An Integrated Emissions Calculation and Data Management Tool for Nonroad Sources in Texas

16th Annual International Emissions Inventory Conference

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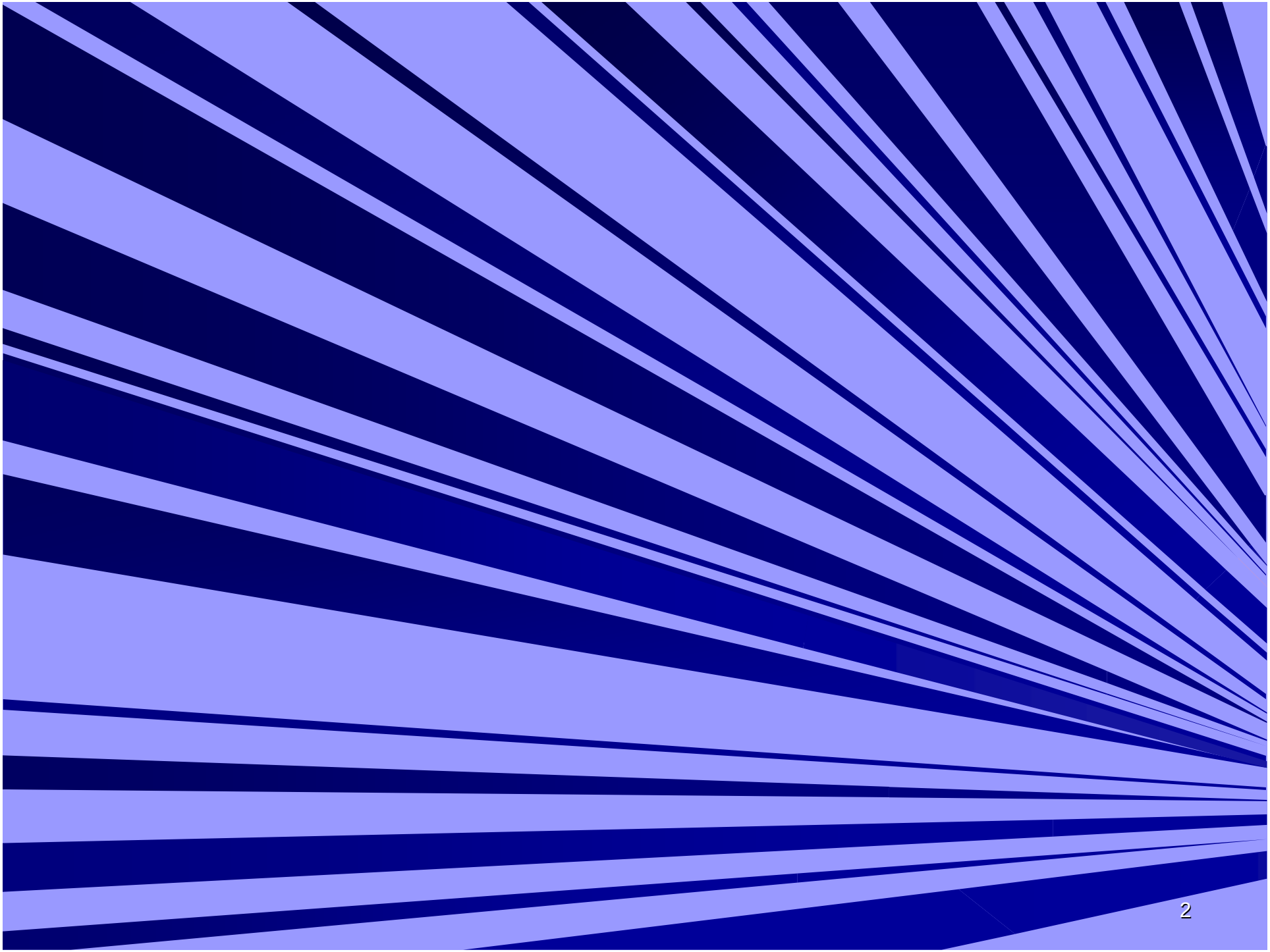

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Stephen P. Anderson, P.E.

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Modeling Nonroad Emissions in Texas

- Many bottom-up surveys
  - Diesel Construction
    - 24 sub-sectors
  - Lawn and Garden
  - LPG Forklifts, etc.
- Region- and Season-specific inputs
  - Temperature / Fuel Specifications
- Highly-detailed post-processing adjustments
  - Ammonia
  - Soil and Ground Cover
  - Altitude
  - Temperature and Humidity NOx Adjustments
  - Emission Controls (e.g. TxLED)

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Modeling Nonroad Emissions in Texas (cont.)

- Unique profiles at the sector/sub-sector level:
  - Population
  - Activity
  - Growth
  - Temporal Allocation
- Each profile can vary by:
  - County/Region
  - SCC

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A Sub-sector Example:
24 Construction Sub-sectors for Diesel Construction

- Agricultural Activities
- Boring and Drilling Equipment
- Brick and Stone Operations
- City and County Road Construction
- Commercial Construction
- Concrete Operations
- County-Owned Construction Equipment
- Cranes
- Heavy Highway Construction
- Landfill Operations
- Landscaping Activities
- Manufacturing Operations
- Municipal-Owned Construction Equipment
- Transportation/Sales/Services
- Residential Construction
- Rough Terrain Forklifts
- Scrap/Recycling Operations
- Skid Steer Loaders
- Special Trades Construction
- Trenchers
- TxDOT Construction Equipment
- Utility Construction
- Mining and Quarry Operation
- Off-Road Tractors, Miscellaneous Equipment, and all Equipment under 25 horsepower

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Limitations of NONROAD

- No county-specific activity, growth
- DCE not broken out into sub-sectors
- Need to run counties and construction sub-sectors individually, manually post-processing adjustments
  - Labor-intensive
  - Problems with consistency across users and transparency of data

