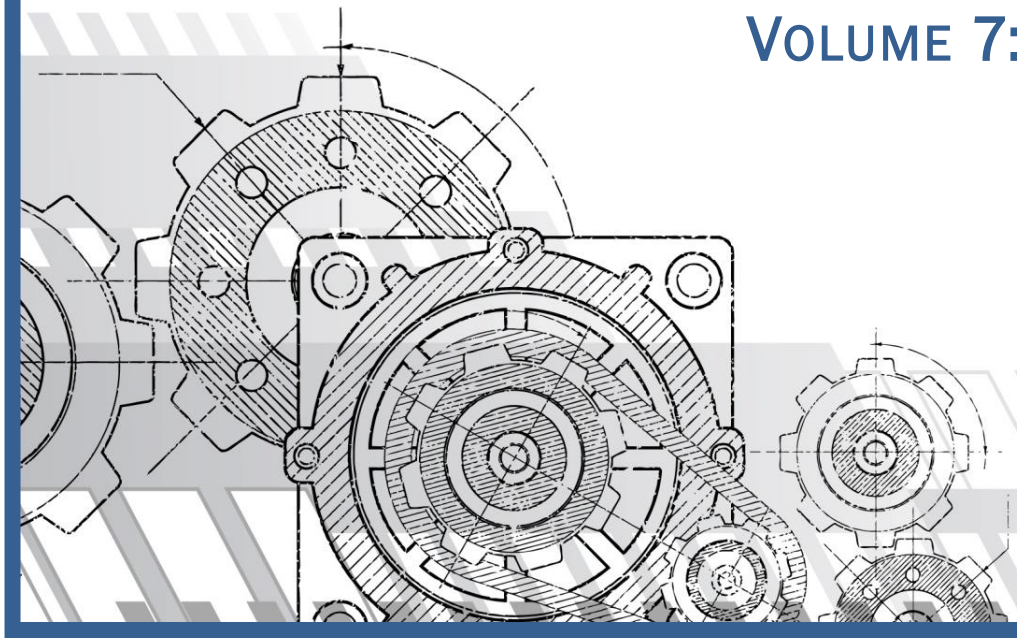
Energy Efficiency Technology Roadmap

Volume 7: Industrial Food Processing



March 2015

Enhanced PDF Functionality

Functionality of the PDF version of this document has been enhanced in the following ways:

- **Embedded Table of Contents Links:** The Table of Contents has been linked to the appropriate sections of the document.
- **Internal links embedded within the document** to facilitate navigation between sections and "Back to Table of Contents."
- **Control + F:** As always, one can navigate through the document by searching for specific words or phrases by pressing the "Control" and "F" keys simultaneously.

SPECIAL NOTE

This document is one component of the Energy Efficiency Technology Roadmap (EE Roadmap), published by the Bonneville Power Administration (BPA) on behalf of regional stakeholders. For the background and purpose of the full EE Roadmap, a complete list of the project team and contributors, and other explanatory and complementary information, see Volume 1: Introduction & Background.

While BPA has funded and managed the overall development and maturation of this Energy Efficiency Technology Roadmap since 2009, the effort would not have been possible without the active engagement of a diverse array of subject matter experts from organizations and institutions throughout North America. Since the beginning of this roadmapping project, more than 200 participants representing 119 organizations have contributed approximately 5,120 hours and $1,100,000 worth of voluntary input. Their expertise is essential to this project. See Volume 1 for a complete list of contributors.

There is still much collaborative work to be done to improve our understanding of the current energy efficiency technology research landscape but we are making strides in the right direction and we truly appreciate the dedication and contributions of all who have been a part of this important endeavor.

For more information about the Energy Efficiency Technology Roadmap, contact:

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TABLE OF CONTENTS

IN THIS VOLUME

ADDITIONAL CONTENT IN VOLUME 1

Introduction to this Volume

This section contains roadmaps in these industrial sector Technology Areas:

- Heating
- Cooling
- Mechanical
- Infrastructure

Technology Area Definitions

Heating

Technologies used for heating food and industrial food processing equipment.

Cooling

Technologies used for cooling food and industrial food processing equipment.

Mechanical

Various mechanical and technical systems used within the industrial food processing facility outside of the realm of heating and cooling technologies, such as raw material storage, transportation, and equipment operation.

Infrastructure

Technical infrastructure to support industrial food processing operations such as lighting, HVAC systems, energy management systems, water treatment, data management, and others.

Other Sources

The list below is intended to be broadly representative rather than exhaustive and will be updated as new information becomes available.

Sources pending.

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USING THE ROADMAP

The EE Roadmap is a reference tool designed to be a living, working document. It was not crafted with any expectation that it would be read from beginning to end like a traditional report or narrative. Rather, its design allows for quick reference to technology development research agendas in relation to energy efficiency product and service areas in the residential, commercial, and industrial sectors.

Roadmap content is organized into eight volumes. Volume 1 provides an overall introduction and background, defines key terms and concepts, and guides readers in understanding how roadmap content is organized and interpreted. The remaining volumes contain multiple roadmaps within the respective area:

- Volume 1: Introduction & Background
- Volume 2: Building Design/Envelope
- Volume 3: Lighting
- Volume 4: Electronics
- Volume 5: Heating, Ventilation, and Air Conditioning
- Volume 6: Sensors, Meters, and Energy Management Systems
- Volume 7: Industrial Food Processing
- Volume 8: Combined Heat & Power

In addition to these volumes, there are two ancillary documents to the EE Roadmap:

- Appendix A contains process documents for all of the technology roadmapping workshops held to date, including minutes from each workshop.
- Appendix B contains more information, when available, about existing R&D programs identified in roadmap diagrams.

Disclaimer

Some roadmaps, project summaries, and appendix pages identify specific vendors, commercial products, or proprietary systems and technologies. BPA, its partner institutions, and other stakeholders make these references solely for context; these references do not constitute endorsement on the part of BPA, the Department of Energy, or any stakeholder involved in the creation and refinement of these roadmaps.

Roadmap "Swim Lane" Definitions

Roadmap diagrams are composed of the following four "swim lanes":

Drivers: Critical factors that constrain, enable, or otherwise influence organizational decisions, operations, and strategic plans. These factors can include: existing or pending regulations and standards; the environment; market conditions and projections; consumer behavior and preference; and organizational goals and culture, among others.

Capability Gaps: Barriers or shortcomings that stand in the way of meeting drivers.

Technology Characteristics: Specific technical attributes of a product or service necessary to overcome capability gaps.

R&D Programs: The iterative process undertaken at universities, national laboratories, some businesses, and related organizations to generate new ideas for products and services, develop models and prototypes, evaluate these in laboratory settings, and conduct engineering and production analyses with the goal of delivering the product or service to the marketplace. Within the *Roadmap Portfolio* the generic abbreviation "R&D" is to be understood as including, when appropriate, design, deployment, and demonstration in addition to research and development.

What is the difference between a "Technology Characteristic" and a "Capability Gap?"

A food processing company finds that the machine it currently uses to peel potatoes removes a significant amount of the flesh of the potato. Removing too much of the flesh reduces the yield of each processed potato and this reduced yield means that the company is not getting as much saleable product out of each unit of potatoes. The company must also pay increased costs to dispose of their wastes.

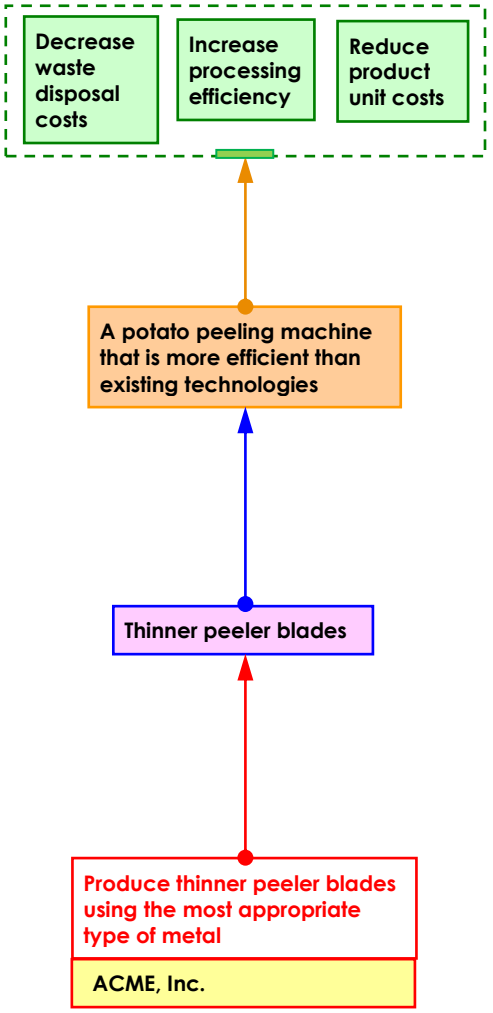
Faced with this situation, the company is facing three Drivers: 1) the desire to increase processing efficiency; 2) the desire to reduce product unit costs; and 3) the desire to reduce waste disposal costs.

Motivated by these drivers, company officials are seeking a solution that will improve the yield of their potato peeling machine. This is their Capability Gap: A peeling machine that is more efficient than existing technology.

Company officials take their request to their engineering team and ask them to develop a solution that will overcome the capability gap and, thereby, meet the three drivers. The engineering team applies their technical expertise to suggest that if they were to reduce the thickness of the peeler cutting blade they would be able to meet the requirements and overcome the capability gap. Thus the engineers have established a Technology Characteristic.

The engineers' next step is to commence an R&D Program in which they investigate the kinds of metal they could use to create thinner blades and then test these blades.

The diagram to the right illustrates this example:



Drivers:

What are the reasons to change?

Capability Gaps:

What are the barriers to change?

Technology Characteristics:

What are the technological solutions needed to overcome barriers to change?

R&D Programs:

What are the research programs and key research questions to pursue to develop technological solutions?

