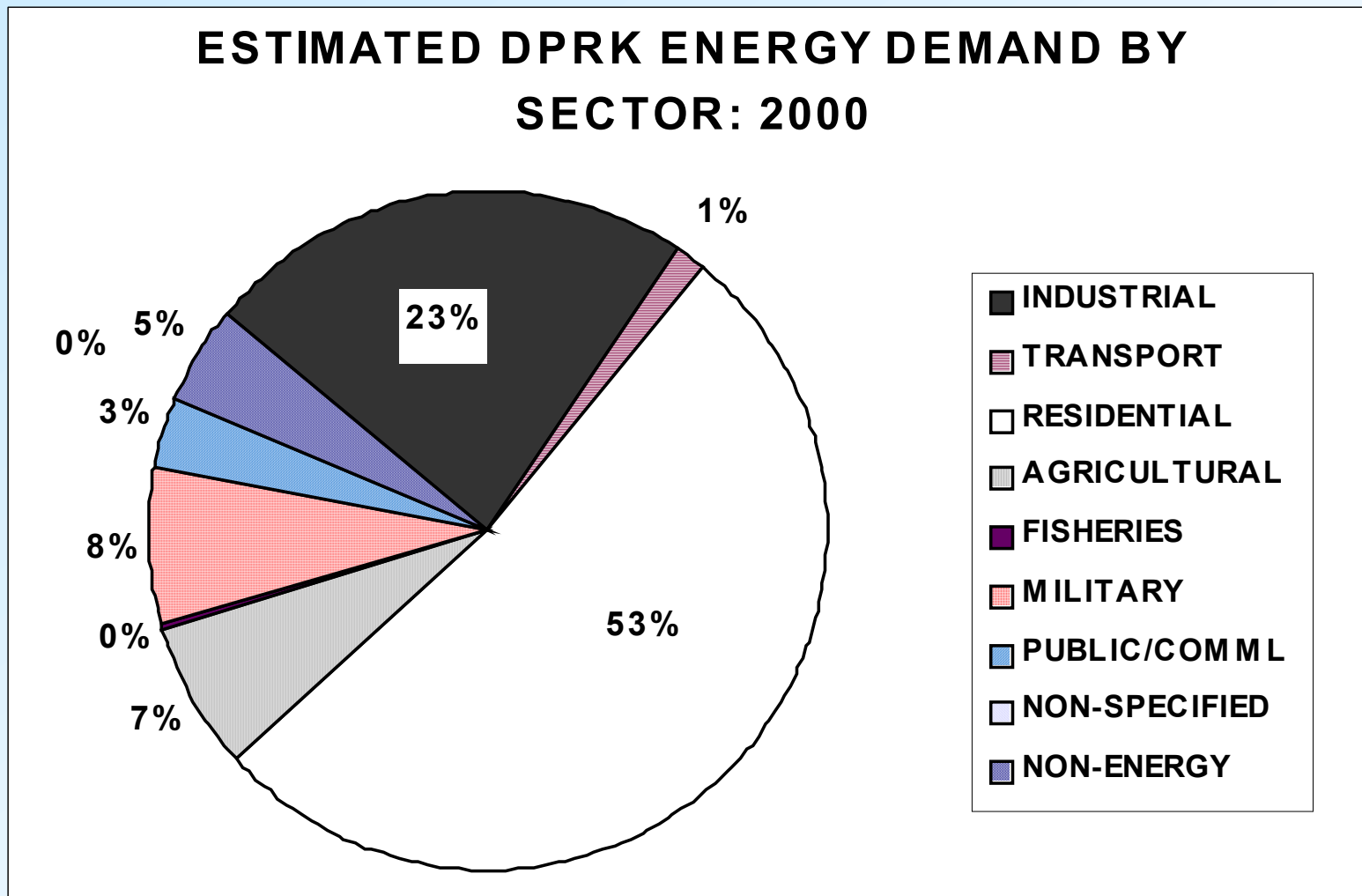
## □ Agriculture/Fisheries

- ◆ Diesel tractor use in 2000 40% of 1990 levels
- ◆ Fisheries marine catch, 42% of 1990 levels

