



## Natural Gas End Use: A Vision for Today and the Future Executive Summary

### Introduction

As a planning tool for the natural gas industry, its customers and government partners, this plan is intended to spur collaborative research efforts in areas of mutual interest and benefit.

Initial activities include awareness building through meetings with industry, government and policymakers highlighting benefits for consumers, manufacturers and the nation.

### Residential and Commercial

#### Market Segment and Impact

The residential and commercial sectors comprise more than 110 million homes and nearly 5 million places of business, respectively. Total primary energy use in these buildings (21.6 quads and 18.5 quads, respectively) accounted for approximately 40 percent of total U.S. energy consumption in 2008, according to the U.S. Department of Energy (DOE).

Technology can play a major role in improving the efficiency of energy use and in reducing the emissions of GHGs from associated energy equipment for both sectors.

#### RD&D Goals

In considering priorities for natural gas-related RD&D in homes and businesses, it is important to identify the major end-use applications. In homes, space heating and cooling, water heating and cooking are the most prominent end-use applications. In commercial buildings, lighting, space heating and cooling, and water heating top the list. For maximum national impact space conditioning (heating and cooling) and water heating should be major areas of focus for RD&D. On-site combined heat and power (CHP)



systems can play a significant role in satisfying the need for power, space conditioning and hot water.

The research plan recommends high-priority RD&D initiatives related to natural gas use in homes and businesses that can assist the industry achieve its long-term natural gas vision.

**The Homes and Businesses RD&D program is intended to achieve two major goals by the year 2030:**

- **Energy efficiencies resulting in a savings of more than 4.0 quads annually; and**
- **Reductions in GHG emissions resulting in nearly 290 million metric tons annually.**

Strategic goals for natural gas technologies in homes and businesses are:

1. Promote wider adoption of best current technology for major residential and commercial energy applications.
2. Provide technical and analytical support regarding development and application of codes, standards and legislation to promote efficiency.
3. Develop advanced equipment for space and water heating, and cooking based on combination configurations, improved heat transfer/recovery and emissions controls.
4. Reduce GHG emissions and electricity end-use and delivery infrastructure costs through advanced CHP and renewables.
5. Improve efficiency, ensure indoor air quality, control emissions and reduce costs through building systems RD&D.
6. Integrate natural gas systems with the evolving smart energy grid.



- Pursue breakthrough technologies through fundamental RD&D (e.g. combustion science).

## Funding Required

Funding requirements for the RD&D program elements discussed above are summarized below. For every RD&D dollar spent over the life of this plan, there will be \$14 of net consumer energy cost savings.

| RD&D Initiative            | Funding (\$ millions) |            |            |
|----------------------------|-----------------------|------------|------------|
|                            | 2010                  | 2015       | 2020       |
| Space Conditioning         | 24                    | 22         | 20         |
| Water Heating              | 14                    | 16         | 18         |
| Cooking/Food Service       | 4                     | 5          | 6          |
| Combined Heat & Power      | 30                    | 28         | 26         |
| Building/Community Systems | 20                    | 21         | 22         |
| Breakthrough Research      | 17                    | 19         | 21         |
| <b>Total</b>               | <b>109</b>            | <b>111</b> | <b>113</b> |

## Industrial

### Market Segment and Impact

Implementing this plan will improve manufacturing competitiveness and stimulate employment in the vital industrial sector while addressing the nation's energy efficiency and environmental goals. Since 1989, the manufacturing share of the economy has declined from 17 percent to 12 percent of gross domestic product. From 2005 to 2006, more than 200,000 jobs were lost in energy-intensive manufacturing industries including paper, primary metals, and motor vehicle and parts

The Industrial RD&D program is intended to achieve two major goals by the year 2030:

- Energy efficiencies resulting in savings of nearly 1.1 quads annually; and
- Reductions of GHG emissions by nearly 110 million metric tons annually.

manufacturing. The industrial sector currently consumes 32 percent of all U.S. energy and 7,000 trillion Btu of natural gas (7.0 quads) annually. The RD&D plan focuses on large energy users in high-energy intensity sectors using steam, power or process heat. The plan also addresses increased use of renewable fuels to enhance energy sustainability and lower carbon emissions.

## RD&D Goals

The plan focuses on expanding the deployment of previous technology successes, creating new



technology solutions, expanding energy efficiency programs and developing the next generation of industrial processes. It maximizes the value of each research dollar to achieve the goals of greater efficiency, increased productivity and renewable fuel use, improved environmental performance

and carbon emission reduction and improving U.S. industry competitiveness. This crosscutting research plan identifies six program goals yet also suggests a need to focus a portion of the program on industry specific technology development that can provide substantial value in U.S. competitiveness and job retention and creation. These efforts can result in step-change technologies leading to unforeseen breakthroughs.

