U.S. Department of Energy
Energy Efficiency and Renewable Energy

biomass program

Biomass as a Feedstock for a Bioenergy and Bioproducts Industry:

The Technical Feasibility of a Billion-Ton Annual Supply

DOE/USDA Biomass Feedstock Gate Review Meeting
March 14-16, 2005

Oak Ridge National Laboratory
USDA Agricultural Research Service
USDA Forest Service

What Was the Purpose of the Study?

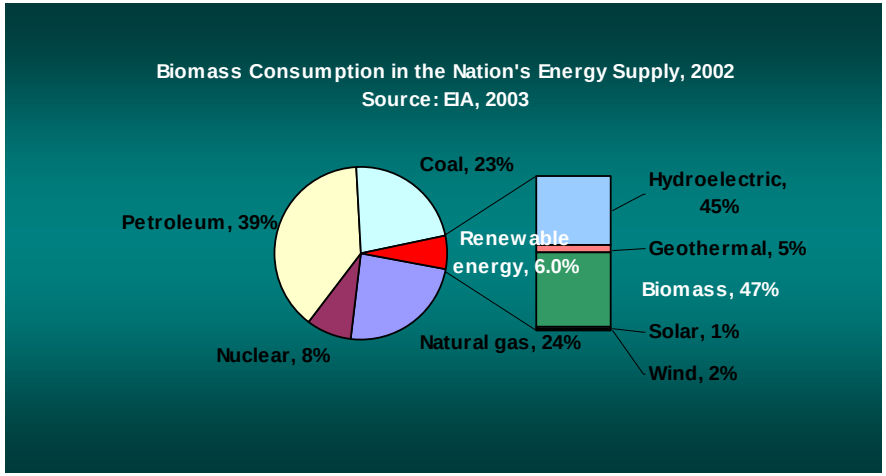
- To determine whether the land resources of the U.S. are capable of producing a sustainable supply of biomass sufficient to displace 30% of the country's present petroleum consumption – approximately equivalent to one billion dry tons.

- Goal was set by a joint advisory committee to the DOE and USDA as a vision for making a major contribution to U.S. energy needs
  - 5% of the nation's power
  - 20% of the nation's transportation fuels
  - 25% of the nation's chemicals & materials from biobased products.

What Is Current Biomass Consumption?

Biomass accounts for approximately:

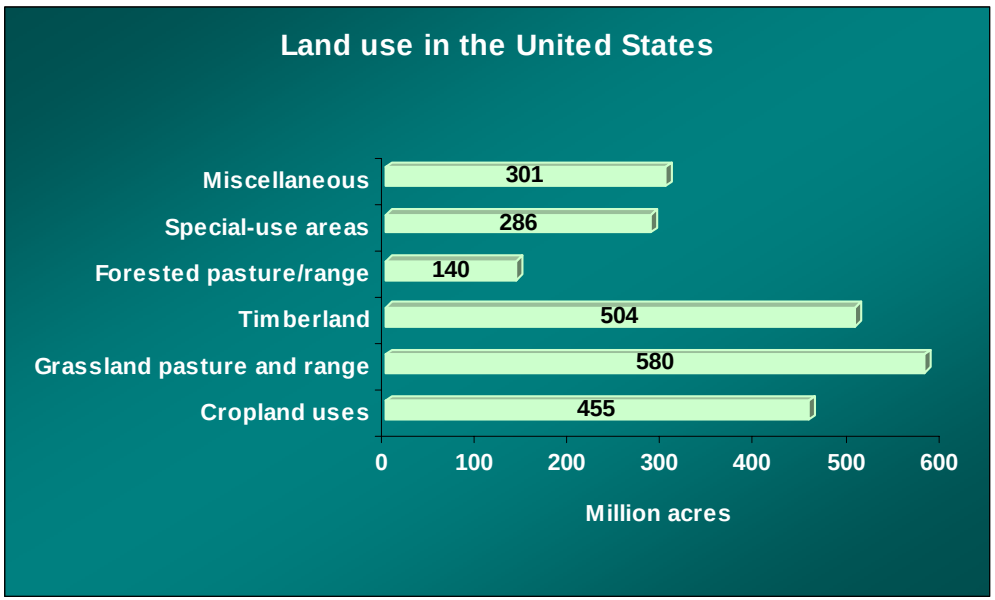
- 13% of renewably generated electricity,
- nearly all (97%) of industrial renewable energy use,
- nearly all renewable energy use in residential and commercial sectors (84% and 90%, respectively), and
- somewhat more than 2.5% of transportation fuel use.