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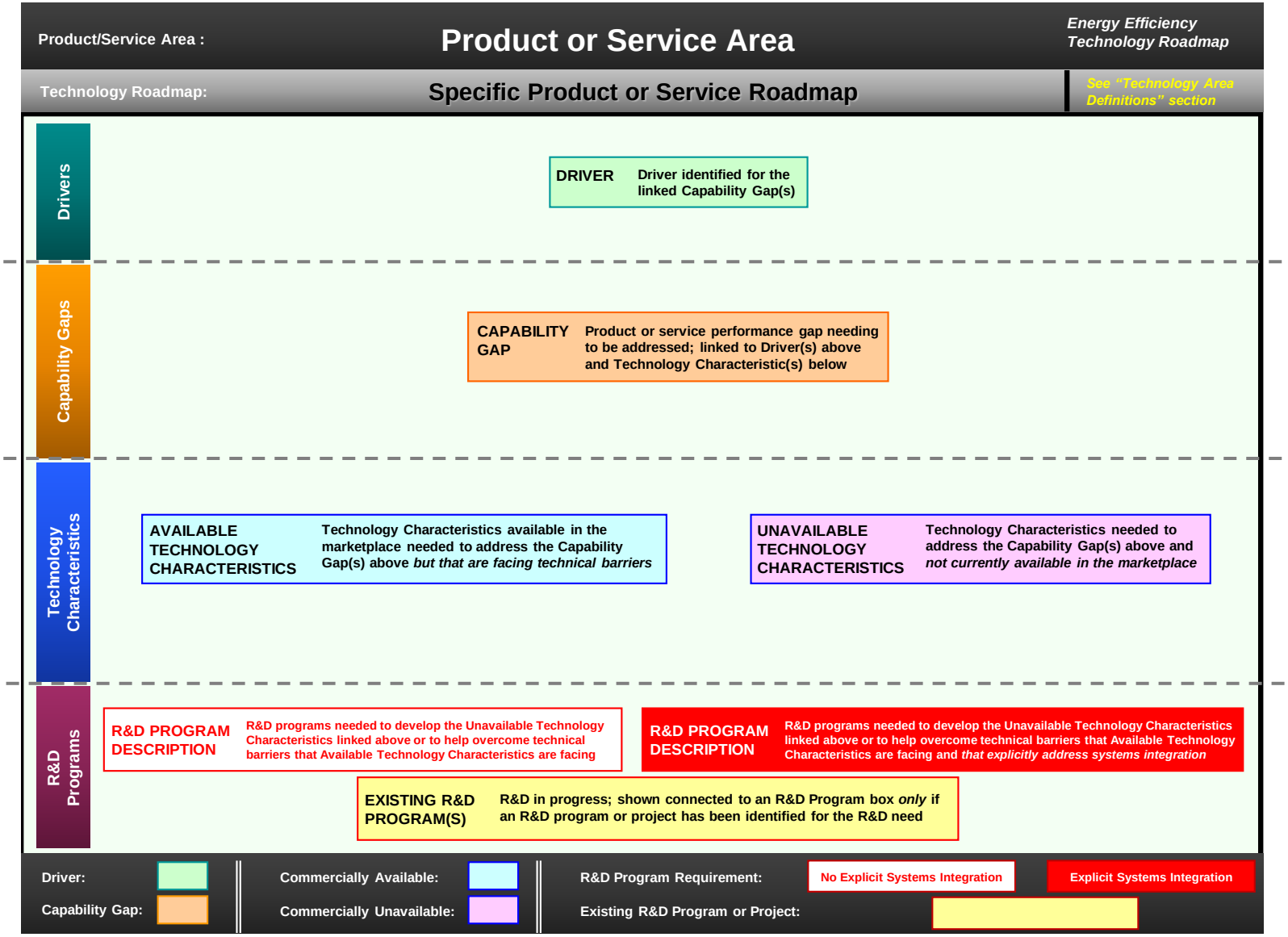
Roadmap Diagram Key



R&D Program Summaries Key

R&D Program Title. Brief summary of R&D program needed to develop the associated Unavailable Technology Characteristics or to help overcome technical barriers that Available Technology Characteristics are facing.

Existing research: Institution(s) listed where R&D program(s) are ongoing.

- Brief descriptive summaries of each institution's R&D program that may include, where applicable, hyperlinks to web pages and/or reference to further program details in Appendix B of the *National Energy Efficiency Technology Roadmap Portfolio*.

Key research questions:

1. One or more research questions that subject matter experts have identified as among the key questions and topic areas to pursue within the R&D program or project; numbers provided for identification only and do not imply prioritization.

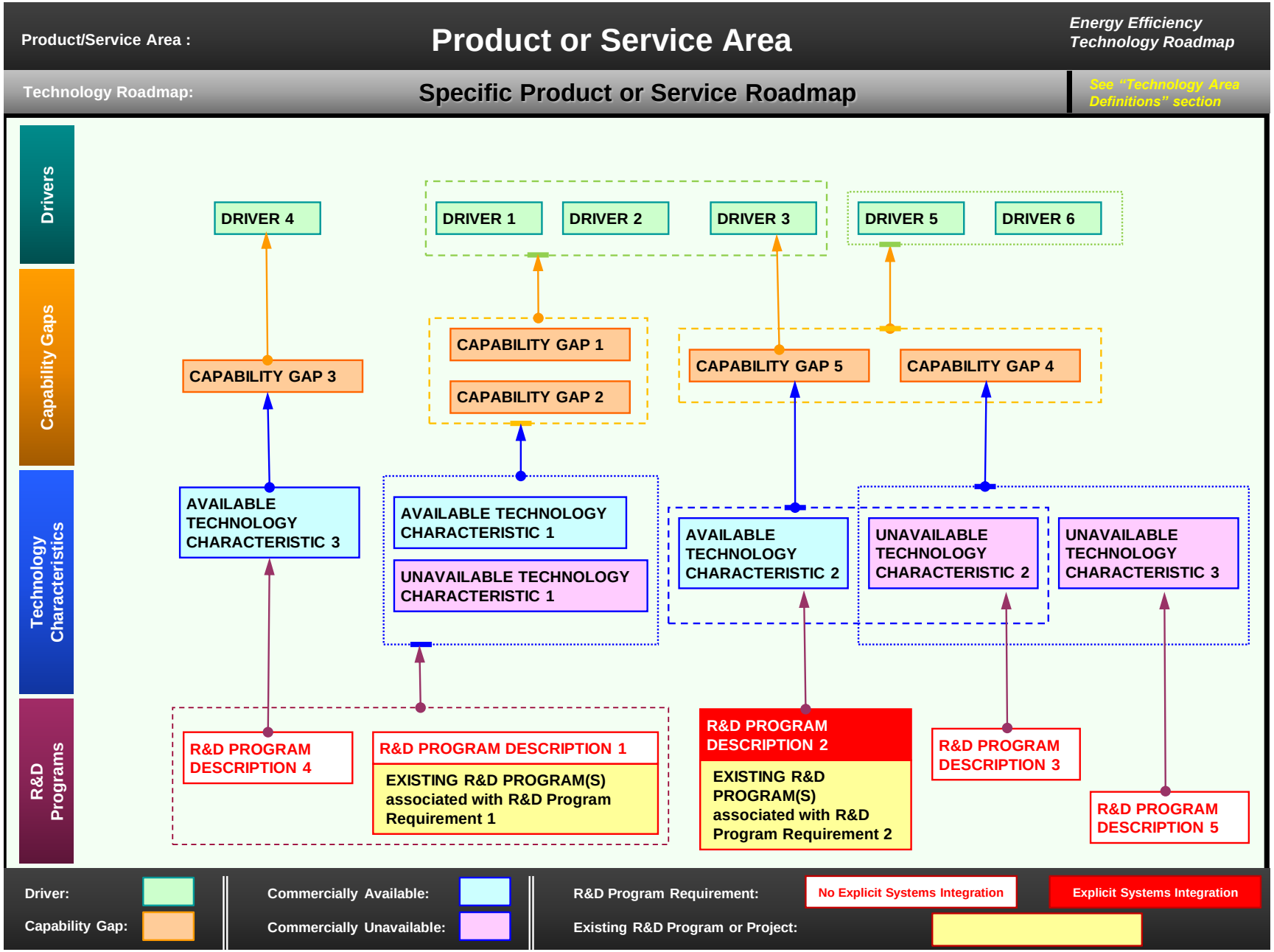
R&D Program Title. Brief summary of R&D program needed to develop the associated Unavailable Technology Characteristics or to help overcome technical barriers that Available Technology Characteristics are facing.

Existing research: None identified. *[R&D program titles that do not have an associated yellow box indicating "Existing R&D Program or Project," by definition, are not underway.]*

Key research questions:

1. One or more research questions that subject matter experts have identified as among the key questions and topic areas to pursue within the R&D program or project; numbers provided for identification only and do not imply prioritization.

How to Interpret Roadmap Pages



The diagram above represents a typical EE Roadmap page. The most straightforward way to interpret portfolio pages is from the R&D Programs "swim lane" at the bottom up through the Technology Characteristics, Capability Gaps, and Drivers swim lanes.

	Arrows connect individual or groups of boxes in swim lanes to identify critical connections between them.
	Dotted and dashed lines indicate that two or more elements in a swim lane are associated and linked either to another element (or group of elements) in the swim lane above and/or below.
	Short, thick solid lines indicate that the arrow is connecting to the dotted or dashed line surrounding two or more boxes.

Thus, in the diagram on the preceding page, the red arrow connects R&D Program Description 4 (at bottom left) to Available Technology Characteristic 3; the blue arrow connects Available Technology Characteristic 3 to Capability Gap 3; and the orange arrow connects Capability Gap 3 to Driver 4. This means that R&D Program Description 4 helps meet Driver 4. Expressed in another way, meeting the requirements of Driver 4 is a rationale for engaging in R&D Program Description 4.

For purposes of illustration some of the other associations to be drawn from the diagram above are explained below. The following abbreviations are used in the examples:

- R&D = R&D Program Description
- ATC = Available Technology Characteristic
- UTC = Unavailable Technology Characteristic
- CG = Capability Gap
- D = Driver

R&D 1 and R&D 4 linked to D 1, D 2, and D 3

R&D 1 and R&D 4 are associated by the surrounding dashed box because they both contribute directly to UTC 1 and ATC 1. This is shown by the red arrow from R&D 1 and R&D 4 to the dotted blue box surrounding UTC 1 and ATC 1.

Both of these technology characteristics, in turn, are associated with CG 1 and CG 2, and both of these capability gaps are linked to D 1, D 2, and D 3.

R&D 3 linked to D 3, D 5, and D 6

R&D 3 is linked to UTC 2, as the red arrow indicates, but *not* to ATC 2 or UTC 3 because the red arrow links directly to the UTC 2 box and not the blue dashed or dotted lines.

UTC 2 is linked to both CG 4 and CG 5 in the following ways: first, the blue dotted box associates both UTC 2 and UTC 3 and these together are linked to CG 4 by a blue arrow; next, the blue dashed box associates both UTC 2 and ATC 2 and these are linked by a blue arrow to CG 5.

CG 4 and CG 5 are associated with one another as indicated by the dashed orange box surrounding them and an orange arrow links both capability gaps to D 5 and D 6.

Though CG 4 and CG 5 are associated in their linkage to D 5 and D 6, CG 5 independently is linked to D 3, as the orange arrow connecting CG 5 and D 3 indicates.

R&D 2 linked to D 3

A red arrow links R&D 2 with ATC 2. R&D 2 is identified with a red-filled box, denoting that this research addresses a need for an integrated systems approach.

ATC 2 and UTC 2 are associated as is shown by the blue dashed box surrounding them. The blue arrow from this box connects to CG 5.

An orange arrow links CG 5 to D 3 but *not* to D 1 and D 2. These three drivers are associated with one another but only in terms of their linkage to CG 1 and CG 2, not in terms of their linkage to CG 5.