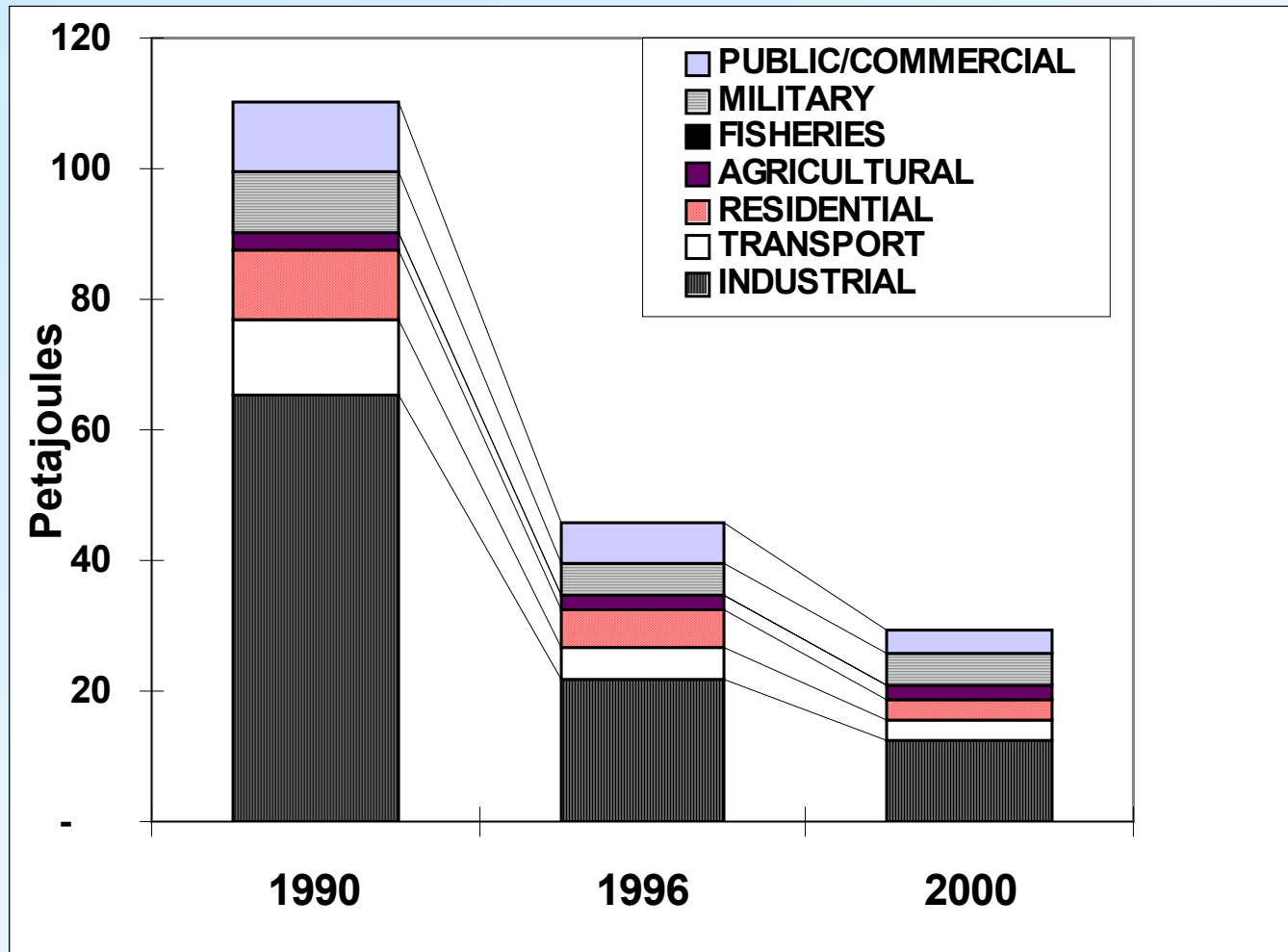


# DPRK ENERGY BALANCE UPDATE: ENERGY DEMAND DATA/RESULTS

ESTIMATED DPRK ENERGY DEMAND BY  
SECTOR: 2000

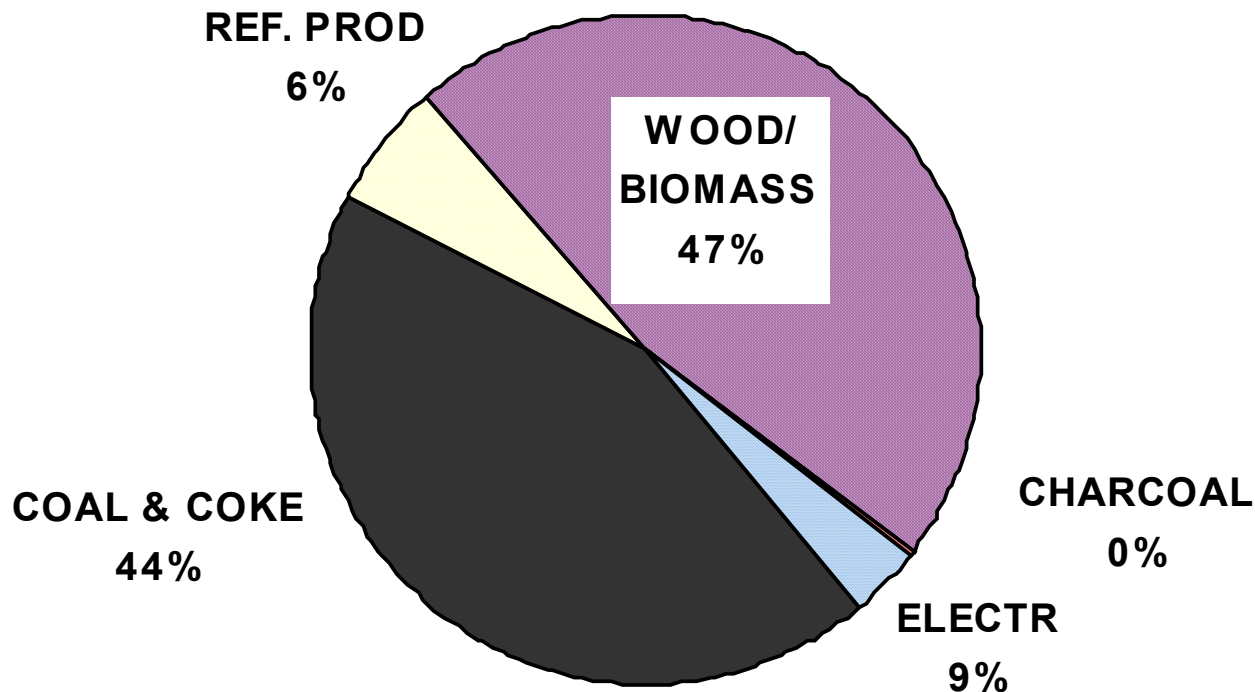


# DPRK ENERGY BALANCE UPDATE: ENERGY DEMAND DATA/RESULTS

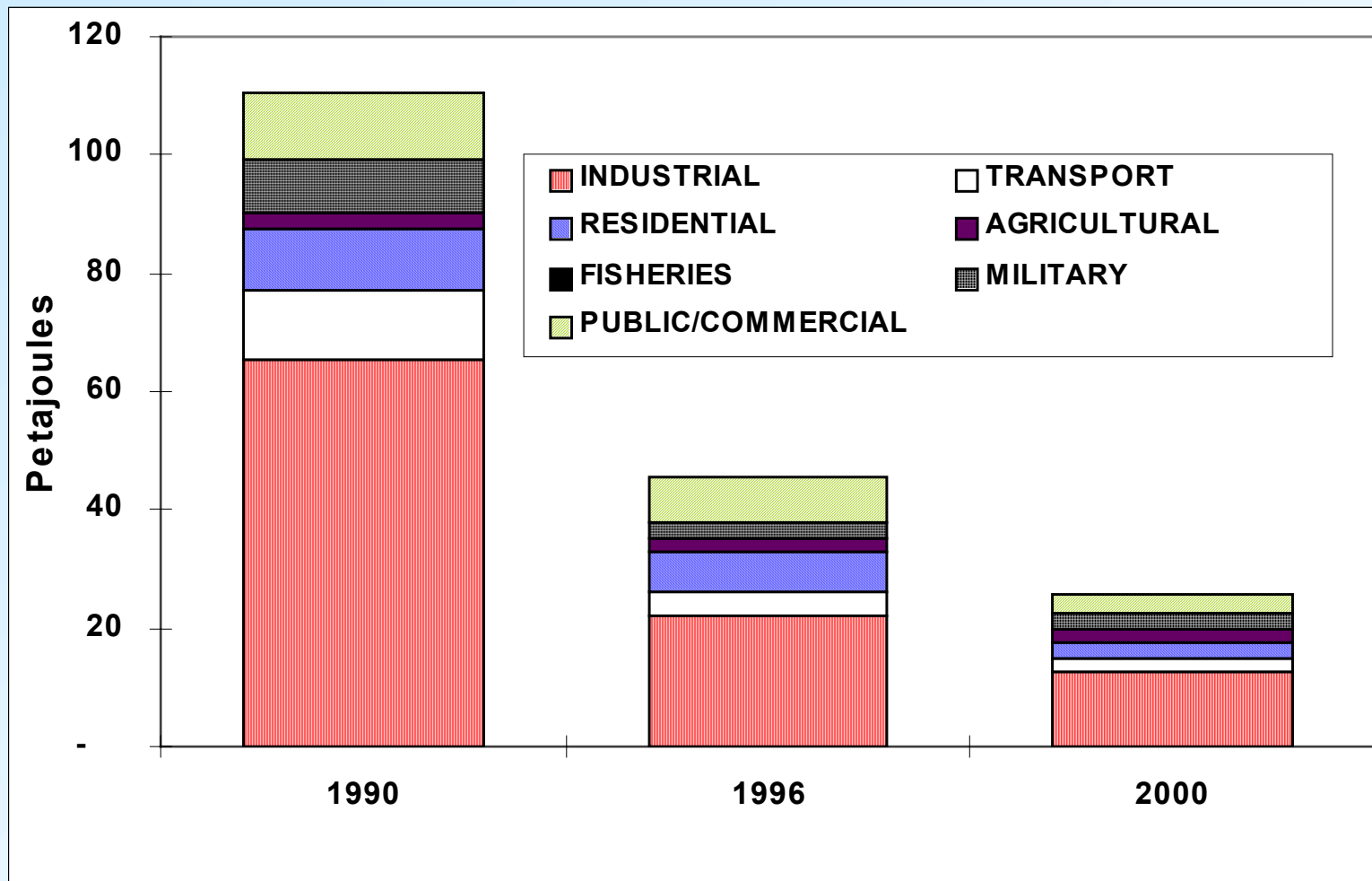


# DPRK ENERGY BALANCE UPDATE: ENERGY DEMAND DATA/RESULTS

## ESTIMATED DPRK FINAL ENERGY DEMAND BY FUEL, 2000



# DPRK ENERGY BALANCE UPDATE: ENERGY DEMAND DATA/RESULTS



# EVALUATION OF ENERGY EFFICIENCY OPTIONS FOR THE DPRK

- Estimates of impact of a small set of energy efficiency measures on electricity and coal consumption in the DPRK (2000 base year)
- Measures to Save Electricity
  - ◆ Industrial Motors and Drives
  - ◆ Motors and Drives in other Sectors
  - ◆ Residential Lighting
  - ◆ Non-residential Lighting
  - ◆ Own Use reduction in Power Plants
  - ◆ Reduction of Emergency Use in Power Plants
  - ◆ Transmission and Distribution Improvements

# EVALUATION OF ENERGY EFFICIENCY OPTIONS FOR THE DPRK

## □ Measures to Save Coal

- ◆ Industrial Boiler and Furnace Improvements
  - ◆ Residential and Other Sector Boiler Improvements
  - ◆ Building Envelope Improvements
  - ◆ Domestic Stove/Heater Improvements
  - ◆ Electric Utility Boiler Improvements
- Measure costs and performance based on data from application of similar measures in China and elsewhere
- Calculation of **energy, environmental** benefits

# EVALUATION OF ENERGY EFFICIENCY OPTIONS FOR THE DPRK

- Efficiency options can be an inexpensive source of energy services with low environmental impact, offer other benefits
- Impacts/costs of measures to save electricity
  - ◆ Energy savings of 2.9 TWh per year for 10-20 years (the equivalent of a 400+ MW power plant)
  - ◆ Total investment of \$400 million (2000 USD) phased in over 10 years
  - ◆ **SO<sub>2</sub>** emissions reduction: 5.5 thousand tonnes/yr
  - ◆ **NO<sub>x</sub>** emissions reduction: 3.5 thousand tonnes/yr
  - ◆ **CO<sub>2</sub>** emissions reduction: 0.9 million tonnes/yr