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Nonroad Analysis and Emissions Estimation System (NAEES) - Overview

- Major Components
  - GUI (VB.NET)
  - DB/file processor (MySQL 5.0)
  - NONROAD 2005
  - Modified ACCESS Reporting Utility (Access 2002)

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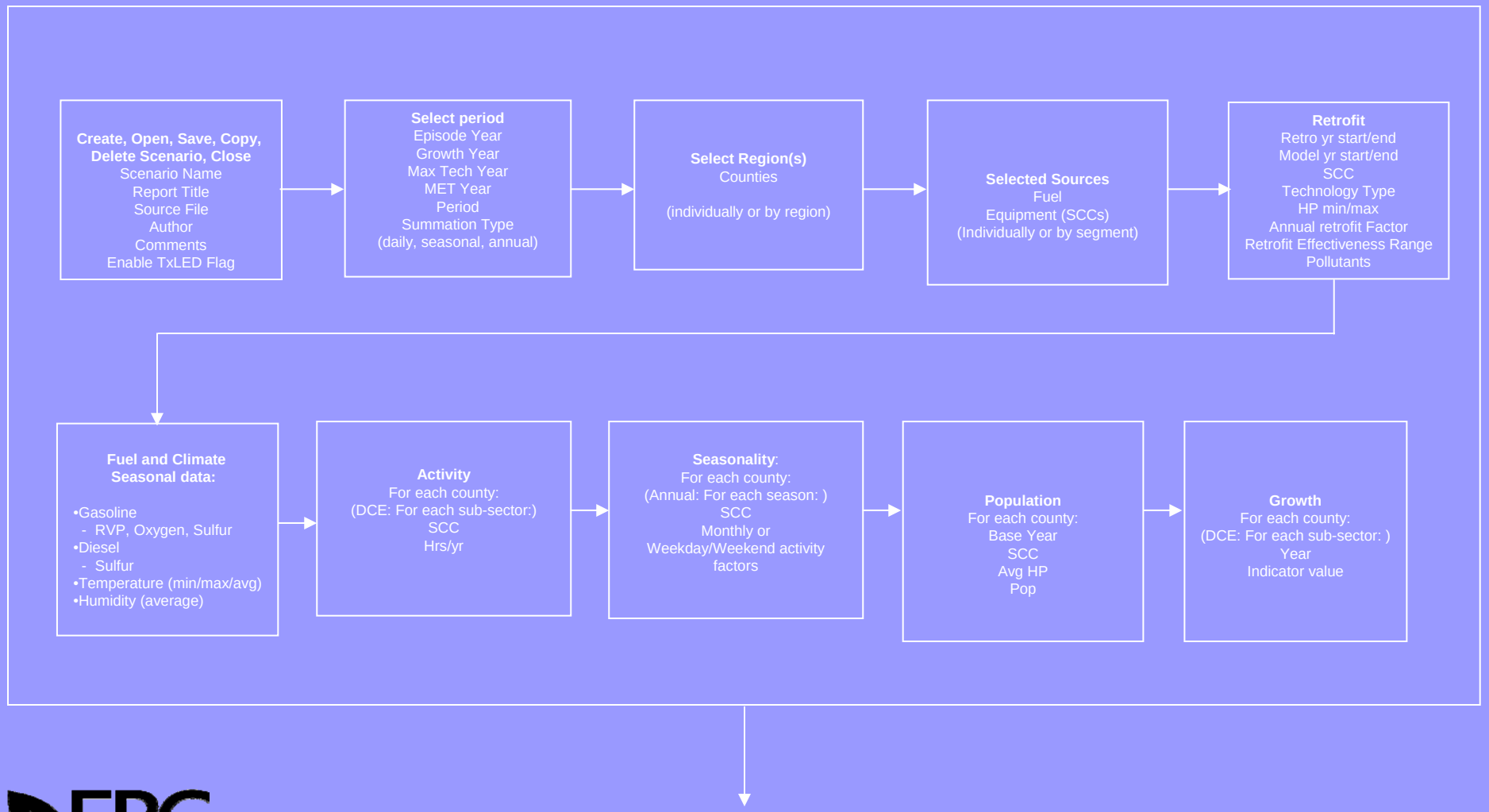
NAEES Data Flow Diagram GUI



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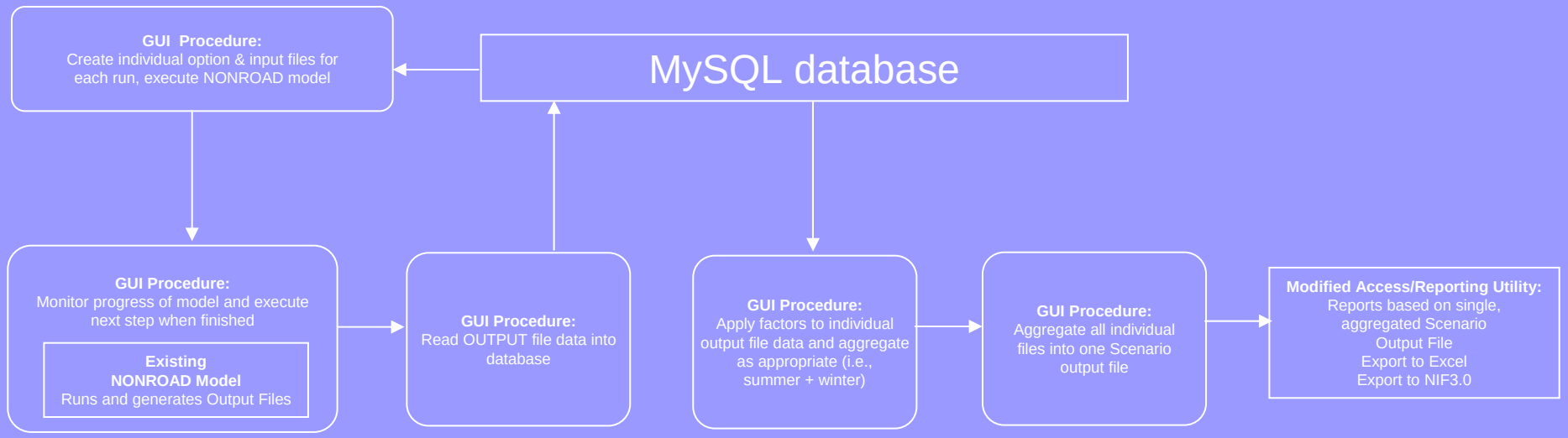
NAEES Data Flow Diagram