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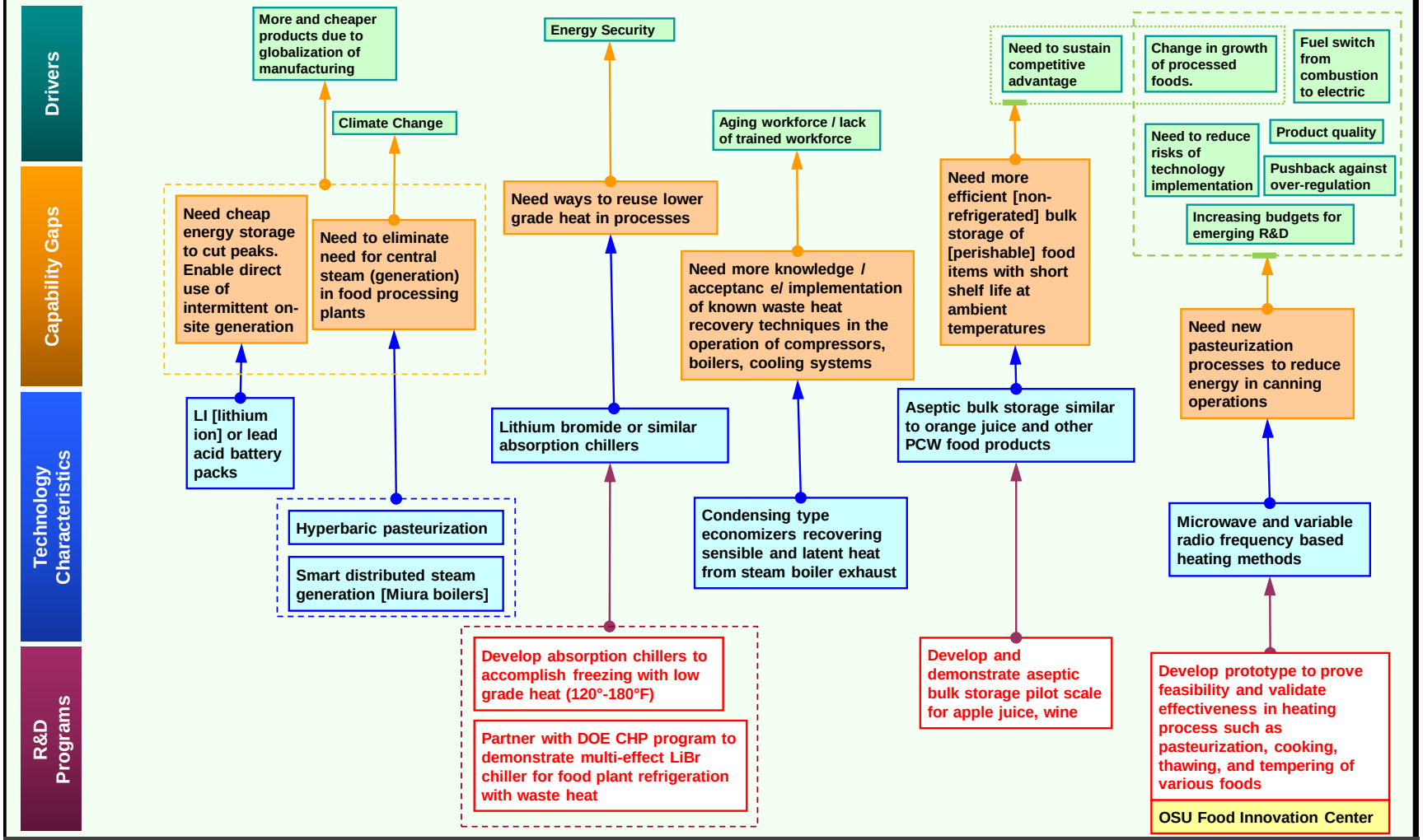
INDUSTRIAL FOOD PROCESSING

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap:

Heating (1of 2)

See "Technology Area Definitions" section



Driver:
Capability Gap:
Commercially Available:
Commercially Unavailable:
R&D Program Requirement:
No Explicit Systems Integration
Explicit Systems Integration
Existing R&D Program or Project:

R&D Program Summaries

Need to develop prototype to prove feasibility and validate the effectiveness in heating process. Examples include pasteurization, cooking, thawing, tempering of various foods.

Existing research: Ongoing R&D in this area at Oregon State University's Food Innovation Center (http://fic.oregonstate.edu/)..

Key research questions:

1. Questions not yet specified.

Develop absorption chillers to accomplish freezing with low grade heat (120-180F). (Summary not yet provided.).

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Develop and demonstrate aseptic bulk storage pilot scale for apple juice, wine. (Summary not yet provided.).

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Partner with DOE CHP program to demonstrate multi-effect lithium bromide (LiBr) chiller for food plant refrigeration with waste heat. (Summary not yet provided.).

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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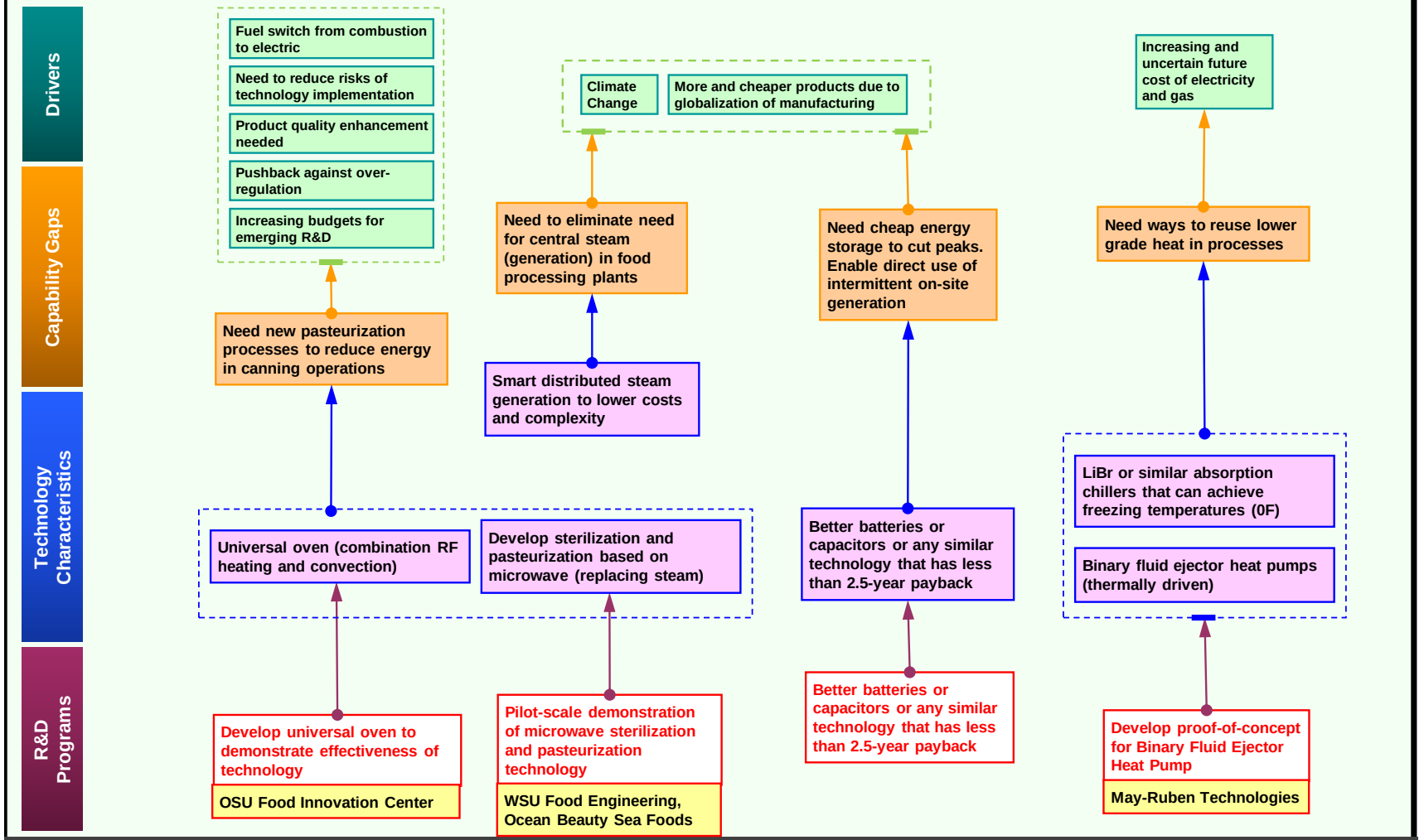
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Heating (2of 2)**

See "Technology Area Definitions" section



Driver: Capability Gap: Commercially Available: Commercially Unavailable: R&D Program Requirement: No Explicit Systems Integration Explicit Systems Integration Existing R&D Program or Project:

R&D Program Summaries

Develop proof-of-concept for Binary Fluid Ejector Heat Pump.

(Summary not yet provided.)

Existing research: R&D ongoing at May-Ruben Technologies (http://may-rubentechnologies.com/), contact Research Support Officer Chelsea Ruben, http://may-rubentechnologies.com/index.php?option=com_content&view=article&id=76&Itemid=116.

Key research questions:

1. Questions not yet specified.

Develop universal oven to demonstrate effectiveness of technology. (Summary not yet provided.)

Existing research: Ongoing R&D in this area at Oregon State University's Food Innovation Center (http://fic.oregonstate.edu/).

Key research questions:

1. Questions not yet specified.

Pilot-scale demonstration of microwave sterilization and pasteurization technology. (Summary not yet provided.)

Existing research: Ongoing R&D in this area involving the Food Engineering team of Washington State University's (WSU) Biological Systems Engineering department (http://bsyse.wsu.edu/core/research/Emphasis/Food/Food.html), and at Ocean Beauty Sea Foods, LLC (http://www.oceanbeauty.com/).

Key research questions:

1. Questions not yet specified.

Better batteries or capacitors or any similar technology that has less than 2.5-year payback. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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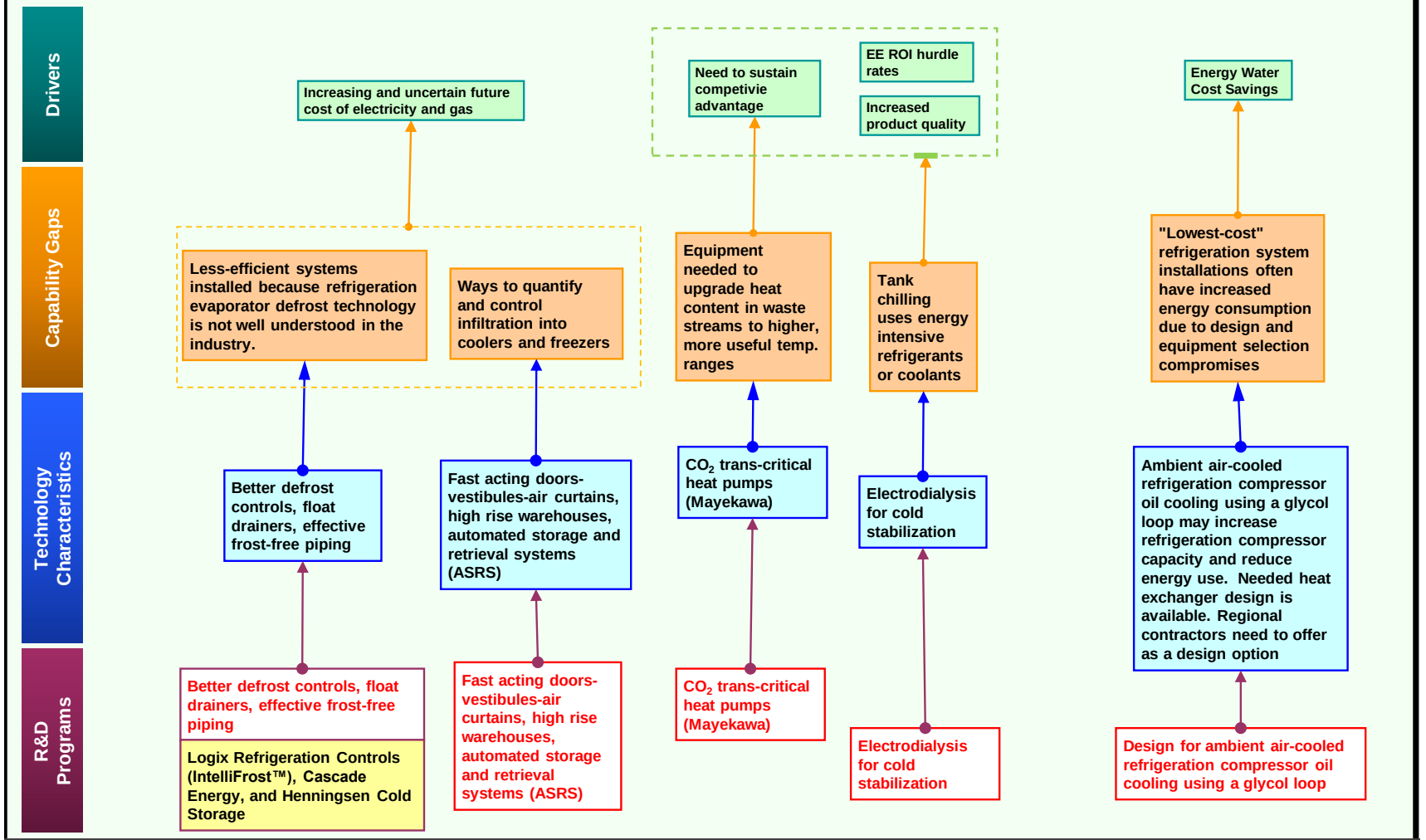
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Cooling (1 of 4)**

See "Technology Area Definitions" section



Driver: Capability Gap: Commercially Available: Commercially Unavailable: R&D Program Requirement: No Explicit Systems Integration Explicit Systems Integration Existing R&D Program or Project:

R&D Program Summaries

Better defrost controls, float drainers, effective frost-free piping.
(Summary not yet provided.)