# EVALUATION OF ENERGY EFFICIENCY OPTIONS FOR THE DPRK

## □ Impacts/Costs of Measures to Save Coal

- ◆ Coal energy savings of 114 PJ per year for 10-20 years (the equivalent of 6 million tonnes/yr)
- ◆ Total investment of \$420 million (2000 USD)
- ◆ **SO<sub>2</sub>** emissions reduction: 56 thousand tonnes/yr
- ◆ **NO<sub>x</sub>** emissions reduction: 35 thousand tonnes/yr
- ◆ **CO<sub>2</sub>** emissions reduction: 9 million tonnes/yr

- Efficiency measures also yield considerable improvements in reliability, productivity, materials use, comfort, convenience



# ENERGY PATHS FOR THE DPRK

- Starting point: 1995-97 DPRK energy sector analysis and previous “Recovery”, “Decline” paths to 2005
- Subjective, illustrative update of paths taking into account DPRK changes since 1996, prospects for change
  - ◆ **NOT** based upon actual quantitative analysis of recent DPRK data (Year 2000 analysis done after the paths work described here)
- Three primary paths: “Recovery”, “Continued Decline”, and “Sustainable Development”

# ENERGY PATHS FOR THE DPRK

## □ “Continued Decline” Path

- ◆ No significant economic or political opening, and only modest rapprochement with the US, ROK
- ◆ Economy doesn't really decline relative to 2000, but continues stagnating
- ◆ Foreign aid and domestic policies keep economy going at a low level, but little (if any) growth in per-capita energy use
- ◆ Infrastructure maintained just enough to keep going
- ◆ No significant increase in energy efficiency

# ENERGY PATHS FOR THE DPRK

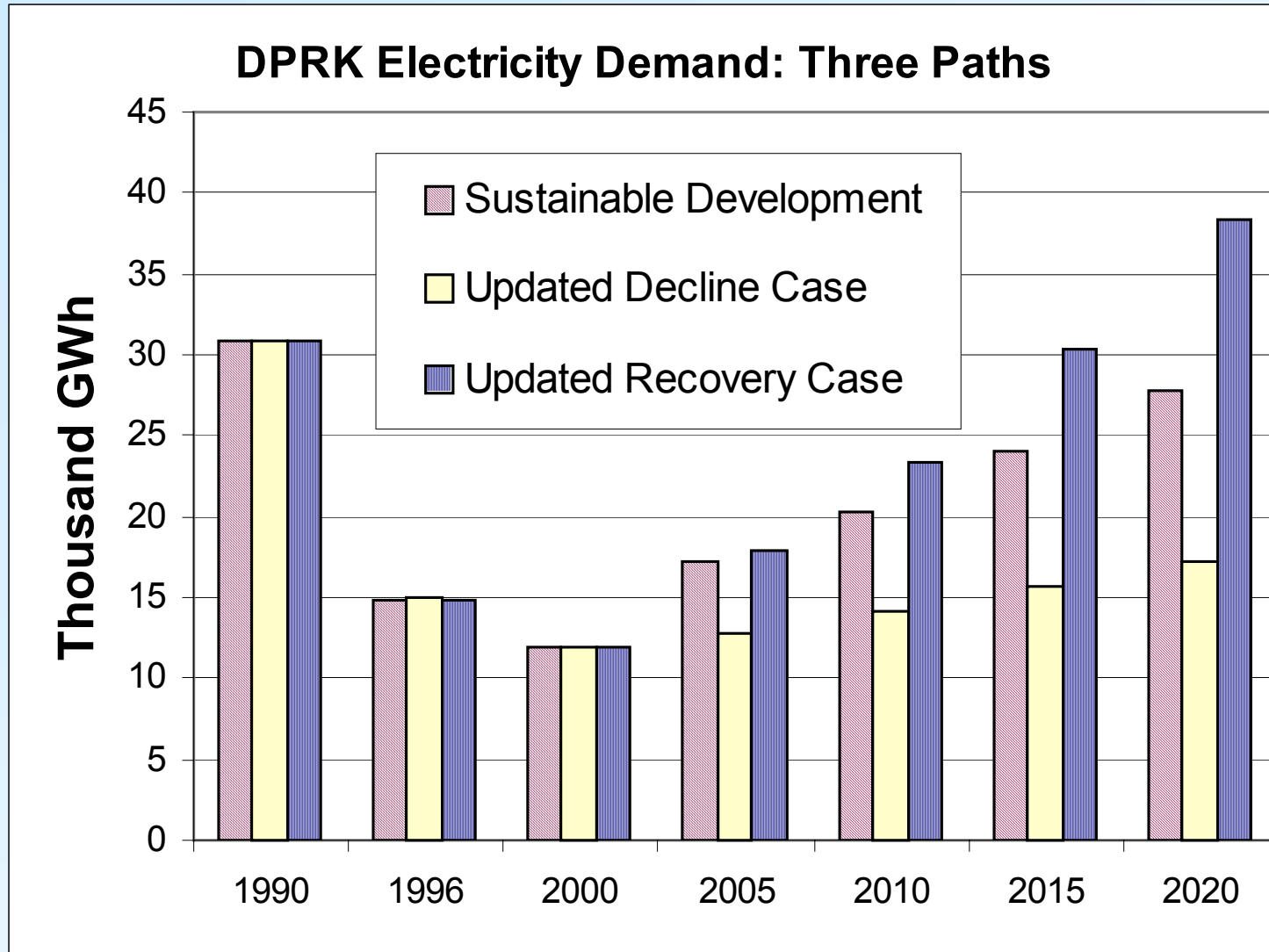
## □ “Recovery” Path

- ◆ With some political, economic opening, increased foreign aid, economy starts to rebuild in ~2003
- ◆ Industrial prod., (lighter industries) increases
- ◆ Increased demand for transport, household energy use (cleaner fuels), commercial activity increase
- ◆ Refurbishment of T&D, hydro, refineries