Post-Processing and Reporting



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Graphical User Interface

- Select run parameters
- Review/edit supporting data for a given scenario
- Interacts with a MySQL database
  - Generates Option (.opt) Files (including temp, fuel, etc.)
  - Creates Scenario-specific data files
- Launches NONROAD for each run within a scenario.
- Calls the NAEES post-processing driver
  - Imports NONROAD output files into the database
  - Performs post-processing adjustments
  - Performs aggregation
  - Exports a single aggregated output file for each scenario

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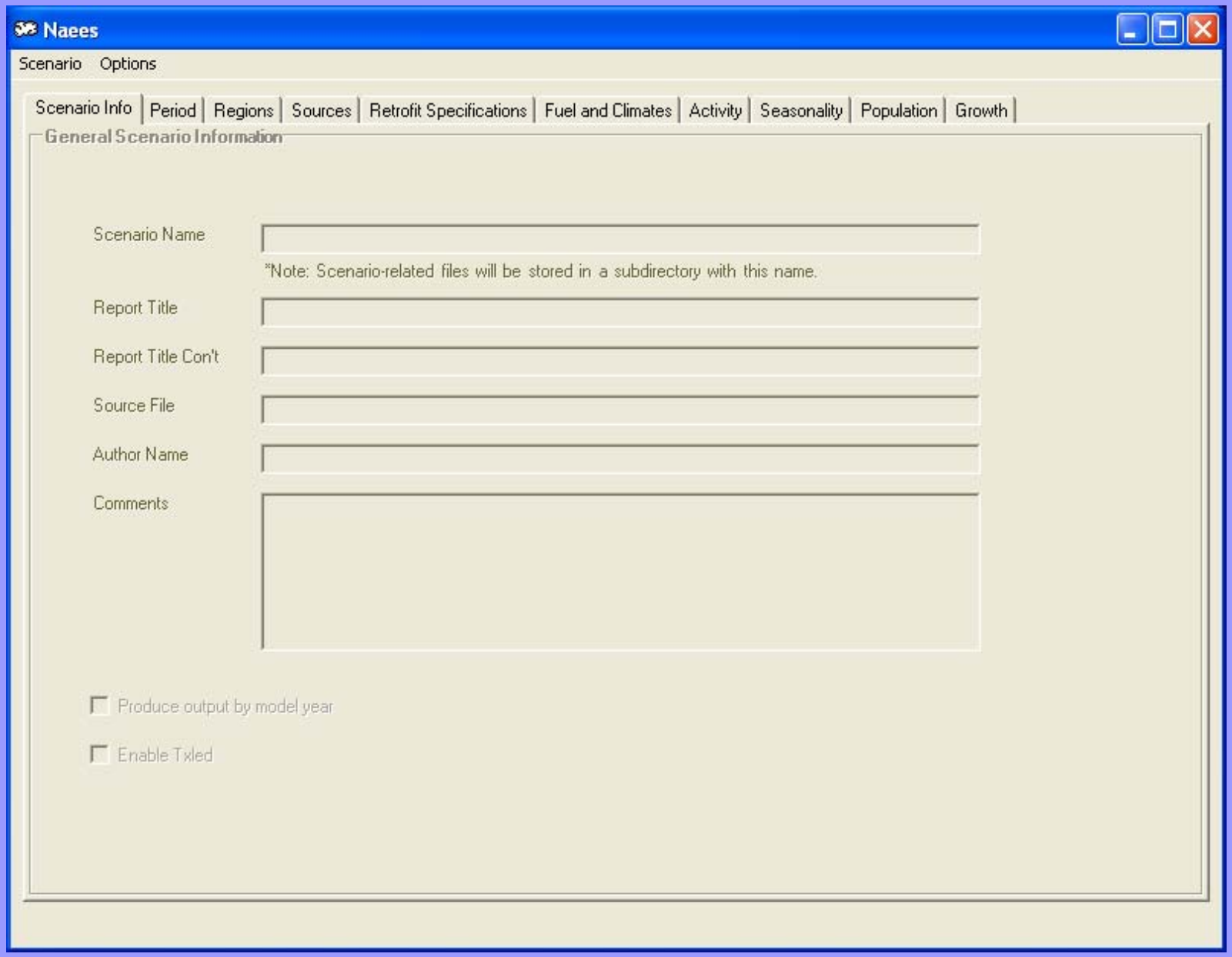
Naees
Scenario
Options
Scenario Info
Period
Regions
Sources
Retrofit Specifications
Fuel and Climates
Activity
Seasonality
Population
Growth
General Scenario Information
Scenario Name
*Note: Scenario-related files will be stored in a subdirectory with this name.
Report Title
Report Title Con't
Source File
Author Name
Comments
Produce output by model year
Enable Txled