Biomass Resource	Million dry tons/yr
Forest products industry	
Wood residues	44
Pulping liquors	52
Urban wood & process wastes	35
Fuelwood (residential/commercial)	24
Electric utilities	10
Biofuels	18
Bioproducts	6
Total	190

The Biomass Feedstock Resource Base

- **About one-half of the land in the contiguous U.S.**
- Forestland resources -- 504 million acres of timberland, 91 million acres of other forestland
- Agricultural resources -- 342 million acres cropland, 39 million acres idle cropland, 68 million acres cropland pasture



Forest resources

- **Logging residues**
- **Forest thinnings (fuel treatments)**
- Fuelwood
- Primary wood processing mill wastes
- Secondary wood processing mill wastes
- Pulping liquors (black liquor)
- Urban wood wastes

Agricultural resources

- **Crop residues**
- Grains
- **Perennial grasses**
- **Perennial woody crops**
- Animal manures
- Food/feed processing wastes
- MSW and landfill gases

What analysis approach was taken?

- Forest resource estimates based on analysis of existing resources, uses, and trends in the demand for forest products
  - Managed less intensively than croplands or not suited for intensive management
  - Expected to provide multiple-use benefits (e.g., wildlife habitat, recreation, and ecological and environmental services)

- Agricultural resource estimates based on scenarios extrapolated from current food/feed trends and R&D
  - Active cropland managed intensively on year-to-year basis
  - Includes perennial crops, such as grasses and woody crops

Forest resource analysis

Forest resource analysis utilizes USDA/Forest Service databases and expert opinion

- Forest Inventory and Analysis database
- Timber Product Output database
- Fuel Treatment Evaluator (an assessment tool used to identify and evaluate forest stands with accumulated biomass – Healthy Forest Restoration Act)
- Resources Planning Act analyses (periodic timber assessment with projections to 2050)
- Forest Products Laboratory data

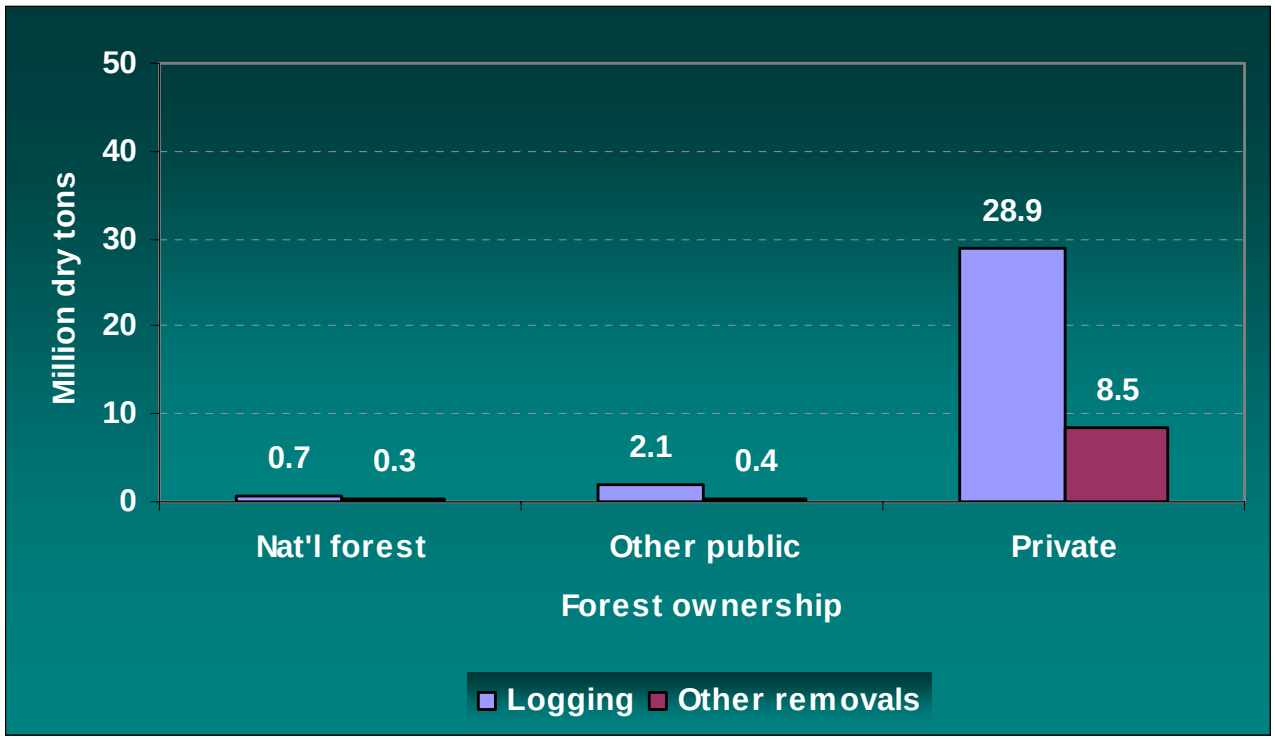
Forest Resource Analysis

Residues from logging, cultural operations & clearing of timberlands

- 70 million dry tons of logging and other removal residues are generated annually
- Current availability is about 42 million dry tons/year
- Collected concurrently with logging/cutting operations
- 50% to 65%of biomass is recoverable (public vs private lands)
- All recovered material for biomass uses
- Estimated to increase to 64 million dry tons/year (mid-20th century)