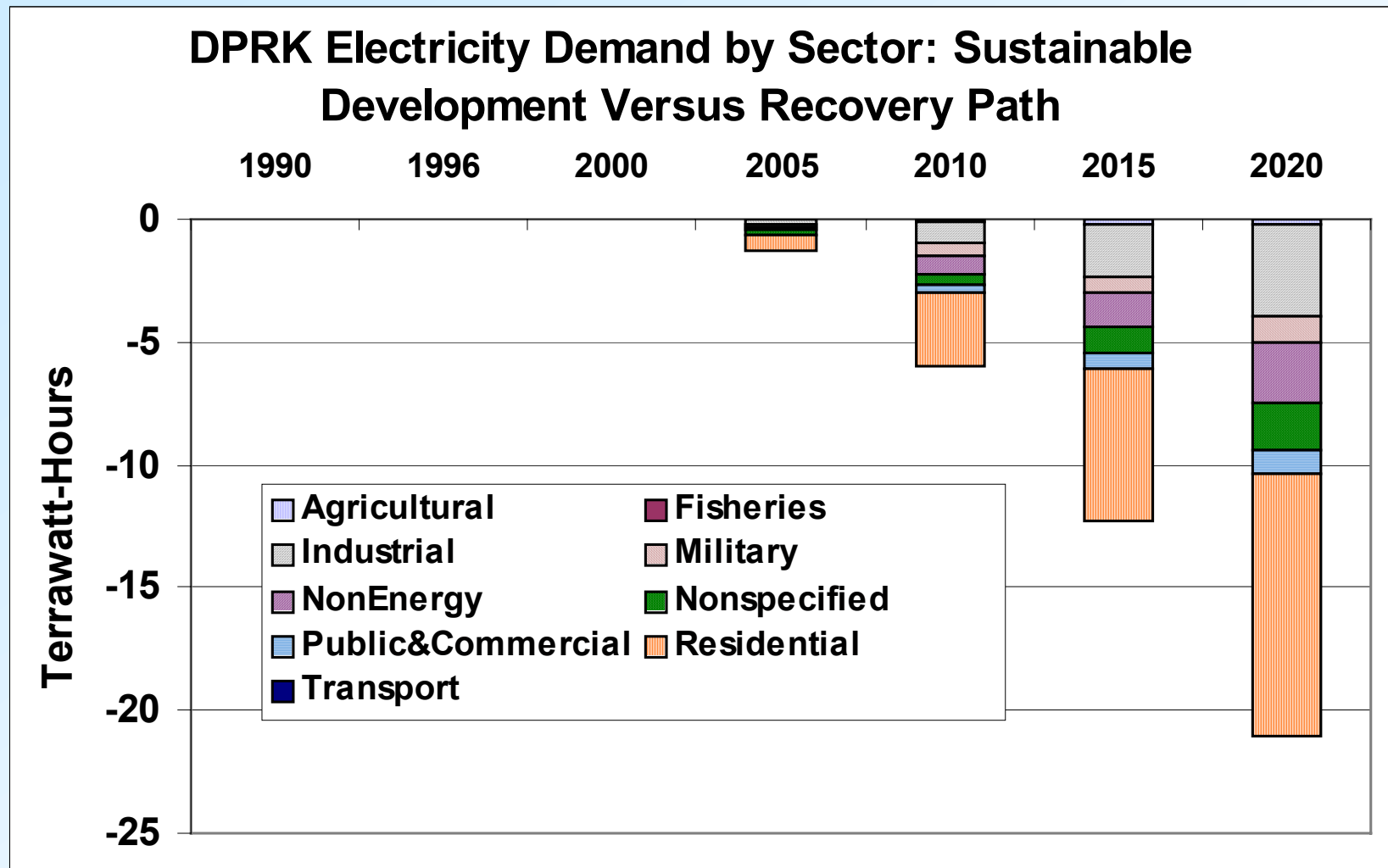
## □ “Sustainable Development” Path

- ◆ Same energy services as “Recovery” path
- ◆ Aggressive implementation of energy efficiency measures
- ◆ Phase-out of older coal power, addition of LNG terminal, Gas CC, IGCC, wind, small hydro