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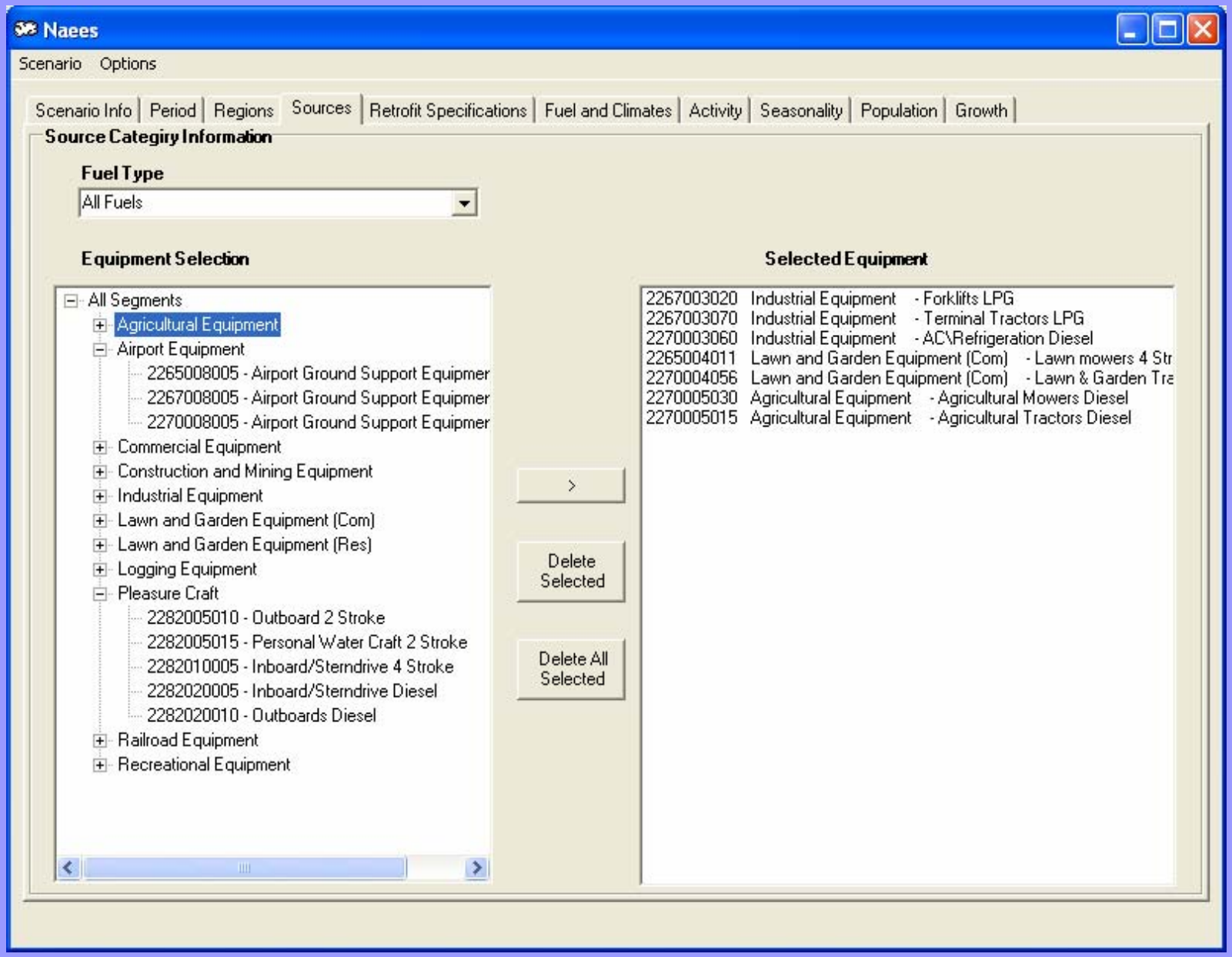
Naees
Scenario
Options
Scenario Info
Period
Regions
Sources
Retrofit Specifications
Fuel and Climates
Activity
Seasonality
Population
Growth
Source Categiry Information
Fuel Type
All Fuels
Equipment Selection
Selected Equipment
All Segments
Agricultural Equipment
Airport Equipment
2265008005 - Airport Ground Support Equipmer
2267008005 - Airport Ground Support Equipmer
2270008005 - Airport Ground Support Equipmer
Commercial Equipment
Construction and Mining Equipment
Industrial Equipment
Lawn and Garden Equipment (Com)
Lawn and Garden Equipment (Res)
Logging Equipment
Pleasure Craft
2282005010 - Outboard 2 Stroke
2282005015 - Personal Water Craft 2 Stroke
2282010005 - Inboard/Sterndrive 4 Stroke
2282020005 - Inboard/Sterndrive Diesel
2282020010 - Outboards Diesel
Railroad Equipment
Recreational Equipment
>
Delete Selected
Delete All Selected
2267003020 Industrial Equipment - Forklifts LPG
2267003070 Industrial Equipment - Terminal Tractors LPG
2270003060 Industrial Equipment - AC\Refrigeration Diesel
2265004011 Lawn and Garden Equipment (Com) - Lawn mowers 4 Str
2270004056 Lawn and Garden Equipment (Com) - Lawn & Garden Tra
2270005030 Agricultural Equipment - Agricultural Mowers Diesel
2270005015 Agricultural Equipment - Agricultural Tractors Diesel