Forest Resources

Residues from commercial logging activities, silvicultural operations & clearing of timberlands



Forest Resource Analysis

Residues generated from fuel treatment operations on timberland and other forestland

- Timberlands
  - Fuel Treatment Evaluator used to identify biomass requiring removal
  - Recovery of 85% of the identified biomass
  - Accessibility – 60% for public lands and 80% for private lands
  - Biomass fraction – 30% (70% conventional forest products)
  - Collection cycle – 30 years
- Other forestlands
  - Forest Inventory Analysis database used to identify biomass (50% removal)
  - Recovery of 85% of the identified biomass
  - Accessibility – 60% for public lands and 80% for private lands
  - Biomass fraction – 90%
  - Collection cycle – 30 years

Forest Resource Analysis

Other forest resources included in analysis

- Fuelwood (residential/commercial space heating applications, electric power)
- Forest products industry (primary and secondary mill residues, pulping liquors)
- Urban wood wastes
- Forest growth and increase in demand for forest products

Fuelwood

- Wood harvested directly from forestlands
- Residential and commercial sectors for space heating (24.4 million dry tons)
- Electric power sector (10.1 million dry tons)
- EIA data consistent with Forest Service Timber Product Output data

Forest Resource Analysis

Forest products industry processing residues

- Primary mill residues (bark and coarse & fine residues): 92 million dry tons generated – 43% used for on-site energy, 41% used for fiber, 14% other products (e.g., mulch), and 2% unused
- Secondary wood residues (shavings, sawdust, cut-offs, etc.): 16 million dry tons generated, 6 million dry tons available
- Pulp and paper mills (black liquor): 52 million dry tons

Urban Wood Wastes

- Wood (finished wood products) and yard & tree trimmings from MSW
  - Landfill survey data, composition sampling, population driven
  - Material destined for MSW landfills
- Construction, remodeling and demolition waste
  - Affected by economic activity (e.g., housing starts)
  - Material destined for C&D landfills
- Contamination/commingling with non-wood products is problematic

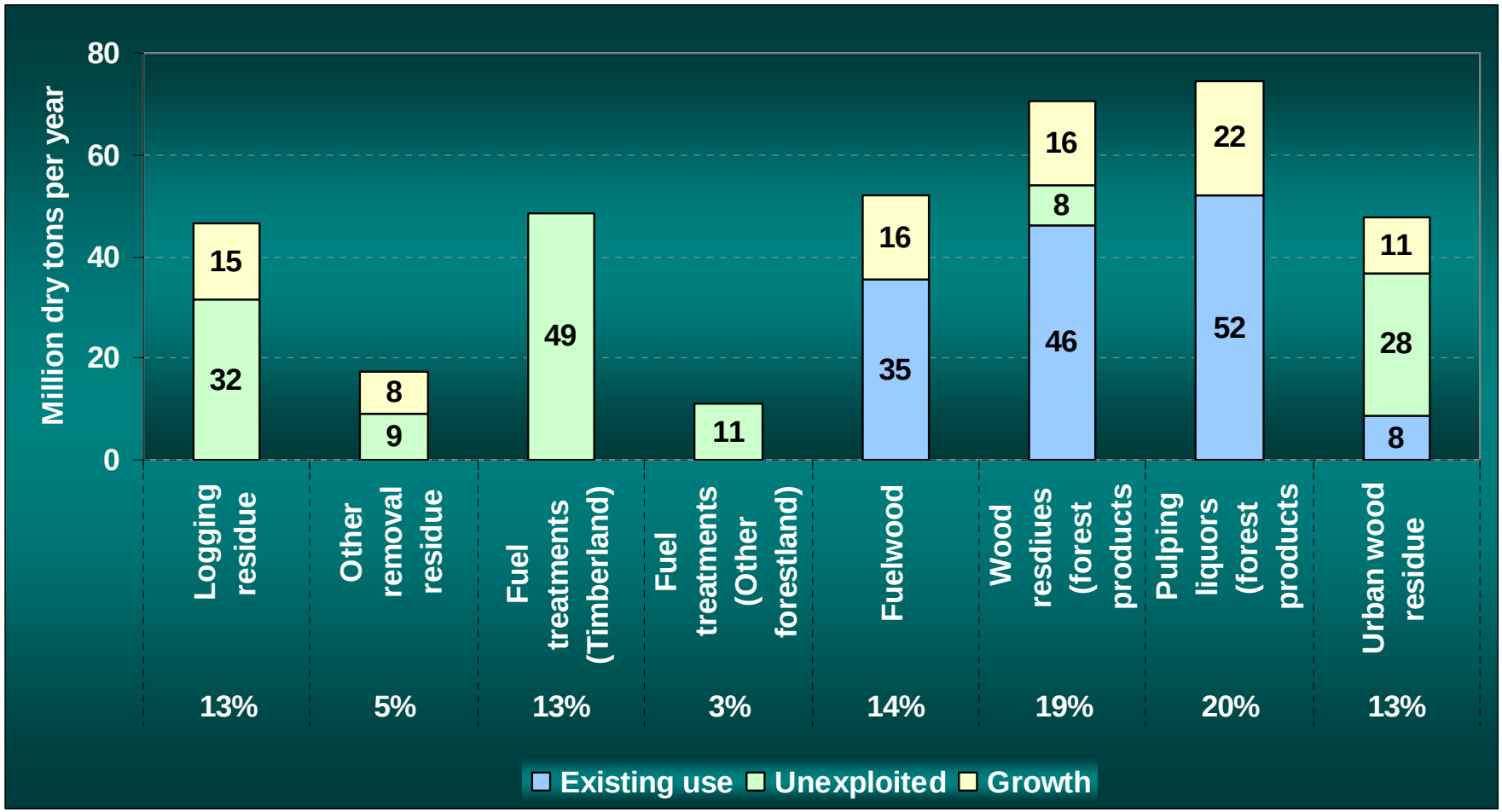
Waste source	Total waste generated	Recovered, energy & unusable	Available
Wood (MSW)	**13.2**	**7.3**	**6.0**
Yard trimmings	**9.8**	**8.0**	**1.7**
Construction waste	**11.6**	**3.0**	**8.6**
Demolition waste	**27.7**	**16.1**	**11.7**
Total	**62.3**	**34.4**	**28.0**