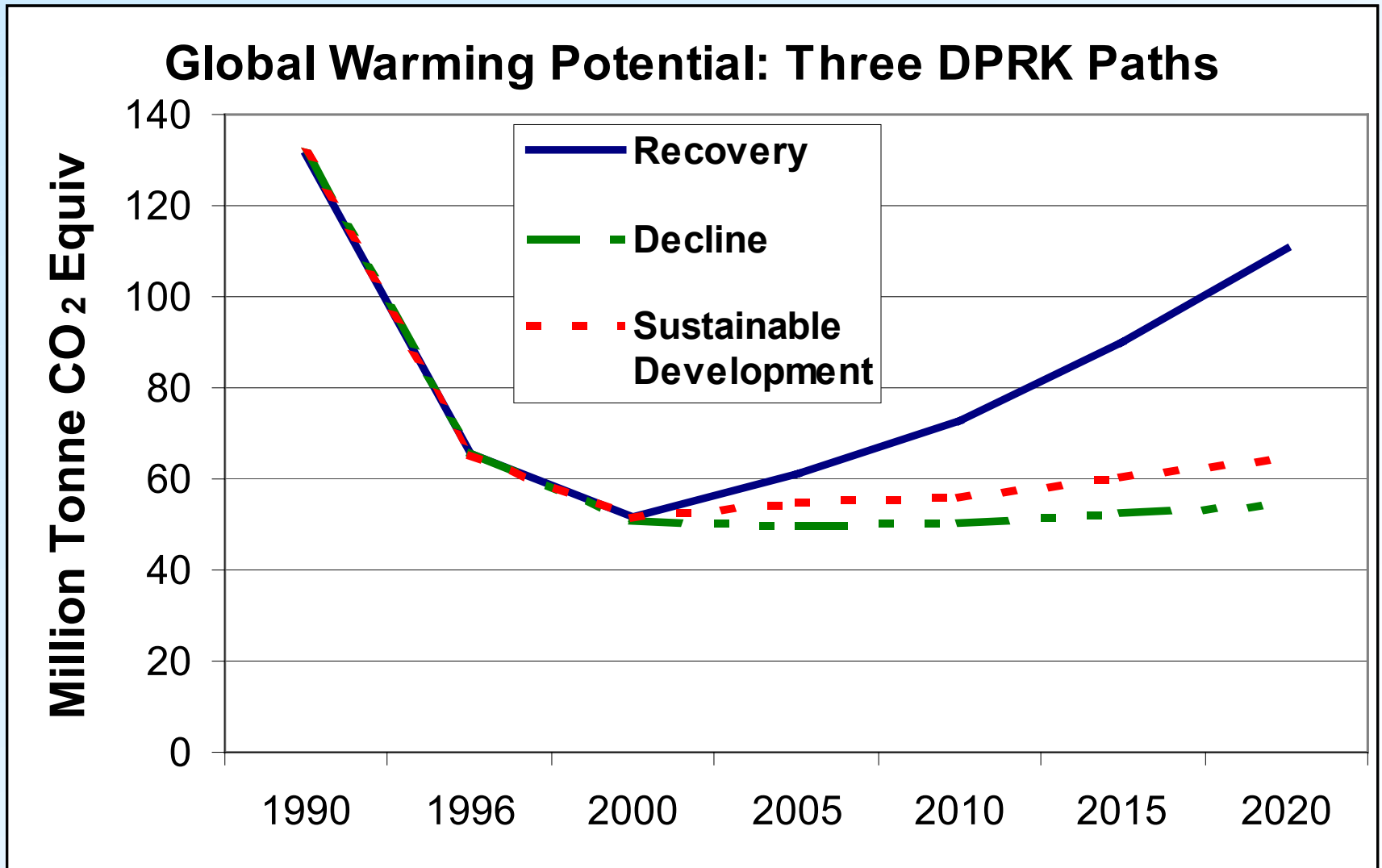
# DPRK PATHS COMPARISONS



# “SUSTAINABLE DEVELOPMENT” PATH RESULTS



# DPRK PATHS COMPARISONS



# NEXT STEPS AND POSSIBLE PATH VARIANTS

- Next Steps on DPRK Paths Analysis
  - ◆ Reconsider existing paths based on year 2000 balance, thoughts about the future
  - ◆ Add costs (demand devices, supply infrastructure, resources/imports)
  - ◆ Further estimates of environmental emissions
  - ◆ Debug data set, and iterate analysis
  - ◆ Consider other path variants
- Work with DPRK Colleagues if Possible

# REGIONAL OPTIONS/OPPORTUNITIES IN AIDING DPRK ENERGY SECTOR

- Providing timely assistance in a coordinated manner will:
  - ◆ Enhance security in Northeast Asia
  - ◆ Accelerate process of DPRK rapprochement
- Nature of the DPRK's energy sector problems, mean that a focus on one or several massive projects will not work
  - ◆ Multi-pronged approach on a number of fronts is required; a large suite of coordinated, smaller, incremental projects addressing needs many areas



# REGIONAL OPTIONS/OPPORTUNITIES IN AIDING DPRK ENERGY SECTOR

- Collaboration on regional energy sharing proposals involving DPRK (large projects, with longer time lines, approached incrementally)
  - ◆ Electricity grid interconnections
  - ◆ Transport interconnections
  - ◆ Gas pipelines
- Involve DPRK colleagues in feasibility studies
  - ◆ Provide training to allow full participation
  - ◆ Develop regional working groups with clear targets, data, results sharing
  - ◆ Work on several fronts--Technical, economic, environmental, institutional

