Extension of ANSWERv5 and GAMS-MARKAL code to permit Modeling of Lumpy Investments

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Modeling of Lumpy Investments

◆ **Lumpy Investment** ≡ _All-or-nothing Building of New Capacity_
  - e.g. construction of natural gas pipelines

◆ **INV(YEAR,TCH)** = **INV_BLOCK(TCH,YEAR)** * **INVINT(YEAR,TCH)**
  where **INVINT(YEAR,TCH)** = 0 or 1 or 2 or 3 ... _is an integer variable_
  - **INV_BLOCK(TCH,YEAR)** specifies size of the ‘lump’ for technology TCH
  - 3 (slightly) different lumpy investment facilities are provided

◆ **Mixed Integer Programming (MIP) Optimizer needed**
  - e.g. OSL or XPRESS or CPLEX
Modeling of Lumpy Investments

◆ Four new Data Parameters in ANSWER
  - INV_BLOCK(TCH,YEAR) specifies size of the ‘lump’ for technology TCH
  - 3 alternate TID indicators INV_INT(TCH), INV_BIN(TCH), INV_SOS(TCH) corresponding to 3 different lumpy investment facilities

◆ INV_INT lumpy investment facility
  - INV(YEAR,TCH) = INV_BLOCK(TCH,YEAR) * INVINT(YEAR,TCH), where INVINT(YEAR,TCH) = 0, 1, 2, ..., 10 is an integer variable

◆ INV_BIN lumpy investment facility
  - INV(YEAR,TCH) = INV_BLOCK(TCH,YEAR) * INVBIN(YEAR,TCH), where INVBIN(YEAR,TCH) = 0 or 1 is a binary variable

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◆ INV_SOS lumpy investment facility
  - same as INV_BIN, that is:
    INV(YEAR,TCH) = INV_BLOCK(TCH,YEAR) * INVBIN(YEAR,TCH), where INVBIN(YEAR,TCH) = 0 or 1 is a binary variable
    - but with investment restricted to occur in at most one period, that is:
      SUM(YEAR, INVBIN(YEAR,TCH)) ≤ 1

◆ MultiUtopDemoLumpy database demonstrates each facility
  - non-base scenario AINV_INT demonstrates INV_INT facility
  - non-base scenario BINV_BIN demonstrates INV_BIN facility
  - non-base scenario CINV-SOS demonstrates INV_SOS facility
INV_SOS Modeling of Lumpy Investments

Modeling of Lumpy Investments – Run Model Considerations

◆ **MIP optimizer (OSL/XPRESS/CPLEX) needed**

◆ **Appropriate settings in options file in GAMS Work folder**
  - e.g. if using OSL, and options file OSLOPT has OPTCR 0.01, MIP optimization will end when within 1% of best possible solution

◆ **Updated Template.GEN (RegionTemplate.GEN/RPT/SLV) files in GAMS Source folder containing the line:**

  \$SET LUMPYINV '<LumpyInvestment>';

◆ **Check new “Lumpy Investment” checkbox on Run Model form**
  - ANSWER remembers this setting the next time this Case is run
Modeling of Lumpy Investments – Run Model Considerations

- Check new “Lumpy Investment” checkbox on Run Model form

Modeling of Lumpy Investments – Comparison of Run Model Results
Modeling of Lumpy Investments – Additional Considerations

◆ Available for both single-region and multi-region
  - not available in conjunction with Stochastics, Macro, Micro, Env_Damage or SAGE
◆ Confine use to intrinsically lumpy investments, since computer run times may become very large when MIP has a large number of integer/binary variables
◆ Additional details in “Modeling Lumpy Investments in ANSWER-MARKAL.doc”
◆ Approach taken similar to that previously implemented in an OMNI version of MARKAL by Dr Ken Stocks of Intelligent Energy Systems, Sydney