Forest growth and demand

- Future supply and demand prospects (RPA assessment)
- Projected increase in logging and other removal residue – increased residue recovery, more efficient logging operations
- Increase in the demand for wood and paper products (mill residue and black liquor)
- Increased use of finished wood products and increased recycling
- Increased demand for fuelwood
- Total forest growth and demand – 89 million dry tons

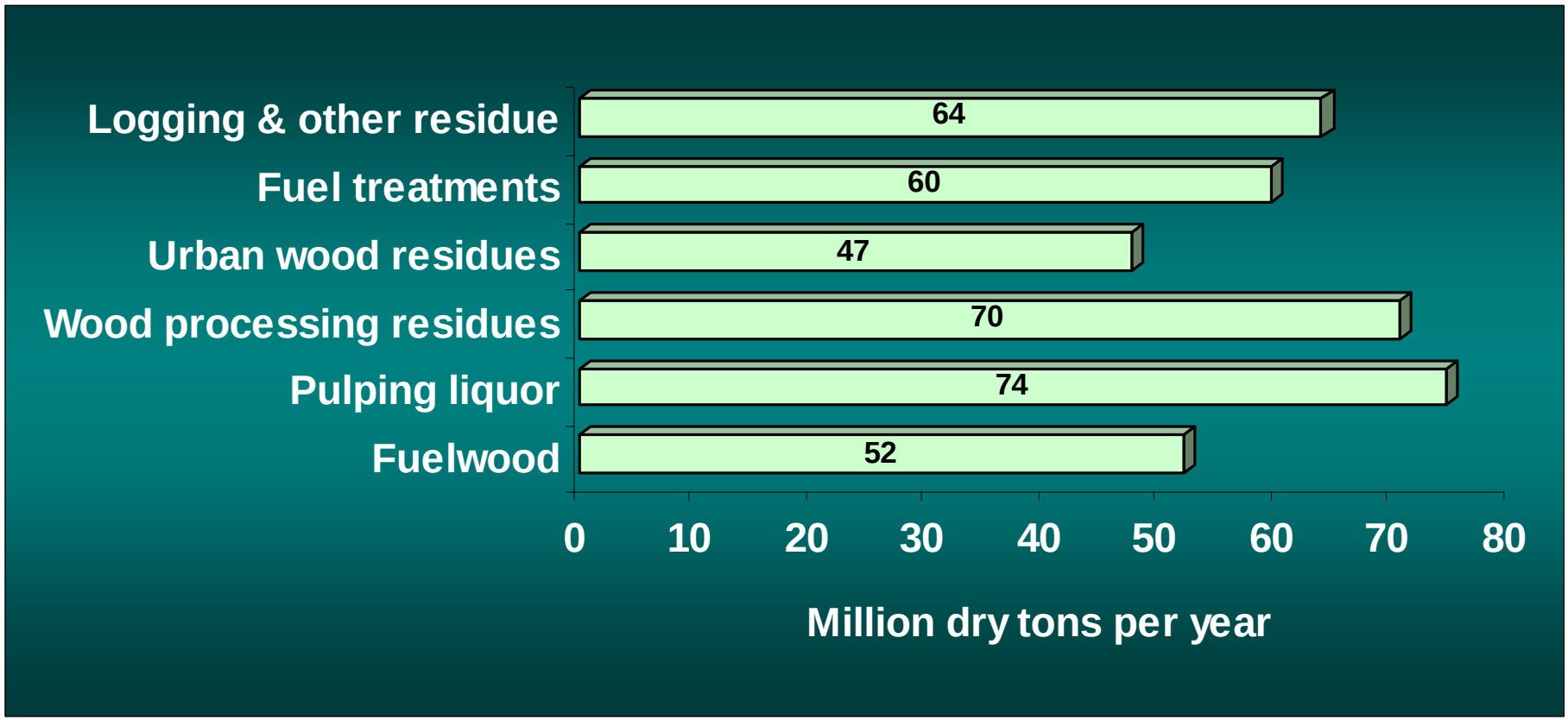
Forest Resource Analysis

The sustainable forest resource potential is nearly 370 million dry tons annually



Forest Resource Analysis

The sustainable forest resource potential -- 370 million dry tons per year



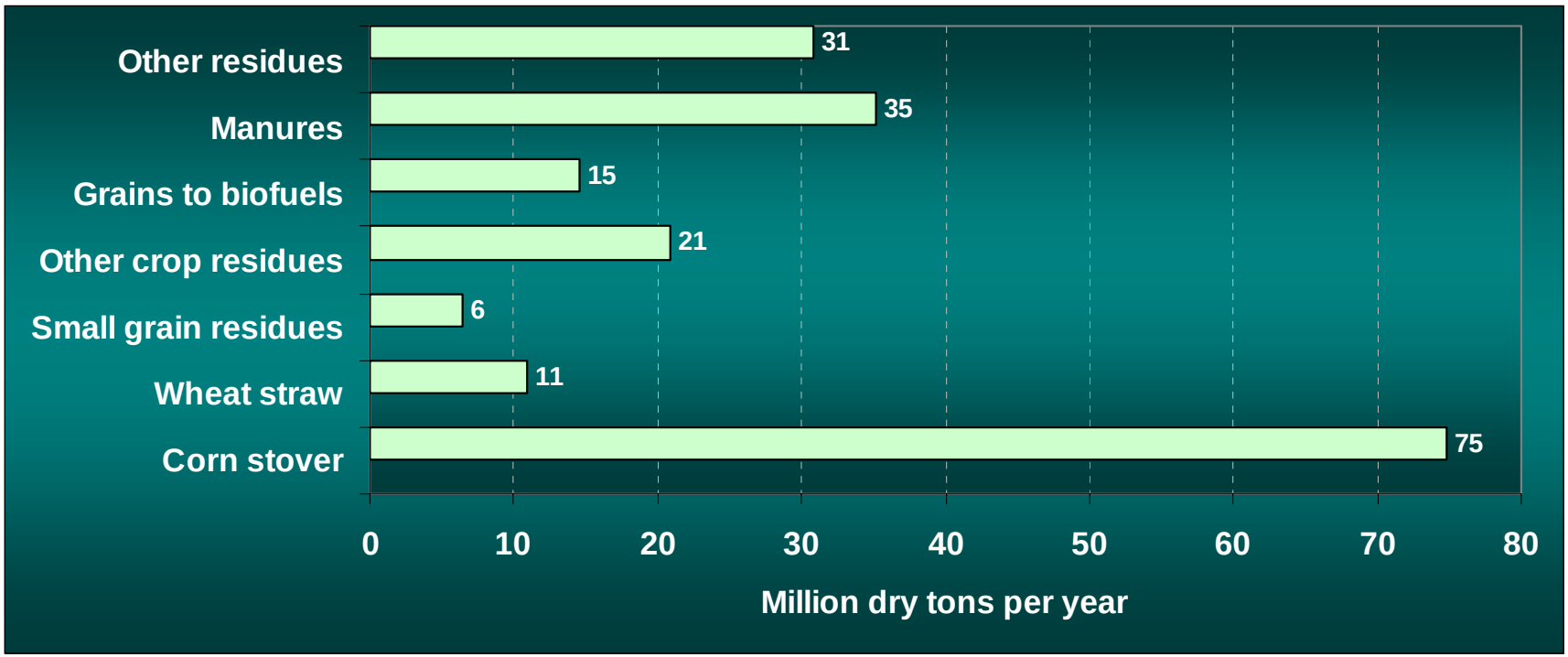
Agricultural resource analysis takes into account a number of factors