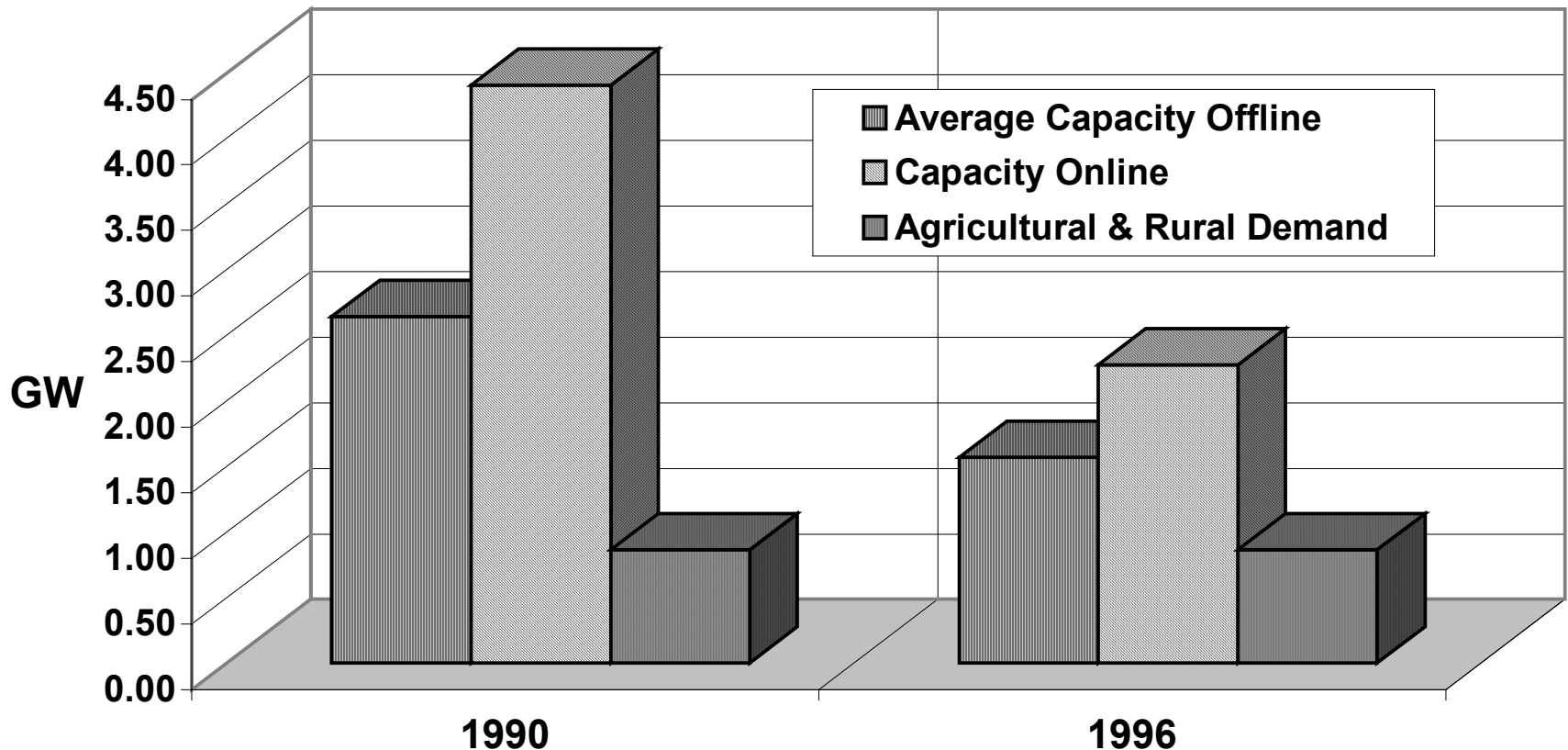
# REGIONAL OPTIONS/OPPORTUNITIES IN AIDING DPRK ENERGY SECTOR

- Encourage regional working groups and/or regional assistance to the DPRK in “small project” areas of energy sector assistance:
  - ◆ Assist with development of alternative sources of small-scale energy--small/mini-hydro, wind, solar thermal and photovoltaic
  - ◆ Implementation of Energy-efficiency Measures
  - ◆ Local manufacturing/joint ventures producing goods needed in DPRK **and** abroad (export earnings potential)
- Smaller-scale activities where colleagues work directly with North Koreans are most effective

# APPLICATION (WITH SURVEY DATA) FOR RURAL NEEDS ANALYSIS

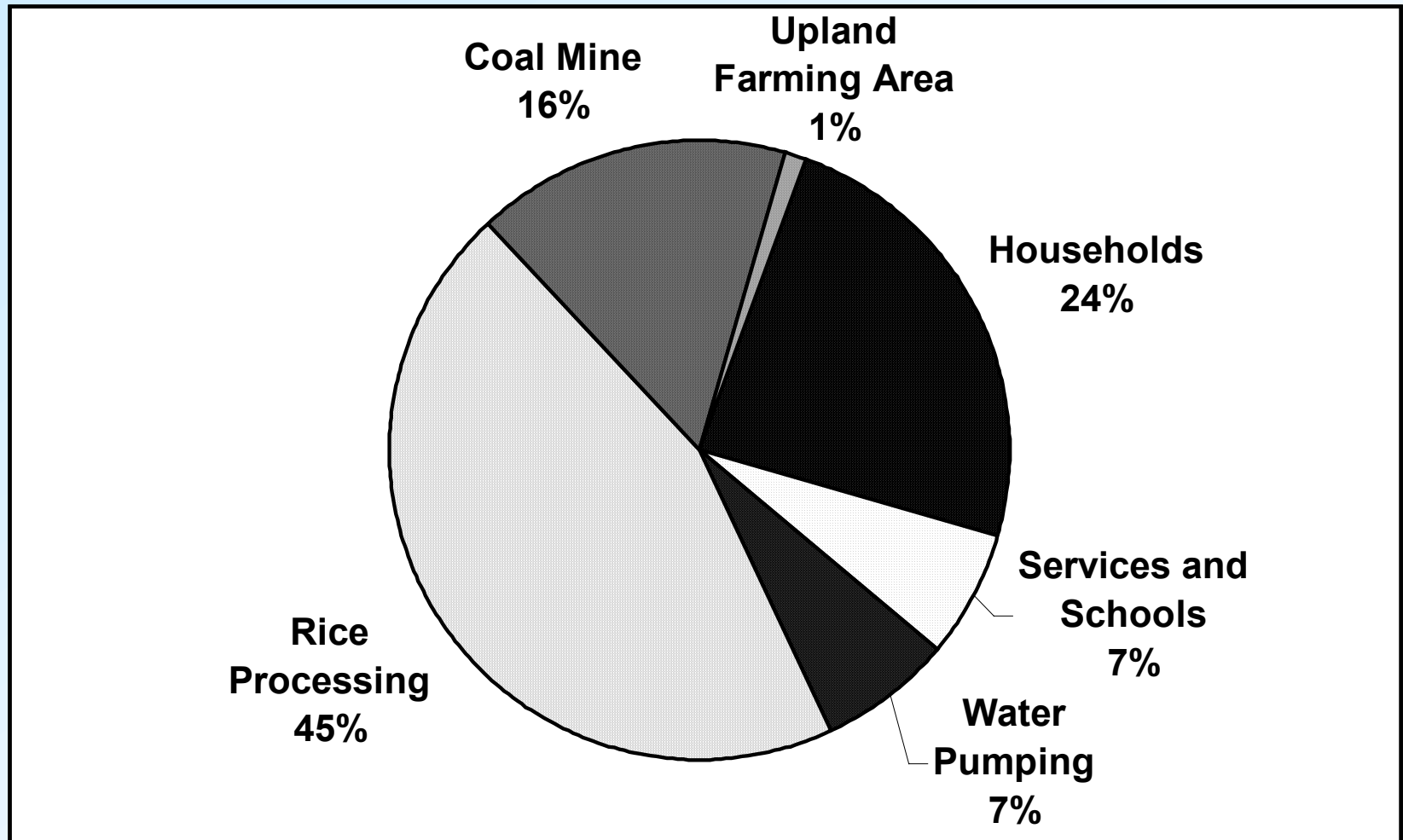
- Use of “Bottom-up” approach on national level..