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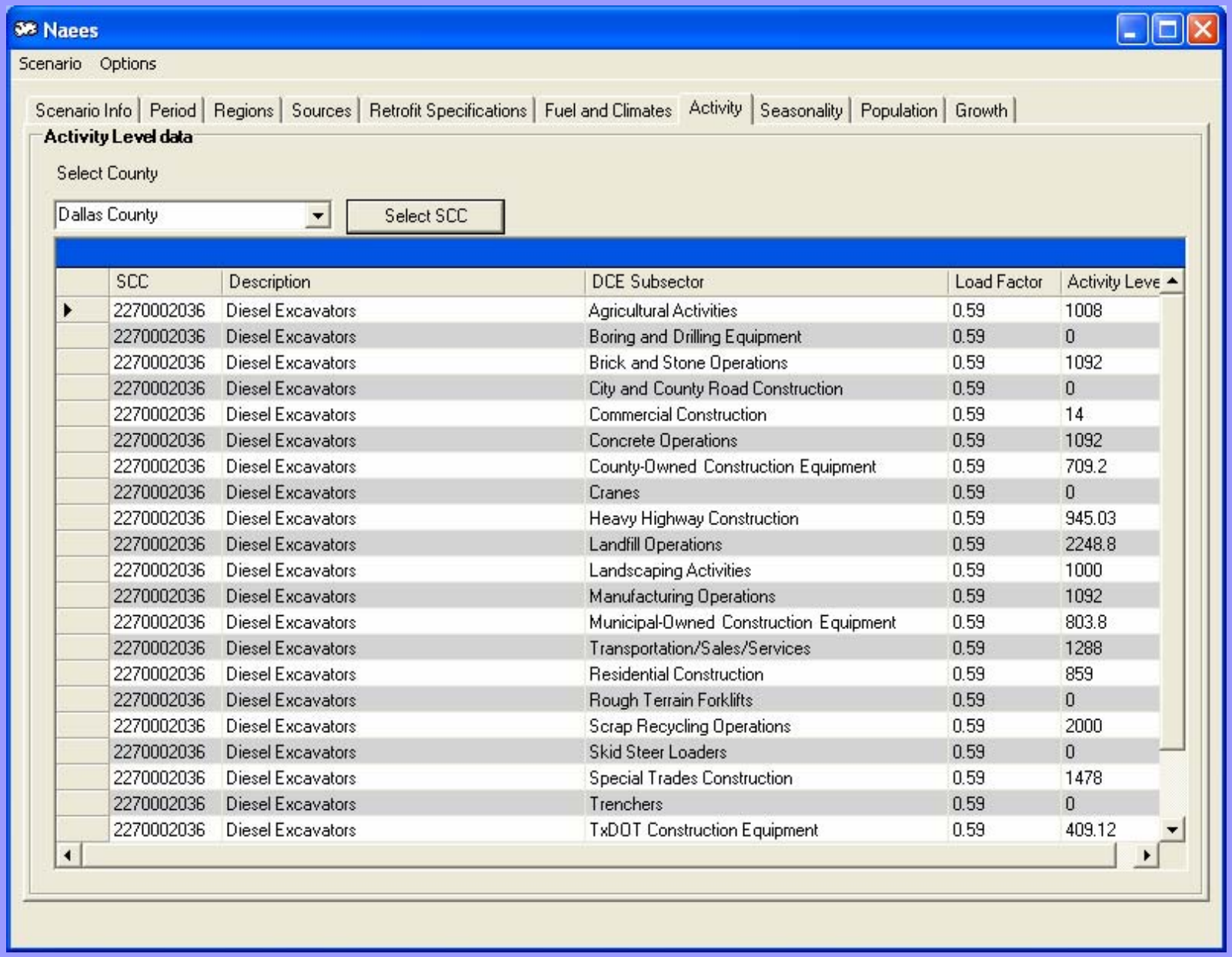

SCC	Description	DCE Subsector	Load Factor	Activity Leve
2270002036	Diesel Excavators	Agricultural Activities	0.59	1008
2270002036	Diesel Excavators	Boring and Drilling Equipment	0.59	0
2270002036	Diesel Excavators	Brick and Stone Operations	0.59	1092
2270002036	Diesel Excavators	City and County Road Construction	0.59	0
2270002036	Diesel Excavators	Commercial Construction	0.59	14
2270002036	Diesel Excavators	Concrete Operations	0.59	1092
2270002036	Diesel Excavators	County-Owned Construction Equipment	0.59	709.2
2270002036	Diesel Excavators	Cranes	0.59	0
2270002036	Diesel Excavators	Heavy Highway Construction	0.59	945.03
2270002036	Diesel Excavators	Landfill Operations	0.59	2248.8
2270002036	Diesel Excavators	Landscaping Activities	0.59	1000
2270002036	Diesel Excavators	Manufacturing Operations	0.59	1092
2270002036	Diesel Excavators	Municipal-Owned Construction Equipment	0.59	803.8
2270002036	Diesel Excavators	Transportation/Sales/Services	0.59	1288
2270002036	Diesel Excavators	Residential Construction	0.59	859
2270002036	Diesel Excavators	Rough Terrain Forklifts	0.59	0
2270002036	Diesel Excavators	Scrap Recycling Operations	0.59	2000
2270002036	Diesel Excavators	Skid Steer Loaders	0.59	0
2270002036	Diesel Excavators	Special Trades Construction	0.59	1478
2270002036	Diesel Excavators	Trenchers	0.59	0
2270002036	Diesel Excavators	TxDOT Construction Equipment	0.59	409.12