Existing research: Stakeholders referred to R&D that includes Logix Refrigeration Controls' IntelliFrost™ product and work at Cascade Energy and Henningsen Cold Storage.

- Logix® IntelliFrost™ Automatic Defrost System: http://www.logix-controls.com/docs/Logix_IntelliFrost_ Technical_Brief.pdf.
- Cascade Energy: http://www.cascadeenergy.com/default.asp.
- Henningsen Cold Storage: henningsen.com

Key research questions:

1. Questions not yet specified.

Fast acting doors-vestibules-air curtains, high rise warehouses, automated storage and retrieval systems (ASRS). (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

CO_2 trans-critical heat pumps. See Mayekawa, http://www.mayekawausa.com.

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Electrodialysis for cold stabilization. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Design for ambient air-cooled refrigeration compressor oil cooling using a glycol loop. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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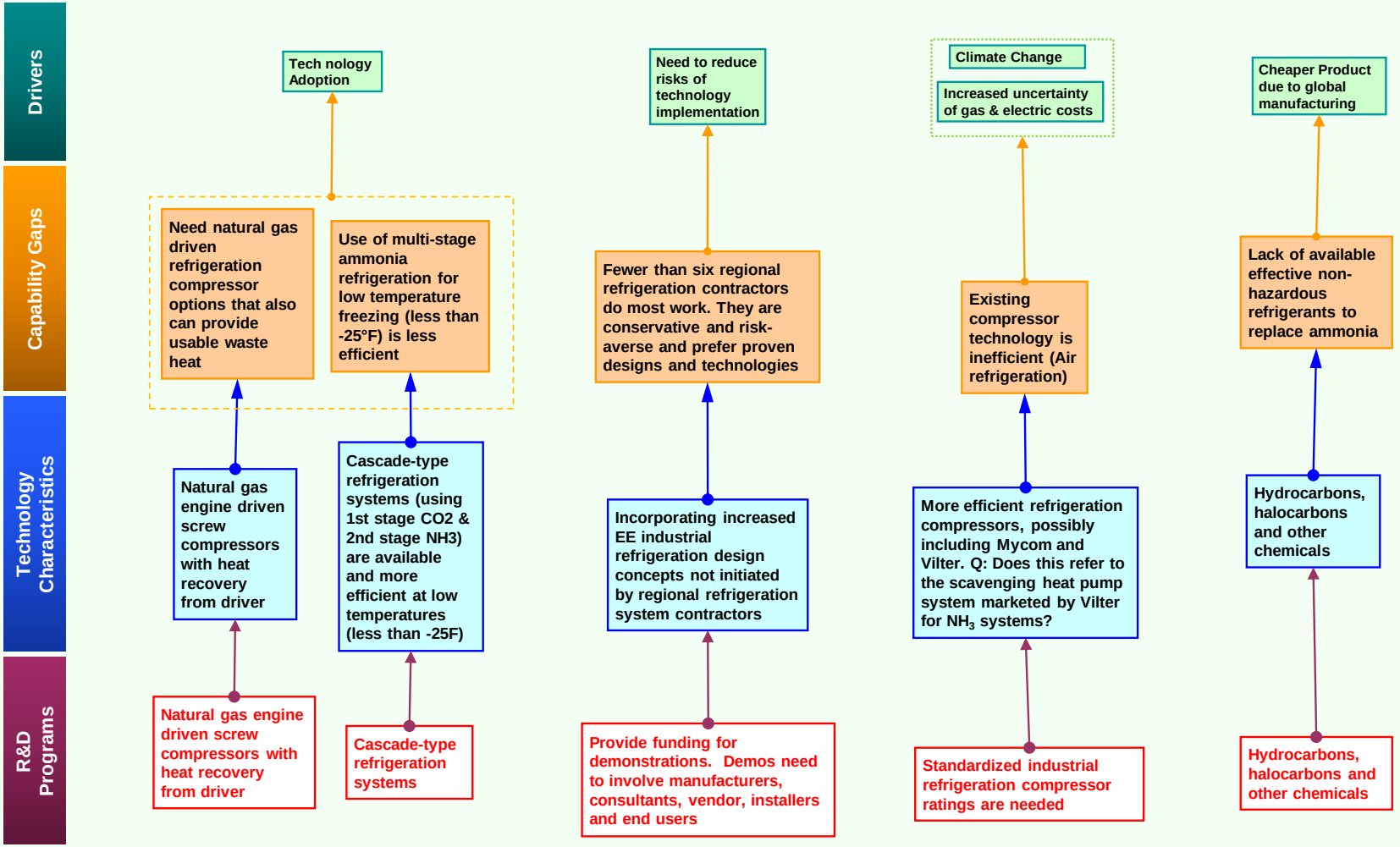
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Cooling (2 of 4)**

See "Technology Area Definitions" section



Driver: Capability Gap: | Commercially Available: Commercially Unavailable: | R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration; Existing R&D Program or Project:

R&D Program Summaries

Standardized industrial refrigeration compressor ratings are needed. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Provide funding for demonstrations. Demos need to involve manufacturers, consultants, vendor, installers and end users.

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Natural gas engine driven screw compressors with heat recovery from driver. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Cascade-type refrigeration systems. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Hydrocarbons, halocarbons and other chemicals. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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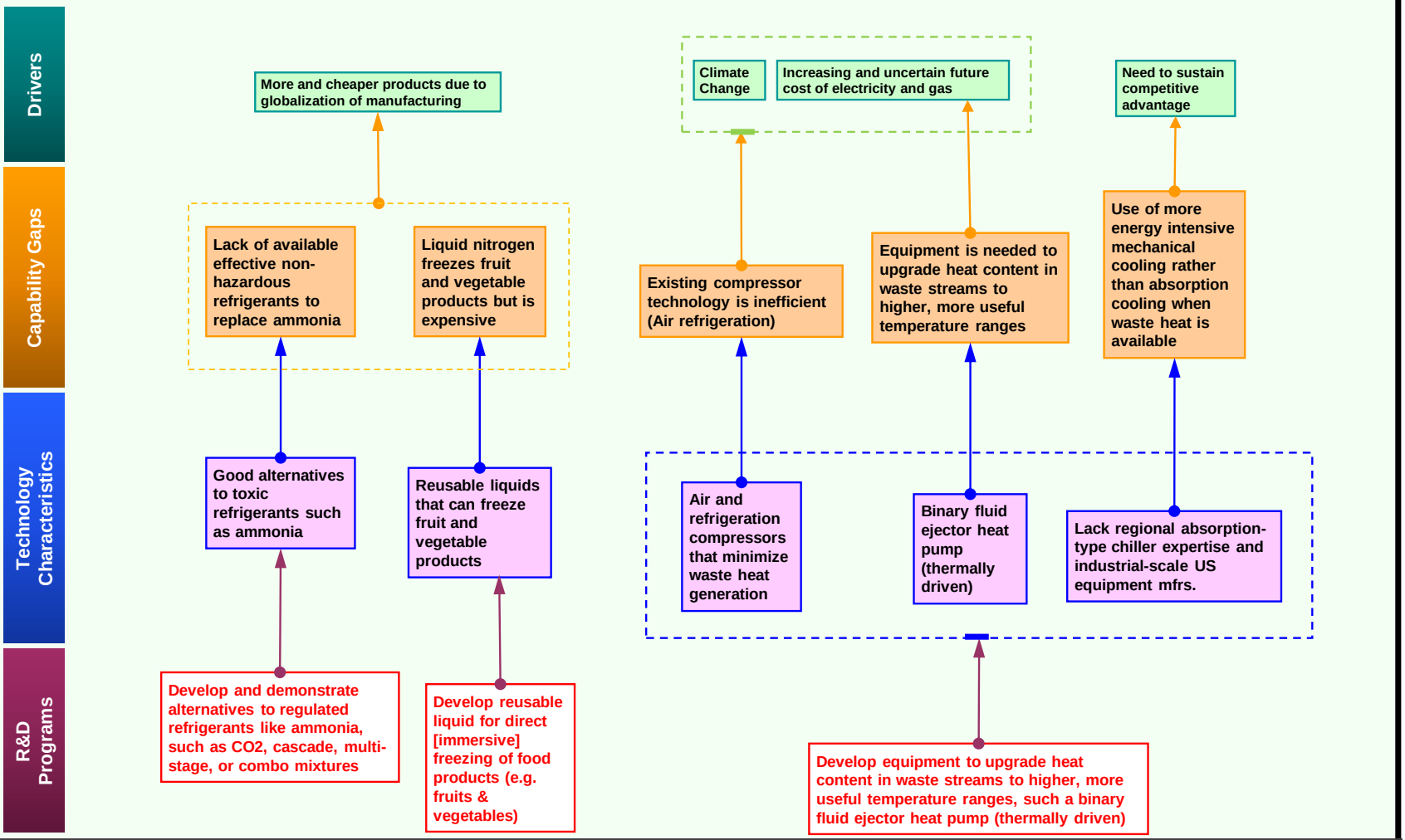
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Cooling (3 of 4)**

See "Technology Area Definitions" section



Driver: Capability Gap: Commercially Available: Commercially Unavailable: R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration; Existing R&D Program or Project:

R&D Program Summaries

Develop reusable liquid for direct [immersive] freezing of food products (e.g. fruits & vegetables). (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Develop equipment to upgrade heat content in waste streams to higher, more useful temperature ranges, such a binary fluid ejector heat pump (thermally driven). (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Develop and demonstrate alternatives to regulated refrigerants like ammonia, such as CO2, cascade, multi-stage, or combo mixtures. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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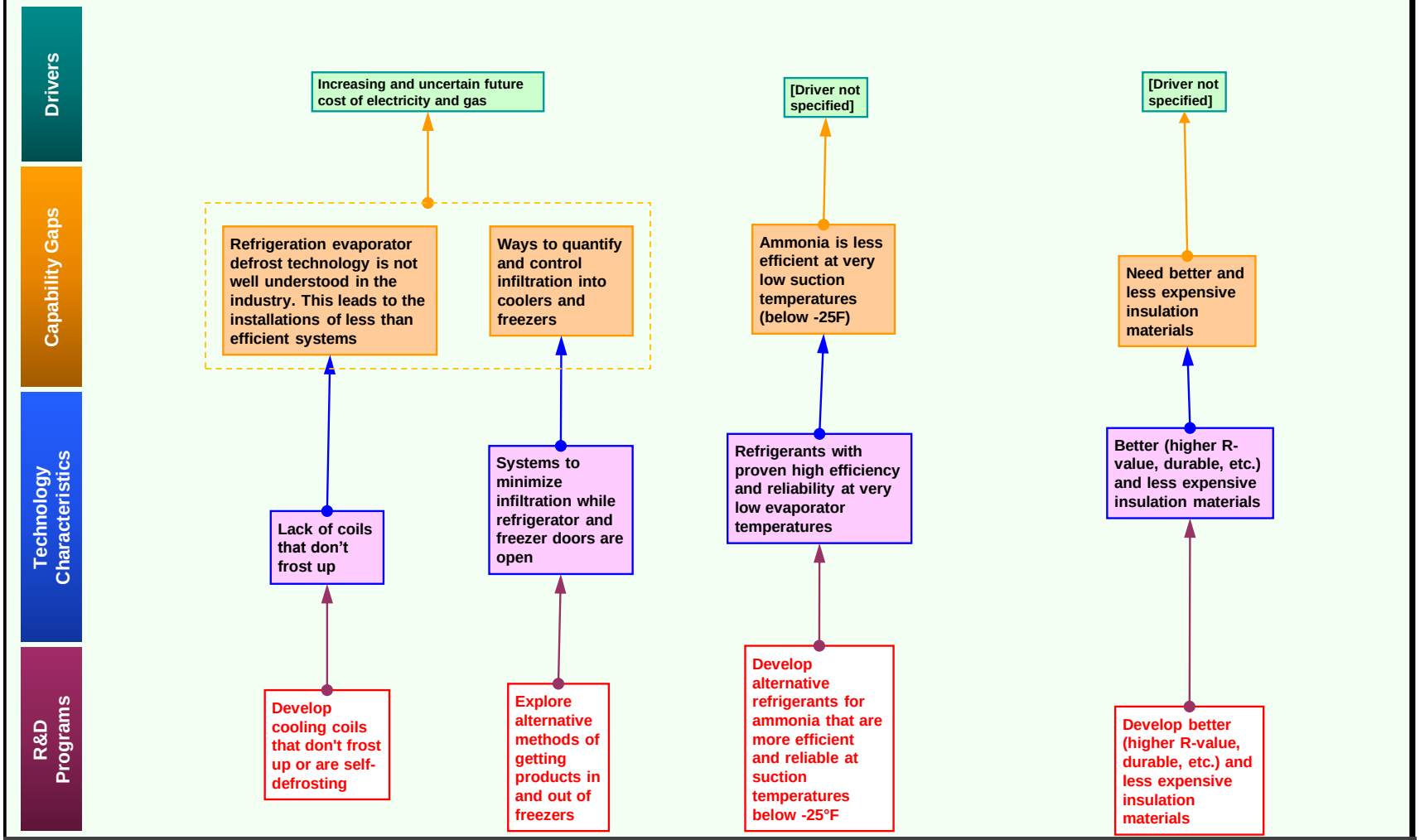
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Cooling (4 of 4)**

See "Technology Area Definitions" section



Driver:

Capability Gap:

Commercially Available:

Commercially Unavailable:

R&D Program Requirement: No Explicit Systems Integration | Explicit Systems Integration

Existing R&D Program or Project:

R&D Program Summaries

Explore alternative methods of getting products in and out of freezers. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Develop cooling coils that don't frost up or are self-defrosting.
Summary.

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Develop better (higher R-value, durable, etc.) and less expensive insulation materials. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Develop alternative refrigerants for ammonia that are more efficient and reliable at suction temperatures below -25°F.
(Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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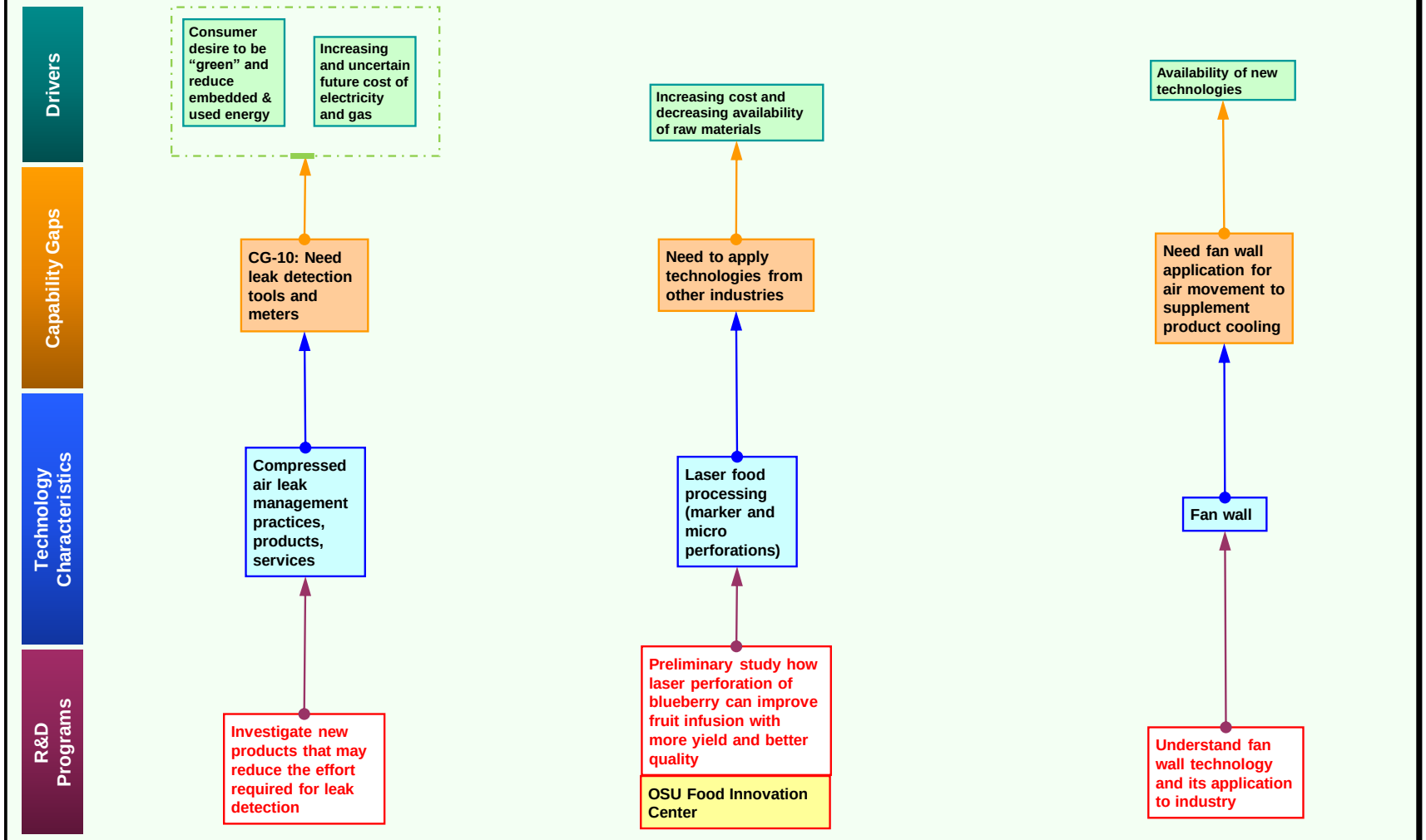
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Mechanical (1 of 5)**

See "Technology Area Definitions" section



Driver: Capability Gap: Commercially Available: Commercially Unavailable: R&D Program Requirement: No Explicit Systems Integration Explicit Systems Integration Existing R&D Program or Project:

R&D Program Summaries

Preliminary study how laser perforation of blueberry can improve fruit infusion with more yield and better quality. (Summary not yet provided.)

Existing research: Ongoing R&D in this area at Oregon State University's Food Innovation Center (http://fic.oregonstate.edu/).

Key research questions:

1. Questions not yet specified.

Investigate new products that may reduce the effort required for leak detection. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

Understand the fan wall technology and its application to industry. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified.

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Product/Service Area :

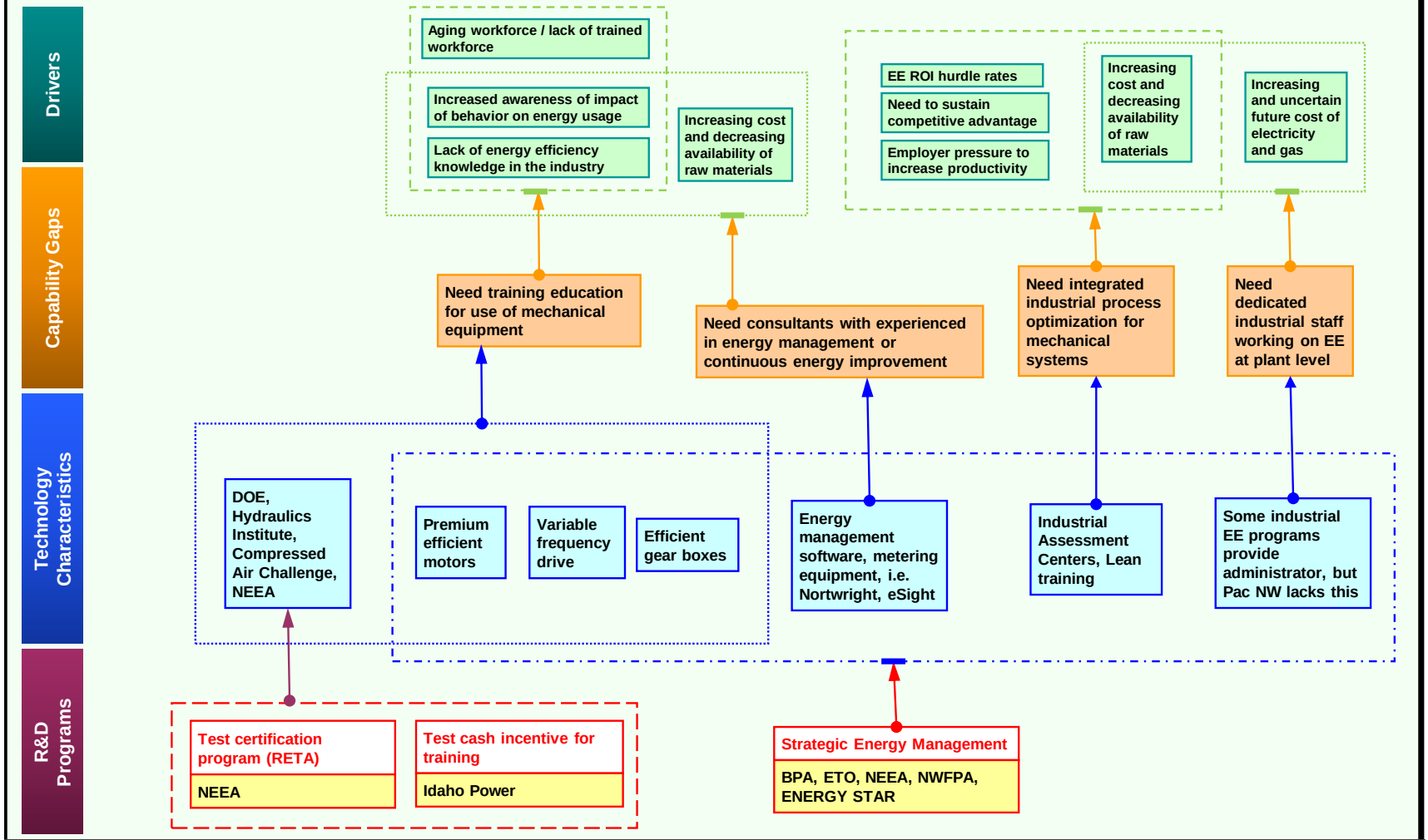
INDUSTRIAL FOOD PROCESSING

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap:

Mechanical (2 of 5)

See "Technology Area Definitions" section



Driver:
Capability Gap:
Commercially Available:
Commercially Unavailable:
R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration
Existing R&D Program or Project:

R&D Program Summaries

Strategic Energy Management. Strategic Energy Management (SEM) is an approach of industrial energy management that combines (1) embedding energy efficiency in the organization's culture, (2) assisting organizations identify low-cost energy efficiency opportunities, and (3) measuring the impact of their actions.