ESTIMATED DPRK ELECTRICAL GENERATING CAPACITY



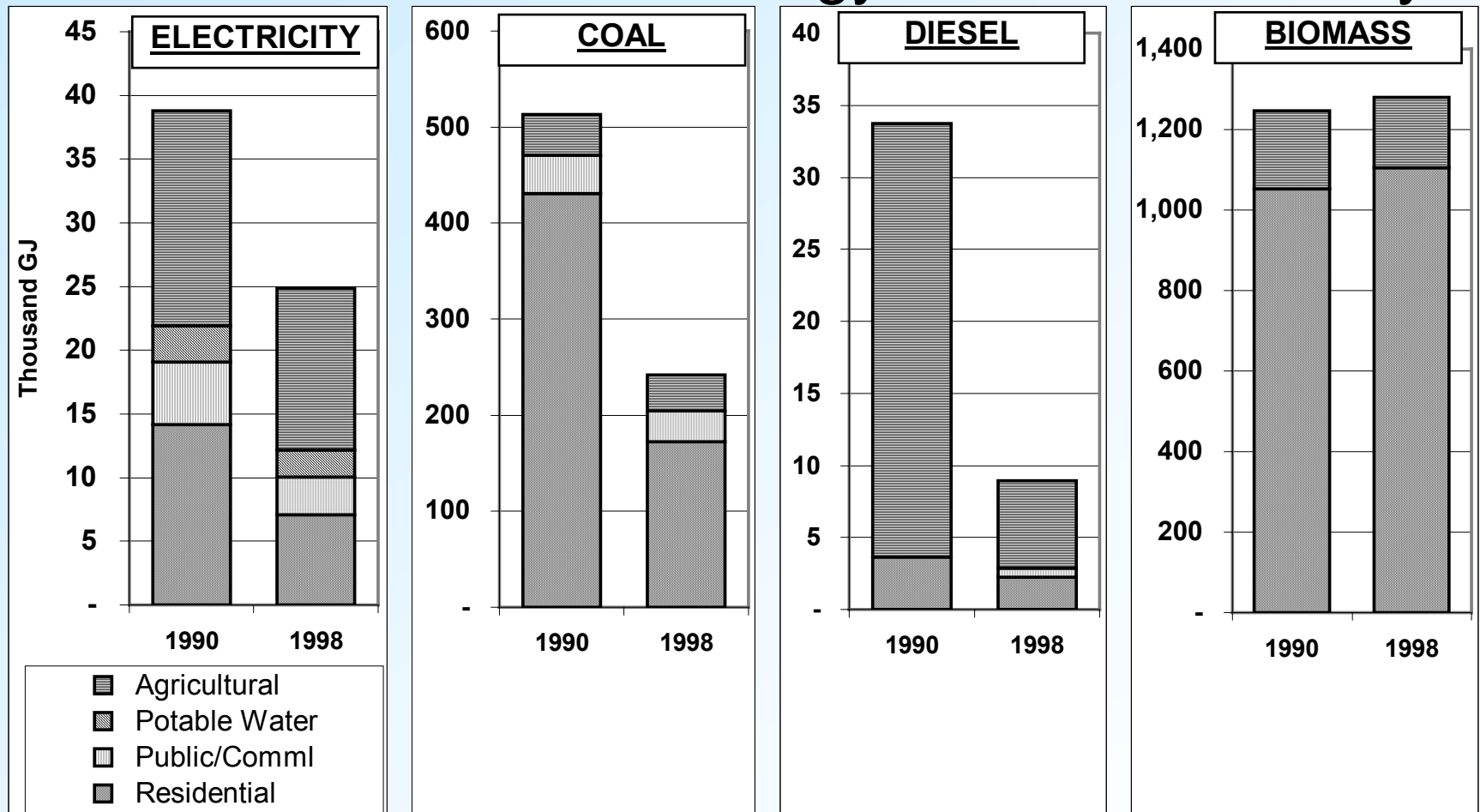
# APPLICATION (WITH SURVEY DATA) FOR RURAL NEEDS ANALYSIS

- Combined with Survey data..



# APPLICATION (WITH SURVEY DATA) FOR RURAL NEEDS ANALYSIS

□ Was used to evaluate energy needs for a county..



# APPLICATION (WITH SURVEY DATA) FOR RURAL NEEDS ANALYSIS

## □ And to semi-quantitatively estimate needs

- ◆ Assistance with designing, implementing mini/ micro hydro and wind power (significant local potential in county), including T&D improvements
- ◆ Assistance with energy efficiency improvements, particularly motors, piping, other infrastructure for pumping, agric. processing
- ◆ Supplies of fertilizer, tractor fuel, parts
- ◆ Assistance with refurbishing energy-using and electricity supply infrastructure in mines
- ◆ Assistance with supply of cooking fuels (LPG?), efficient residential lights and appliances