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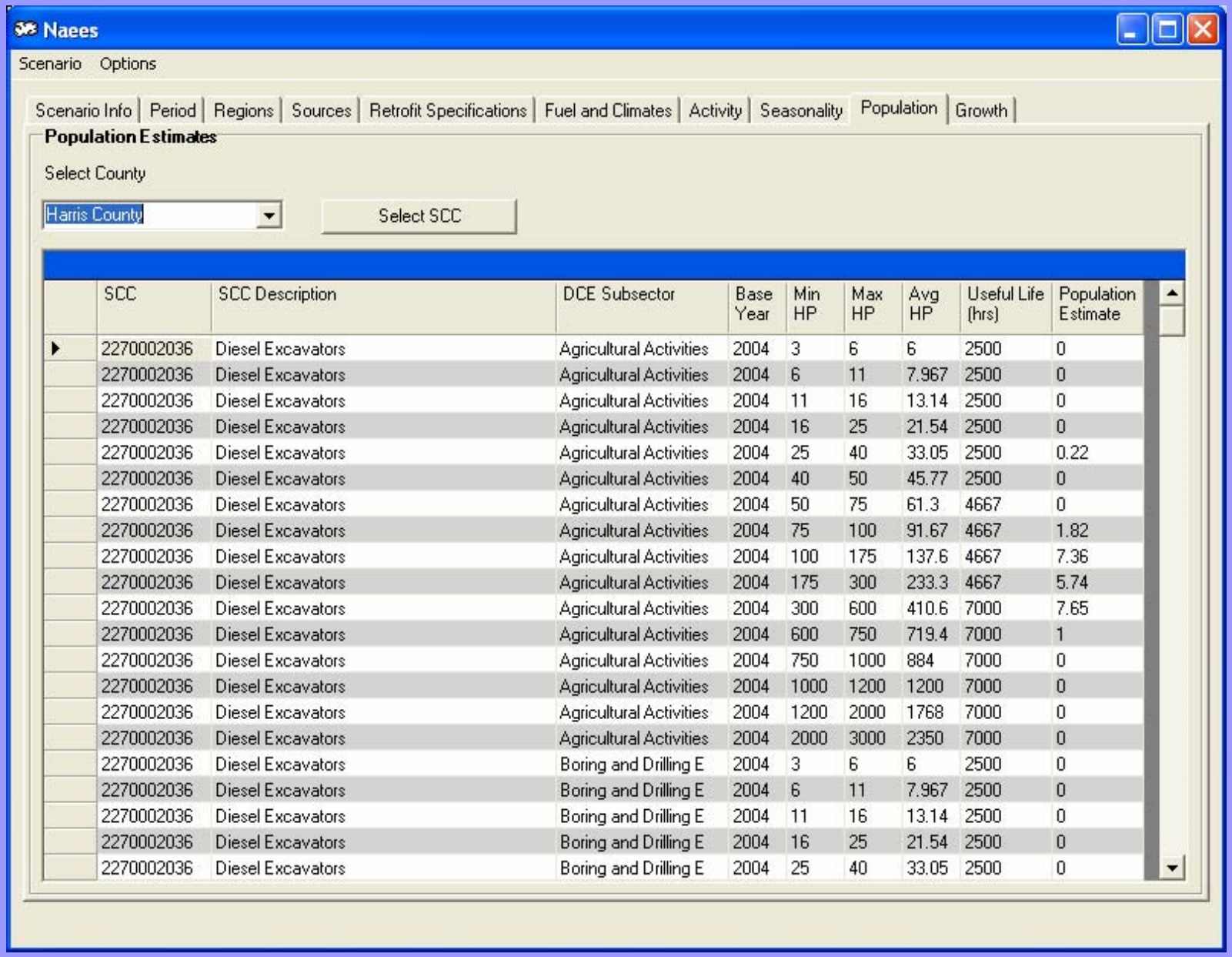

SCC	SCC Description	DCE Subsector	Base Year	Min HP	Max HP	Avg HP	Useful Life (hrs)	Population Estimate
2270002036	Diesel Excavators	Agricultural Activities	2004	3	6	6	2500	0
2270002036	Diesel Excavators	Agricultural Activities	2004	6	11	7.967	2500	0
2270002036	Diesel Excavators	Agricultural Activities	2004	11	16	13.14	2500	0
2270002036	Diesel Excavators	Agricultural Activities	2004	16	25	21.54	2500	0
2270002036	Diesel Excavators	Agricultural Activities	2004	25	40	33.05	2500	0.22
2270002036	Diesel Excavators	Agricultural Activities	2004	40	50	45.77	2500	0
2270002036	Diesel Excavators	Agricultural Activities	2004	50	75	61.3	4667	0
2270002036	Diesel Excavators	Agricultural Activities	2004	75	100	91.67	4667	1.82
2270002036	Diesel Excavators	Agricultural Activities	2004	100	175	137.6	4667	7.36
2270002036	Diesel Excavators	Agricultural Activities	2004	175	300	233.3	4667	5.74
2270002036	Diesel Excavators	Agricultural Activities	2004	300	600	410.6	7000	7.65
2270002036	Diesel Excavators	Agricultural Activities	2004	600	750	719.4	7000	1
2270002036	Diesel Excavators	Agricultural Activities	2004	750	1000	884	7000	0
2270002036	Diesel Excavators	Agricultural Activities	2004	1000	1200	1200	7000	0
2270002036	Diesel Excavators	Agricultural Activities	2004	1200	2000	1768	7000	0
2270002036	Diesel Excavators	Agricultural Activities	2004	2000	3000	2350	7000	0
2270002036	Diesel Excavators	Boring and Drilling E	2004	3	6	6	2500	0
2270002036	Diesel Excavators	Boring and Drilling E	2004	6	11	7.967	2500	0
2270002036	Diesel Excavators	Boring and Drilling E	2004	11	16	13.14	2500	0
2270002036	Diesel Excavators	Boring and Drilling E	2004	16	25	21.54	2500	0
2270002036	Diesel Excavators	Boring and Drilling E	2004	25	40	33.05	2500	0