The Pacific Northwest has settled on a common SEM curriculum. A cluster of non-competitive industries is coached through a year of monthly, half-day energy management training sessions. The training sessions are supplemented by a minimum of three site visits. These site visits identify major energy users (energy drivers), ensure executive engagements, and engage employees. To measure the energy savings utility meter and production data is collected and an energy model is developed.

SEM programs are scaled to large industrial sites. Utilities can invest up to $50,000 to train the site and develop the energy model because of the large potential for savings. On average sites enrolled in SEM program reduce their energy consumption by 7.5%. Large organizations can assign an individual to attend training and manage energy.

Existing research: The Northwest Energy Efficiency Alliance (NEEA), the ENERGY STAR program, Bonneville Power Administration (BPA), and the Northwest Food Processors Association (NWFPA) are involved in developing Strategic Energy Management solutions.

There is internal and national consensus on the requirements for an SEM program. In 2011 , the International Organization for Standardization (ISO) released the specification of an energy management system (50001). ISO 50001 is an auditable standard for energy management systems designed to improve energy performance. ISO 50001 is widely adopted in Germany. Initially adoption in North America has been limited to companies with European headquarters.

US Department of Energy (US DOE) developed Superior Energy Performance (SEP) help set energy performance goals and a method for measuring energy savings. BPA signed an agreement with US DOE to participate in the SEP accelerator. If BPA can find a utility and industry that wants to participate in SEP, BPA will combine SEP with the High Performance Energy Management (HPEM) program.

BPA worked with US DOE to define the method of measuring energy savings. BPA posts these requirements in BPA Measuring Tracking & Reporting (MT&R) Guidelines. The MT&R Guidelines are published on BPA's web sites. In 2011, BPA contracted an impact evaluation of the MT&R Guidelines. This is the only impact evaluation of energy management measurement guidelines that BPA is aware of.

The Energy Trust of Oregon (ETO) runs a small-to-medium SEM pilot. The pilot is very similar to large SEM.NEEA developed Online SEM, web-based SEM training. Online SEM has not been tested without significant in-person coaching or with rigorous energy savings measurement. Online SEM is not customizable—content can not be tailored to an individual site.

- NEEA's work in this area includes a Strategic Energy Management study they released in January 2012; see http://neea.org/research/reportdetail.aspx?ID=1619.
- ENERGY STAR Strategic Energy Management approach: http://www.energystar.gov/index.cfm?c=guidelines.guidelines_index.
- For SEM at BPA, see http://www.bpa.gov/energy/n/industrial/index.cfm.
- NWFPA's work in this area can be found at http://www.nwfpa.org/nwfpa.info/component/content/article/37-boiler/55--energy-roadmap-projects-put-nwfpa-membership-on-the-road

Key research questions:

1. Questions not yet specified.

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Test cash incentive for training. (Summary not yet provided.)

Existing research: Stakeholders indicated that the Northwest Energy Efficiency Alliance (NEEA) is working in this area; see http://neea.org/.

Key research questions:

1. Questions not yet specified.

Test certification program. (Summary not yet provided.)

Existing research: See programs at RETA and NEEA.

- Refrigerating Engineers & Technicians Association (RETA), http://www.reta.com/.
- Northwest Energy Efficiency Alliance (NEEA); http://neea.org/.

Key research questions:

1. Questions not yet specified.

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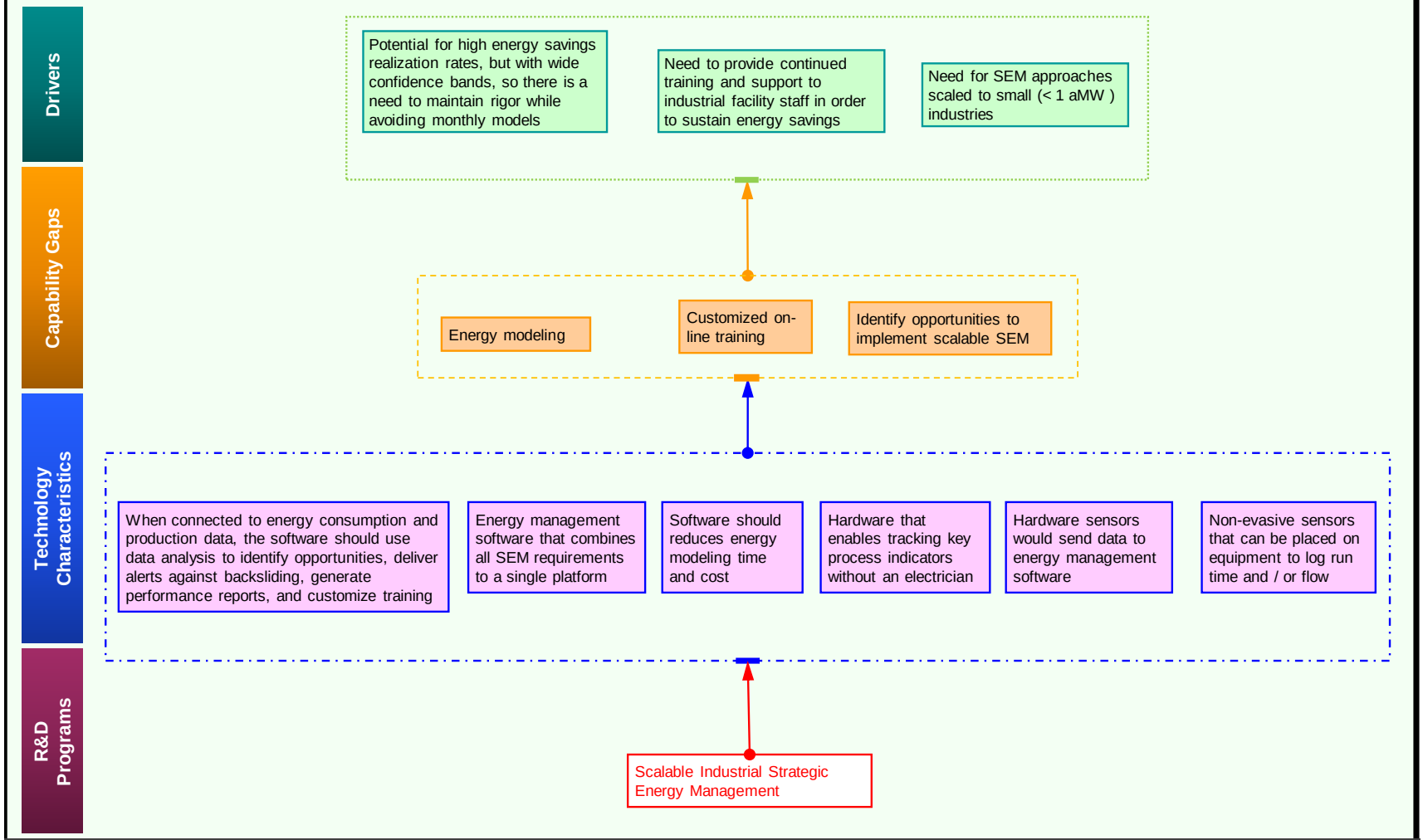
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Mechanical (3 of 5)**

See "Technology Area Definitions" section



Driver: Capability Gap: Commercially Available: Commercially Unavailable: R&D Program Requirement: No Explicit Systems Integration Explicit Systems Integration Existing R&D Program or Project:

R&D Program Summaries

Scalable Industrial Strategic Energy Management. Strategic Energy Management (SEM) is an approach of industrial energy management that combines (1) embedding energy efficiency in the organization's culture, (2) assisting organizations identify low-cost energy efficiency opportunities, and (3) measuring the impact of their actions.

The Pacific Northwest has settled on a common SEM curriculum. A cluster of non-competitive industries is coached through a year of monthly, half-day energy management training sessions. The training sessions are supplemented by a minimum of three site visits. These site visits identify major energy users (energy drivers), ensure executive engagements, and engage employees. To measure the energy savings utility meter and production data is collected and an energy model is developed.

SEM programs are scaled to large industrial sites. Utilities can invest up to $50,000 to train the site and develop the energy model because of the large potential for savings. On average sites enrolled in SEM program reduce their energy consumption by 7.5%. Large organizations can assign an individual to attend training and manage energy.

To address small industrial end users, SEM programs need to reduce the utilities' financial commitment and end-users' time commitment. For utilities to continue to meet industrial energy management targets for energy efficiency they will need technologies that scale energy management cost effectively for small (< 1 aMW) and medium facilities.

Existing research: There is internal and national consensus on the requirements for an SEM program. In 2011 , the International Organization for Standardization (ISO) released the specification of an energy management system (50001). ISO 50001 is an auditable standard for energy management systems designed to improve energy performance. ISO 50001 is widely adopted in Germany. Initially adoption in North America has been limited to companies with European headquarters.

US Department of Energy (US DOE) developed Superior Energy Performance (SEP) help set energy performance goals and a method for measuring energy savings. BPA signed an agreement with US DOE to participate in the SEP accelerator. If BPA can find a utility and industry that wants to participate in SEP, BPA will combine SEP with the High Performance Energy Management (HPEM) program.

BPA worked with US DOE to define the method of measuring energy savings. BPA posts these requirements in BPA Measuring Tracking & Reporting (MT&R) Guidelines. The MT&R Guidelines are published on BPA's web sites. In 2011, BPA contracted an impact evaluation of the MT&R Guidelines. This is the only impact evaluation of energy management measurement guidelines that BPA is aware of.

The Energy Trust of Oregon (ETO) runs a small-to-medium SEM pilot. The pilot is very similar to large SEM. Most participants are "medium." ETO also can apply gas savings. It is difficult for BPA to apply lessons from ETO's small-to-medium SEM pilot to small industrial sites.

NEEA developed Online SEM, web-based SEM training. Online SEM has not been tested without significant in-person coaching or with rigorous energy savings measurement. Online SEM is not customizable—content can not be tailored to an individual site.