- Approach ("what if") based on available information & expert opinion on potentials (e.g., crop yields, equipment efficiency, etc.)
- Crop yields (annual and perennial crops)
  - 15% to 50% for annual crops
  - 5 to 8 dry tons/acre/year for perennial crops
- Residue to grain ratios
  - Vary by crop; only soybean ratios change in scenarios
- Harvest/collection efficiency
  - 40%, 60%, 75%
- Tillage practices (no-till)
  - Current levels up to 100% no-till
- Allocation of cropland acres
  - Perennial crops accommodated with reductions in active cropland, idle cropland, and cropland pasture

Agricultural Resource Analysis

Current availability of biomass from agricultural lands

- Total current availability is approximately 194 million dry tons per year
- Slightly more than one-fifth is currently used
- Corn stover is largest source of agriculture-derived biomass



Agricultural Resource Analysis

How were the variation factors selected?

- Used current trends, research directions and previous analysis results such as:
  - 30 yr average corn yield increase at 1.7 bu/ac
  - Research to develop soybeans with higher forage content (higher residue to grain ratio)
  - Research to develop more efficient and one-pass harvesting equipment
  - Increasing levels of no-till management
  - POLYSYS analysis indicating potential acreage available to energy crops under various market conditions.
- Consultation with USDA scientists

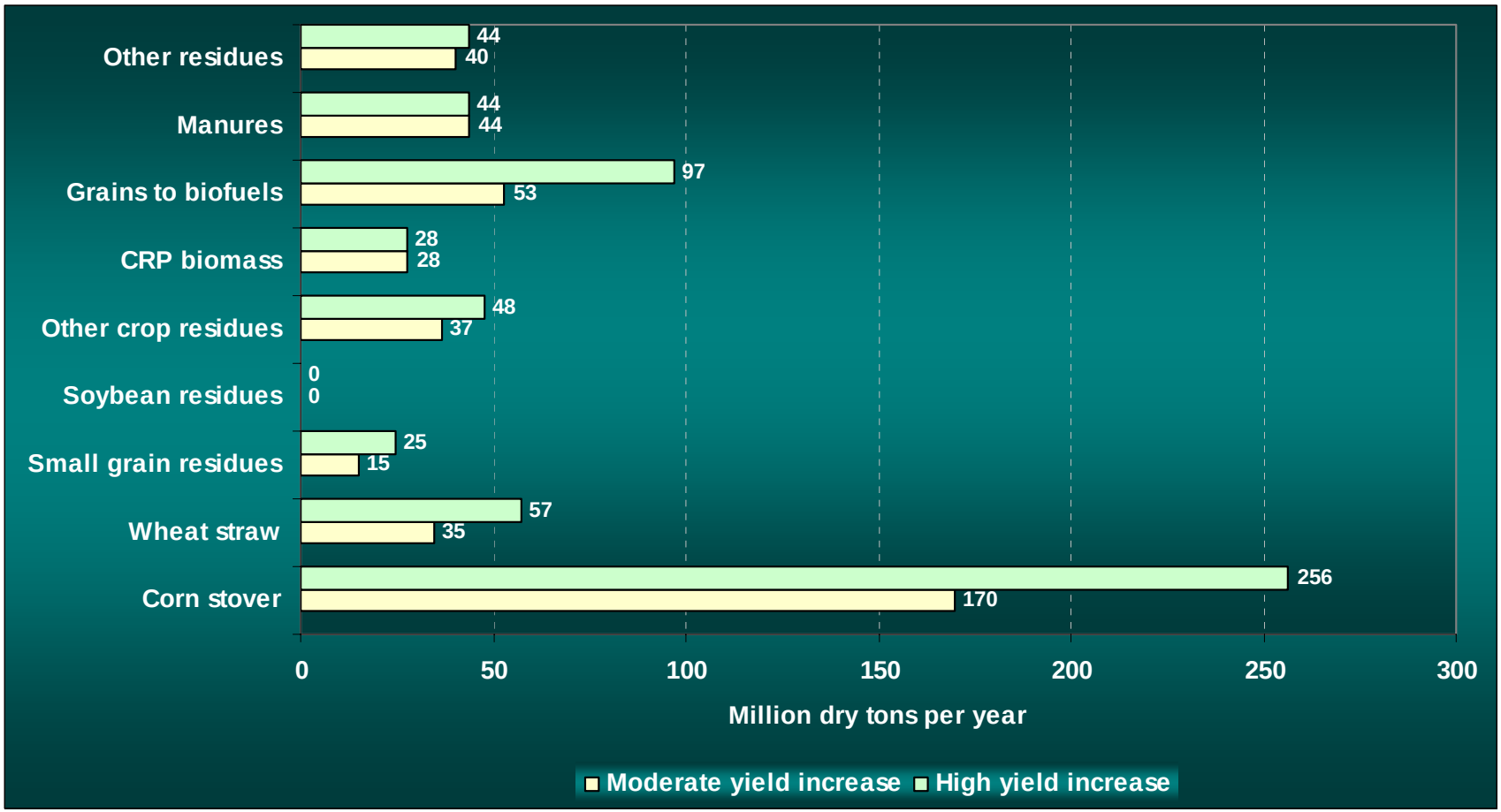
Agricultural Resource Analysis

Availability of biomass under increased crop yields and technology changes -- no land use changes & perennial crops