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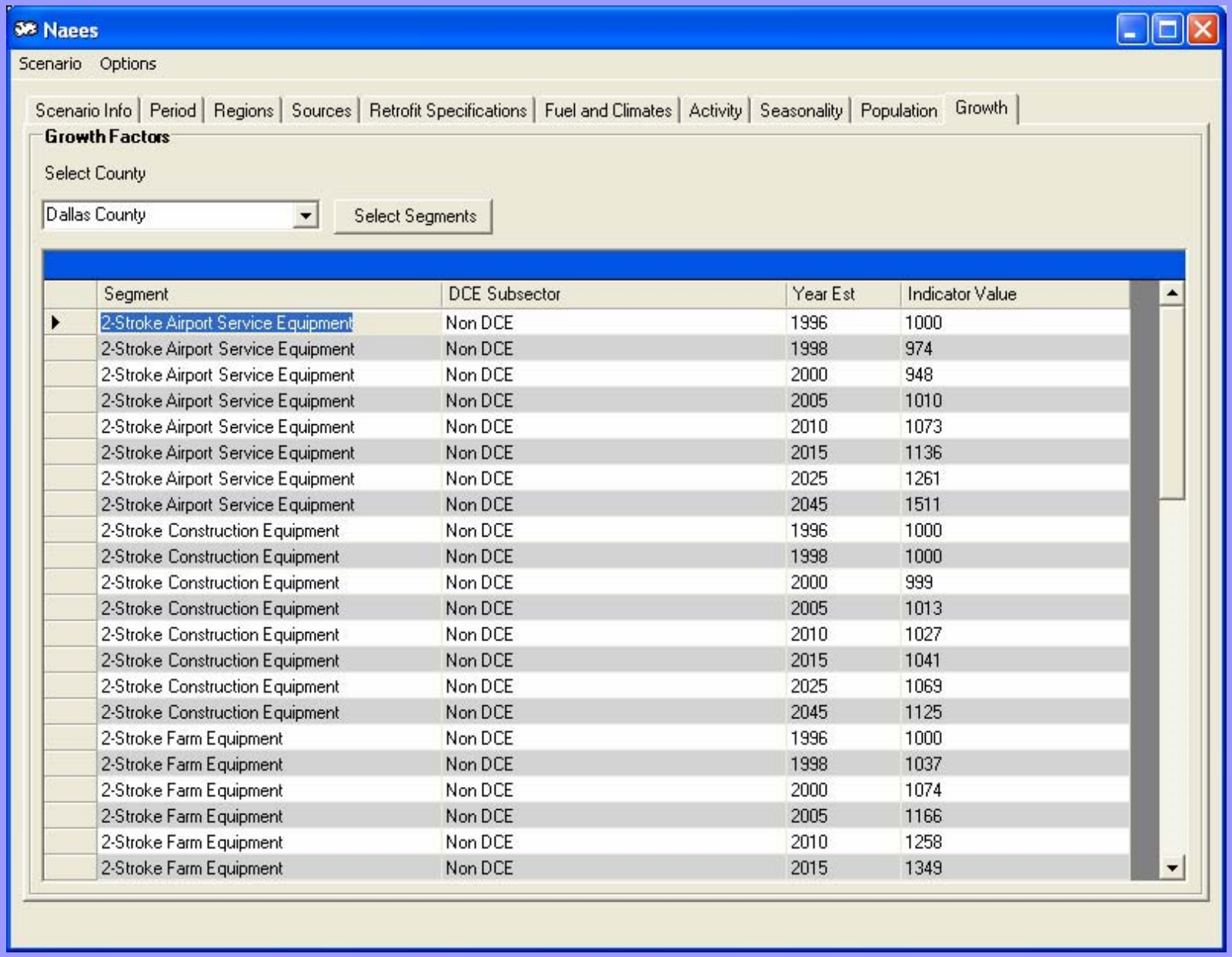
Naees
Scenario
Options
Scenario Info
Period
Regions
Sources
Retrofit Specifications
Fuel and Climates
Activity
Seasonality
Population
Growth
Growth Factors
Select County
Dallas County
Select Segments
Segment
DCE Subsector
Year Est
Indicator Value
2-Stroke Airport Service Equipment Non DCE 1996 1000
2-Stroke Airport Service Equipment Non DCE 1998 974
2-Stroke Airport Service Equipment Non DCE 2000 948
2-Stroke Airport Service Equipment Non DCE 2005 1010
2-Stroke Airport Service Equipment Non DCE 2010 1073
2-Stroke Airport Service Equipment Non DCE 2015 1136
2-Stroke Airport Service Equipment Non DCE 2025 1261
2-Stroke Airport Service Equipment Non DCE 2045 1511
2-Stroke Construction Equipment Non DCE 1996 1000
2-Stroke Construction Equipment Non DCE 1998 1000
2-Stroke Construction Equipment Non DCE 2000 999
2-Stroke Construction Equipment Non DCE 2005 1013
2-Stroke Construction Equipment Non DCE 2010 1027
2-Stroke Construction Equipment Non DCE 2015 1041
2-Stroke Construction Equipment Non DCE 2025 1069
2-Stroke Construction Equipment Non DCE 2045 1125
2-Stroke Farm Equipment Non DCE 1996 1000
2-Stroke Farm Equipment Non DCE 1998 1037
2-Stroke Farm Equipment Non DCE 2000 1074
2-Stroke Farm Equipment Non DCE 2005 1166
2-Stroke Farm Equipment Non DCE 2010 1258
2-Stroke Farm Equipment Non DCE 2015 1349