In 2014 BPA will offer Small Industrial HPEM—a pilot small SEM program—to 10 industrial sites. The goal of the pilot is test theories about online training, enabling technologies that may improve small SEM cost effectiveness.

Key research questions:

1. Hardware: Can non-evasive sensors be used to track key process indictors and communication with an energy management software platform?
2. Hardware: Do non-evasive sensors reduce the cost of energy modeling?
3. Software: Can energy modeling, individual coaching, training modules, and reporting be combined on a single software platform?
4. Software: Does combining all energy management functions on a single platform increase energy savings and reduce program cost?
5. Coaching / Behavior Change: What combination of alerts, messaging, and training is most effective for establishing energy efficiency in organization's culture?
6. Coaching / Behavior Change: What data sources and analysis are needed to enable customized alerts, messages, and training?

Product/Service Area :

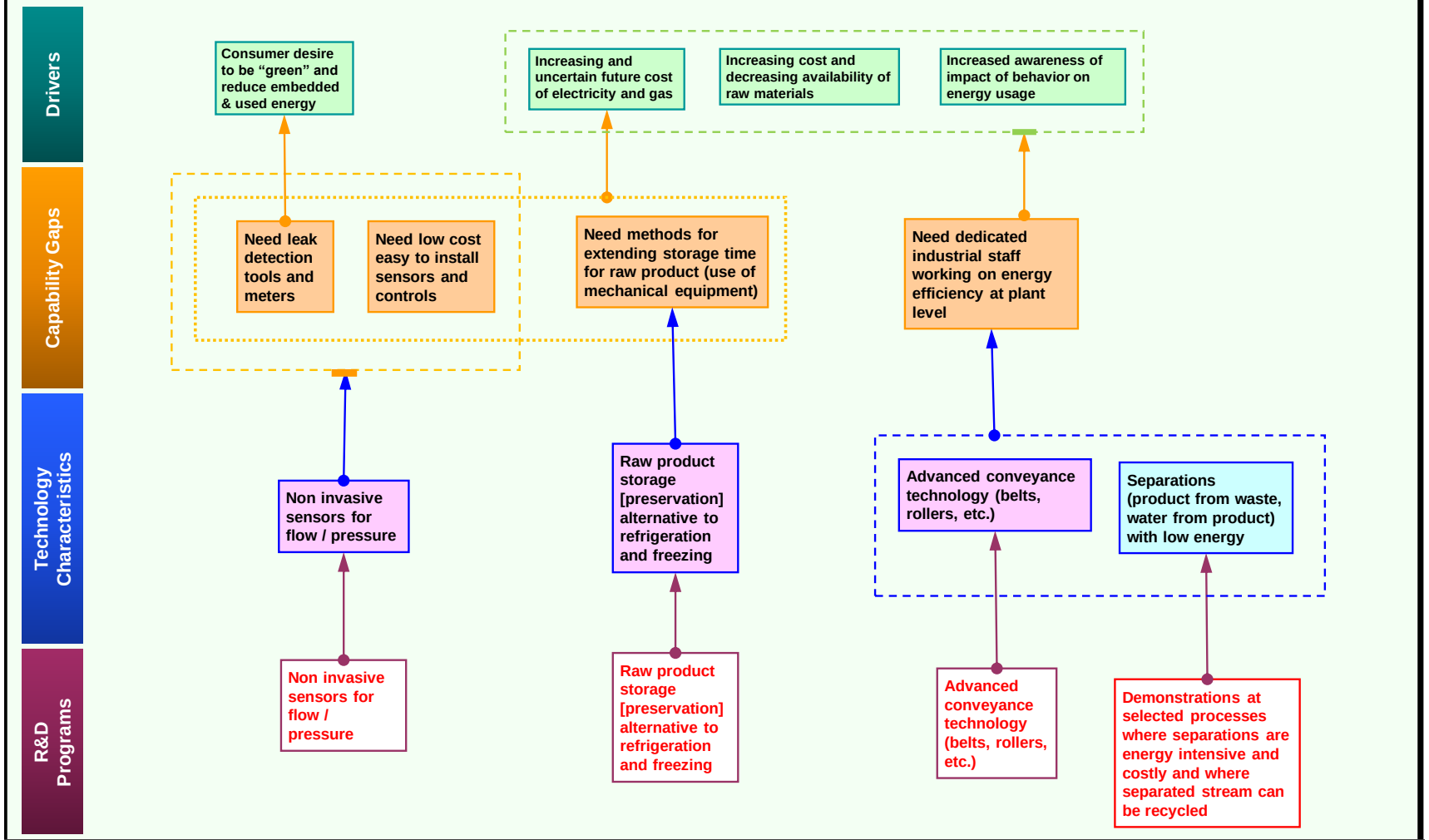
INDUSTRIAL FOOD PROCESSING

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap:

Mechanical (4 of 5)

See "Technology Area Definitions" section



Driver:

Capability Gap:

Commercially Available:

Commercially Unavailable:

R&D Program Requirement: No Explicit Systems Integration | Explicit Systems Integration

Existing R&D Program or Project:

R&D Program Summaries

Advanced conveyance technology (belts, rollers, etc.). (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

Demonstrations at selected processes where separations are energy intensive and costly and where separated stream can be recycled. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

Non invasive sensors for flow / pressure. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

Raw product storage [preservation] alternative to refrigeration and freezing. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

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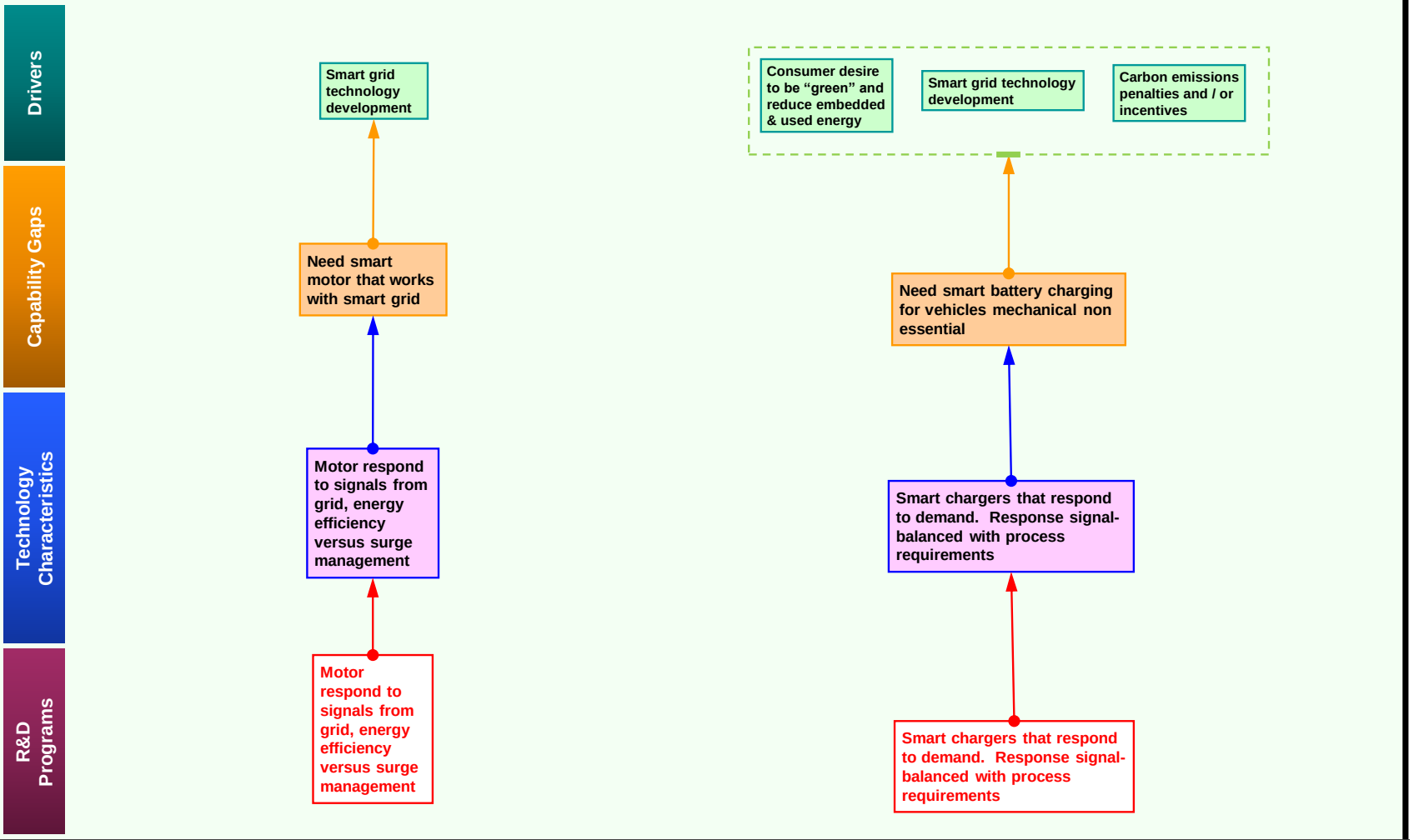
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Mechanical (5 of 5)**

See "Technology Area Definitions" section



Driver:

Capability Gap:

Commercially Available:

Commercially Unavailable:

R&D Program Requirement: No Explicit Systems Integration | Explicit Systems Integration

Existing R&D Program or Project:

R&D Program Summaries

Motor respond to signals from grid, energy efficiency versus surge management. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

Smart chargers that respond to demand. Response signal-balanced with process requirements. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

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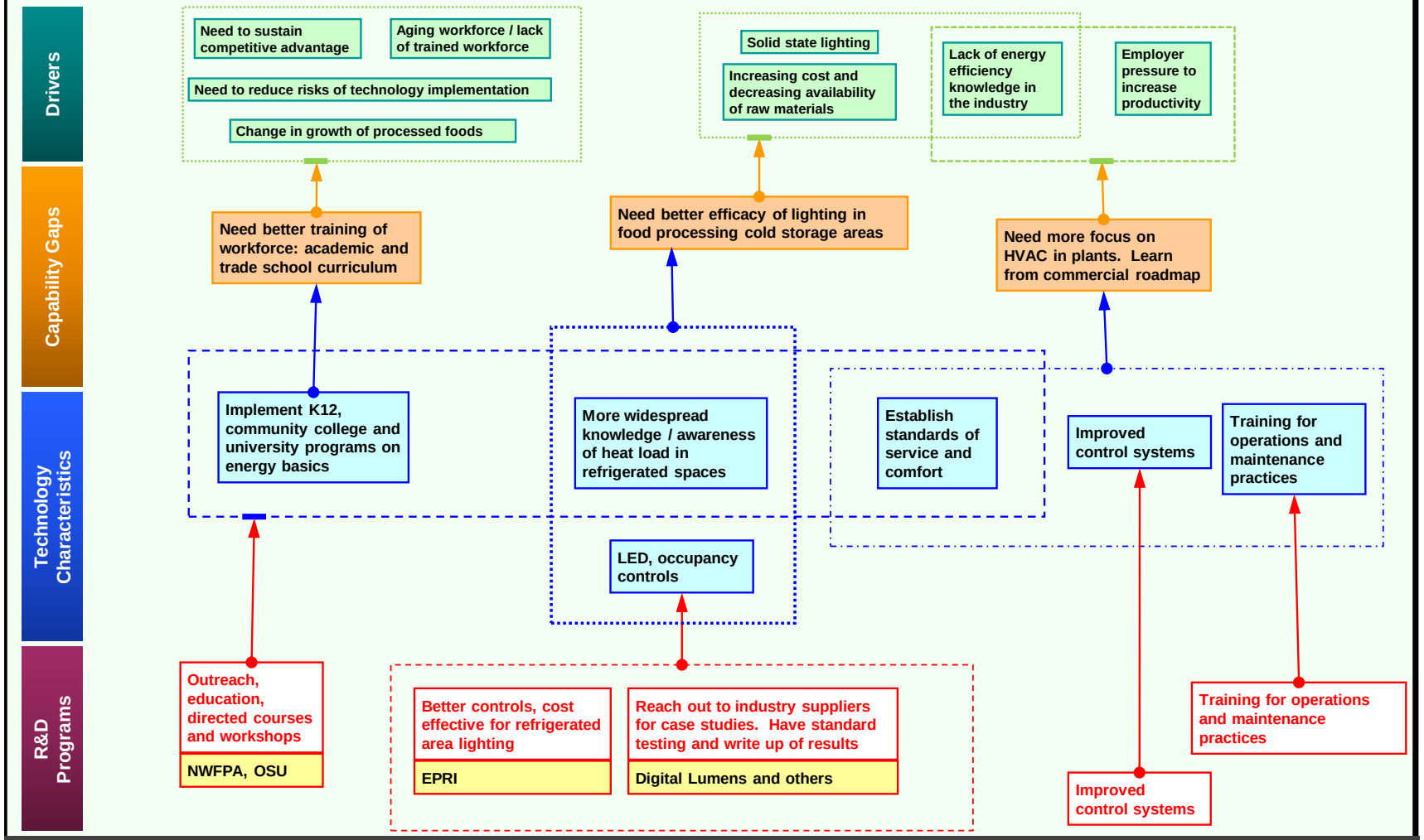
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Infrastructure (1 of 6)**