Strategic goals for gas technologies in industrial applications are:

1. Reduce energy consumption by 8 percent to 20 percent for industrial steam users by expanding portfolio of ultra-efficient systems.
2. Improve the efficiency of industrial heating and on-site power generation systems to recover 25 percent of the lost energy to create more cost-efficient systems for a variety of industrial applications.
3. Reduce GHG emissions and electricity end-use and delivery infrastructure costs through advanced CHP technologies.
4. Increase the use of renewable fuels in the industrial sector by up to 15 percent leading to reduced carbon dioxide (CO<sub>2</sub>) emissions and energy costs.
5. Provide recommendations that will allow manufacturers to reduce overall energy use by up to 20 percent in their process operations and facilities.
6. Improve manufacturing production and other industrial process efficiency by up to 10 percent leading to reduced energy consumption and lower operating costs.

## Funding Required

Funding requirements for the RD&D program elements discussed above are summarized below. For every RD&D dollar spent over the life of this plan, there will be \$6 of benefit to U.S. economy.

| RD&D Initiative              | Funding (\$ millions) |            |            |
|------------------------------|-----------------------|------------|------------|
|                              | 2010                  | 2015       | 2020       |
| Industry Specific R&D        | 31                    | 36         | 40         |
| Steam Generation             | 35                    | 41         | 47         |
| Process Heating Systems      | 49                    | 58         | 66         |
| Onsite Power Generation      | 62                    | 72         | 83         |
| Renewable Fuel Utilization   | 18                    | 21         | 24         |
| Industrial Energy Efficiency | 16                    | 18         | 21         |
| Controls and Sensors         | 4                     | 5          | 6          |
| <b>Total</b>                 | <b>215</b>            | <b>251</b> | <b>287</b> |

## Transportation

### Market Segment and Impact

The transportation sector represents a vital part of the U.S. economy. Presently, 29 percent of total U.S. energy – nearly 28 quads of energy – are used to move commercial goods and for private transportation. U.S. import reliance on petroleum and related products has steadily grown to 60 percent, contributing to a negative balance of trade along with heightened energy security concerns.

There are multiple pathways by which natural gas is currently being used in the transportation sector. The most significant is an indirect route via ethanol production. Natural gas is a key enabling energy source that is vital to ethanol production. More conventional direct routes for using natural gas in vehicles are CNG (compressed natural gas) and LNG (liquefied natural gas) vehicles. Current U.S. natural gas vehicle (NGV) fuel use is about 300 million equivalent gallons of gasoline per year –

**The Transportation RD&D program is intended to achieve two major goals by the year 2030:**

- Reduce emissions of greenhouse gases by nearly 40 million metric tons annually; and
- Reduce foreign crude oil purchases by over \$16 billion – while increasing domestic jobs for energy production and delivery.

roughly 37 bcf of natural gas. There are approximately 120,000 vehicles and 1,100 NGV fueling stations in the U.S. Most fuel consumption is associated with heavy-duty vehicles such as transit buses, refuse trucks, and pick-up and delivery vehicles.



## RD&D Goals

The RD&D plan identifies six high-priority research, development, and deployment goals for ensuring natural gas is being used in the most efficient and environmentally acceptable manner in the transportation sector:

1. Integrate available and emerging ultra-low emission natural gas engines with vehicle manufacturers in priority weight classes.
2. Develop advanced CNG and LNG on-board fuel storage systems using advanced composite materials and alloy metals. Enhance vehicle fuel storage safety with nationally recognized codes and standards and certification programs.
3. Develop advanced CNG and LNG fueling station equipment and systems to reduce cost, enhance fuel delivery performance, and ensure accurate and timely filling of vehicles.
4. Develop advanced technology medium- and heavy-duty hybrid NGV platforms for use in trucks, transit buses and school buses.
5. Develop and deploy advanced renewable methane technology to ensure the fuel quality requirements of advanced technology vehicles are met with integrated gas clean-up systems.
6. Develop breakthrough vehicle and infrastructure technologies including; advanced natural gas hybrid commuter vehicles, special-purpose auxiliary power units (APUs) for medium and heavy-duty vehicles, and natural gas-to-hydrogen fuel stations for hydrogen fuel cell vehicles.



## Funding Required

Funding requirements for the RD&D program elements discussed above are summarized below. The research program will also provide over \$1 billion in transportation fuel cost savings annually for consumers and businesses.

| RD&D Initiative              | Funding (\$ millions) |           |           |
|------------------------------|-----------------------|-----------|-----------|
|                              | 2010                  | 2015      | 2020      |
| NG Engine and Vehicle Tech   | 16                    | 16        | 16        |
| Fuel Storage Tech            | 5                     | 6         | 7         |
| Fueling Infrastructure       | 5                     | 6         | 7         |
| Renewable Methane            | 5                     | 7         | 9         |
| Safety, Codes, and Standards | 2                     | 2         | 2         |
| Next-Gen Tech Development    | 2                     | 3         | 4         |
| <b>Total</b>                 | <b>35</b>             | <b>40</b> | <b>45</b> |