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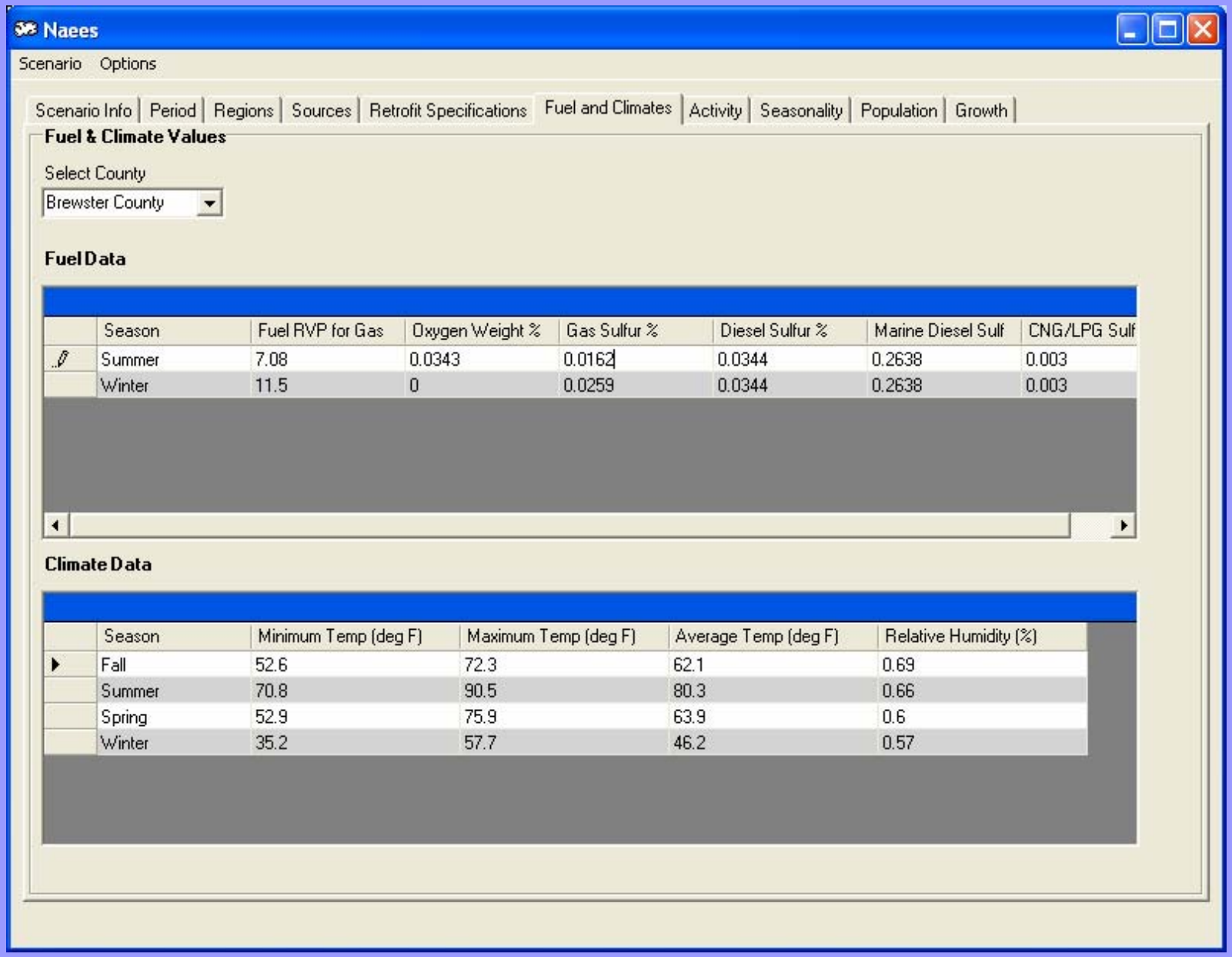
Naees
Scenario
Options
Scenario Info
Period
Regions
Sources
Retrofit Specifications
Fuel and Climates
Activity
Seasonality
Population
Growth
Fuel & Climate Values
Select County
Brewster County
Fuel Data
Season
Fuel RVP for Gas
Oxygen Weight %
Gas Sulfur %
Diesel Sulfur %
Marine Diesel Sulf
CNG/LPG Sulf
Summer
7.08
0.0343
0.0162
0.0344
0.2638
0.003
Winter
11.5
0
0.0259
0.0344
0.2638
0.003
Climate Data
Season
Minimum Temp (deg F)
Maximum Temp (deg F)
Average Temp (deg F)
Relative Humidity (%)
Fall
52.6
72.3
62.1
0.69
Summer
70.8
90.5
80.3
0.66
Spring
52.9
75.9
63.9
0.6
Winter
35.2
57.7
46.2
0.57

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Database

- MySQL
  - Freeware
  - Version 5.0
- Scenario/File Management
- Post-processing Adjustments
  - County and year-specific temperature and humidity adjustments for NOx emissions
  - Adjustments for Texas Low Emission Diesel (TxLED) impacts
  - Altitude, correcting for engine efficiency
  - Soil compaction, reflecting ease or difficulty digging
  - Ground cover, reflecting ease or difficulty in land-clearing

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Scenario/File Management

User Selections			Number of Runs	How the Number of Runs are Calculated
Period	Region	Equipment		
Ozone Season Day (OSD) or One Season	One County	Non-Diesel Construction Equipment (Non-DCE)	1	One for the selected county [1 segment * 1 county]
Annual	One County	Non-DCE	4	One for each County and Season [1 segment * 1 county * 4 seasons]
OSD or One Season	Three Counties	Non-DCE	3	One for each selected county [1 segment * 3 counties]
OSD or One Season	One County	DCE	24	One for each of the 24 DCE sectors for the selected county [24 segments * 1 county]
Annual	One County	DCE	96	One for each of the 4 seasons and each of the 24 DCE sectors for the selected county [24 segments * 1 county * 4 seasons]
OSD or One Season	Three Counties	DCE	72	One for each of the 24 DCE sectors for each of the selected counties [24 segments * 3 counties]
Annual	Statewide	All	25,400	One for each of the DCE sectors and one for Non-DCE Equipment for each county for each season [(24 + 1) SCC segments * 254 counties * 4 seasons]

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Reporting

- Modified NONROAD ACCESS Reporting Utility
  - Opened through Scenario drop-down within NAEES
  - Almost identical to the NONROAD version
  - Two additional standard query reports
    - Emission Totals by County and SCC
    - Emission Totals by Horsepower and SCC
  - Ammonia emissions included in NIF3.0 and Excel export files

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Conclusions

- Provides a central repository for different equipment population and activity profiles across the state
- Reduces the effort associated with NONROAD file preparation, model execution, and output file aggregation
  - GUI allows users to directly view and update supporting data
  - Database back-end creates Option files allowing dynamic population of key fields and enforces certain data constraints
- Promotes internal consistency and reproducibility across users
  - The Scenario Tab allows users to clearly document iterative modeling changes for sensitivity analyses and inventory updates
  - Resulting “data transparency” is valuable for inventory QA, as well as emission control assessments

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Conclusions (cont.)

- Improves precision, functionality, efficiency, documentation, and data integrity of the emissions modeling process
- NAEES provides a foundation for highly resolved inventory development within equipment use categories, and can easily be expanded to other sectors (e.g., agricultural/industrial equipment)

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