- Total availability ranges from 420 to 597 million dry tons/year at yield increases between 25 and 50% for corn and other grains & between 15 and 30% for other crops
- Changes in tillage practices (170 to 340 million acres no-till), residue to grain and seed ratios, and residue collection technology and equipment (60 to 75%) are required

Agricultural Resource Analysis

Availability of biomass under increased crop yields and technology changes -- no land use changes & perennial crops (cont.)



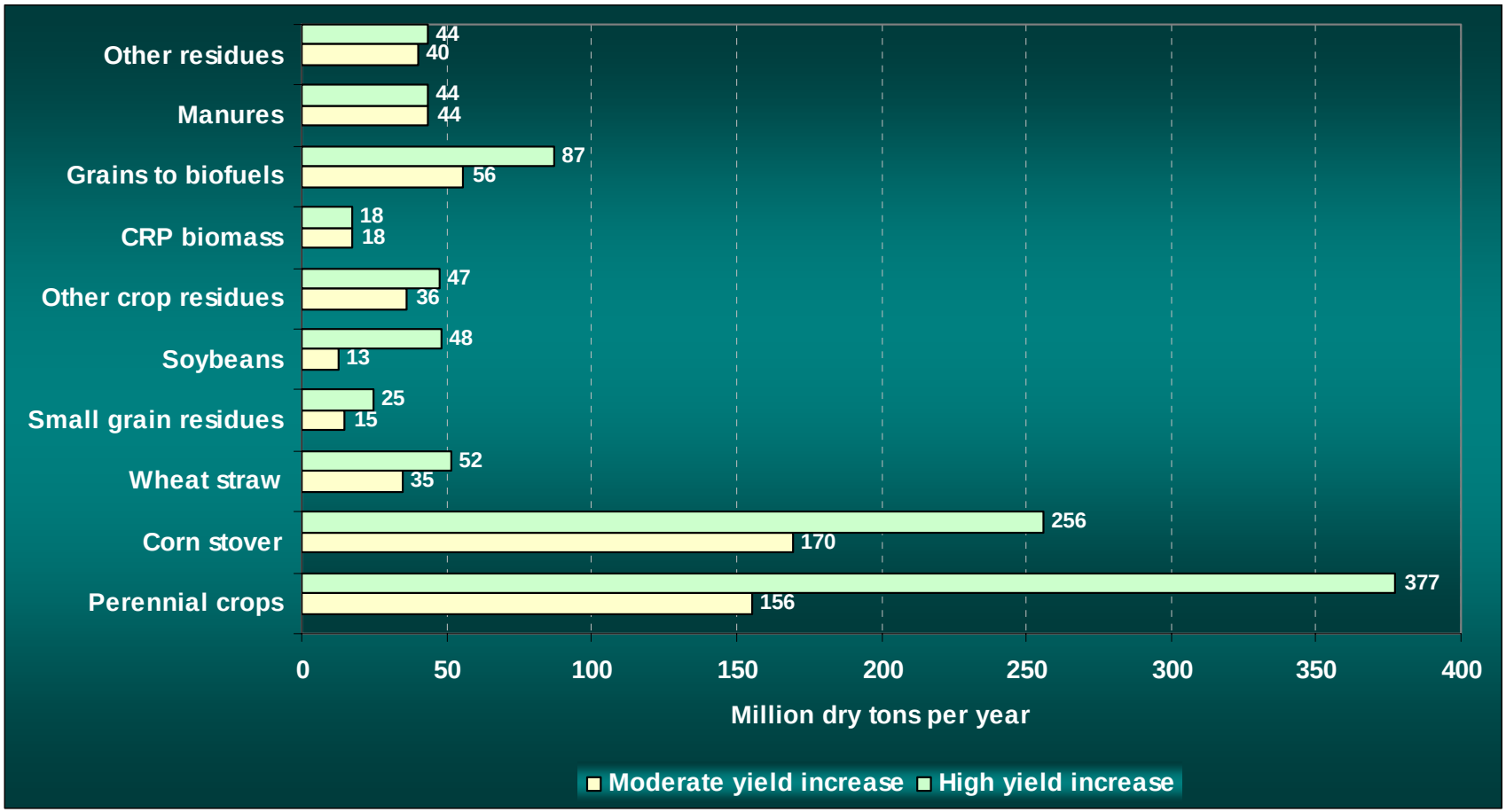
Agricultural Resource Analysis

Availability of biomass under increased crop yields, technology changes, and inclusion of perennial crops

- Total availability ranges from 581 to 998 million dry tons/year at yield increases between 25 and 50% for corn and other grains & between 15 and 30% for other crops
- Changes in tillage practices (170 to 340 million acres no-till), residue to grain and seed ratios, and residue collection technology and equipment (60 to 75%) are also required
- The allocation of some active cropland, idle cropland, and cropland pasture is required

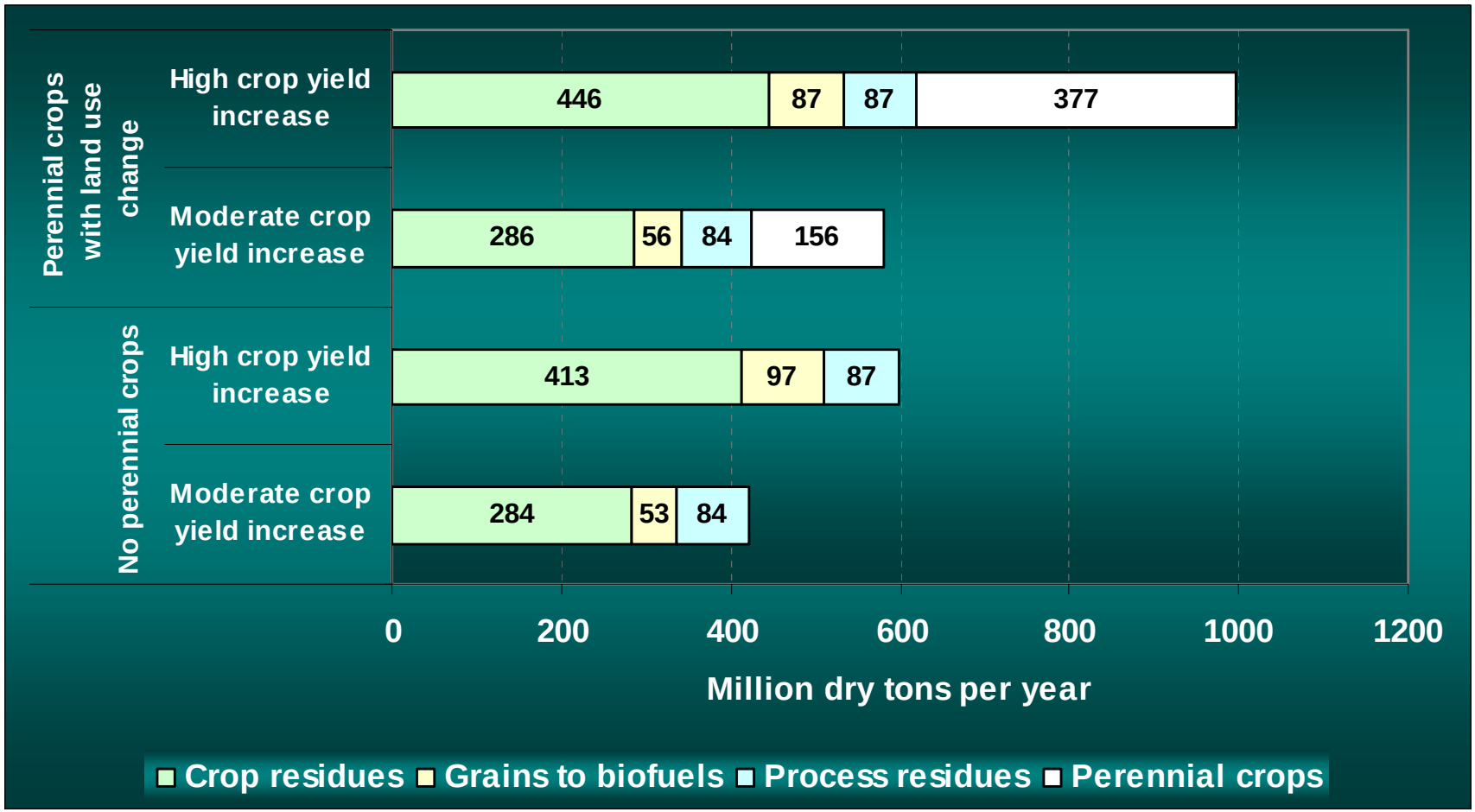
Agricultural Resource Analysis

Availability of biomass under increased crop yields, technology changes, and inclusion of perennial crops (cont.)



Agricultural Resource Analysis

Sustainable agricultural resource potential exceeds 998 million dry tons



Summary

Are there sufficient resources to meet 30% of the country's petroleum requirements?

- Land resources can sustainably supply more than 1.3 billion dry tons annually & still meet food, feed, and export demands
- Will require R&D, policy change, stakeholder involvement
- Required changes are not unreasonable given current trends