See "Technology Area Definitions" section



Driver: Capability Gap: | Commercially Available: Commercially Unavailable: | R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration; Existing R&D Program or Project:

R&D Program Summaries

Better controls, cost effective for refrigerated area lighting. (Summary not yet provided.)

Existing research: Ongoing R&D at the Electric Power Research Institute (EPRI, http://et.epri.com/index.html).

Key research questions:

1. Questions not yet specified

Outreach, education, directed courses and workshops. (Summary not yet provided.)

Existing research: Ongoing R&D at the Northwest Food Processors Association (NWFPA, http://www.nwfpa.org/) and in Oregon State University's (OSU) Department of Food Science and Technology (http://oregonstate.edu/dept/foodsci/extservices/ext_index.htm).

Key research questions:

1. Questions not yet specified

Reach-out to industry suppliers for case studies. Have standard testing and write up of results

Existing research: Stakeholders indicated ongoing R&D at Digital Lumens (www.digitallumens.com) and others.

Key research questions:

1. Questions not yet specified

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Product/Service Area :

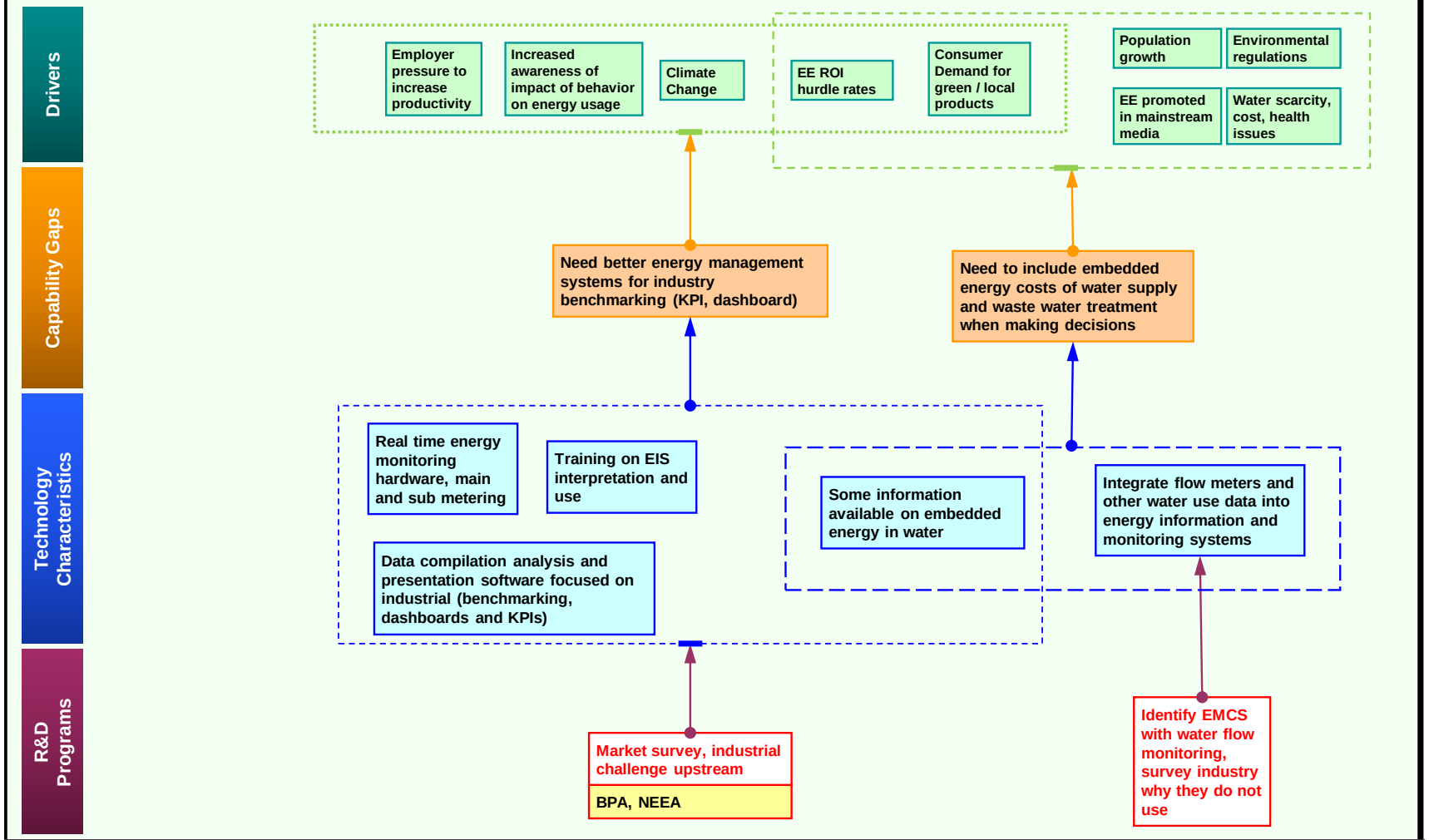
INDUSTRIAL FOOD PROCESSING

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap:

Infrastructure (2 of 6)

See "Technology Area Definitions" section



Driver: Capability Gap: | Commercially Available: Commercially Unavailable: | R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration; Existing R&D Program or Project:

R&D Program Summaries

Market survey, industrial challenge upstream. (Summary not yet provided.)

Existing research: Ongoing R&D at the Bonneville Power Administration's (BPA) Energy Efficiency department (http://www.bpa.gov/Energy/N/) and the Northwest Energy Efficiency Alliance (NEEA, http://neea.org/).

Key research questions:

1. Questions not yet specified

Identify EMCS with water flow monitoring, survey industry why they do not use. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

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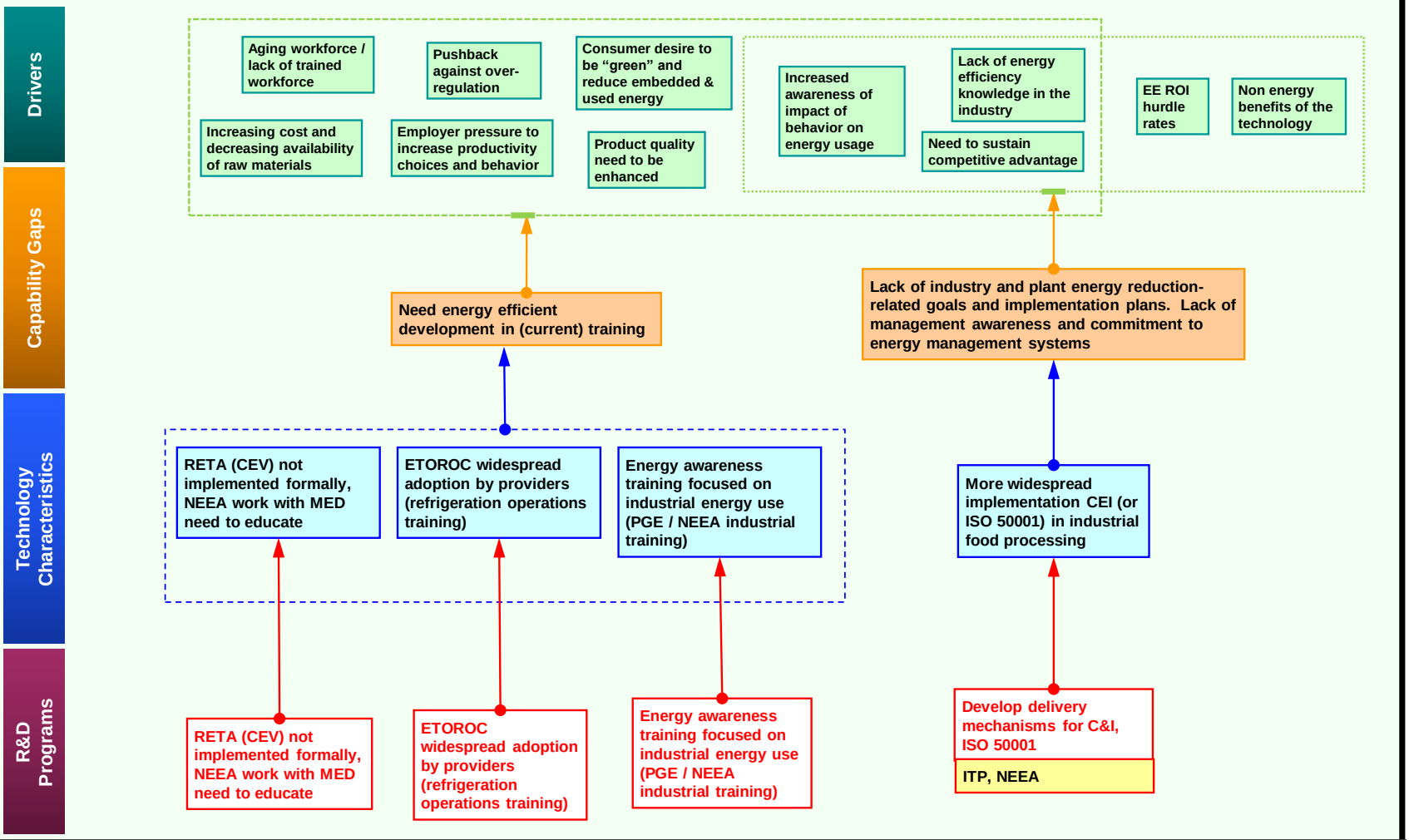
Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Infrastructure (3 of 6)**

See "Technology Area Definitions" section



Driver: Capability Gap: | Commercially Available: Commercially Unavailable: | R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration | Existing R&D Program or Project:

R&D Program Summaries

Develop delivery mechanisms for C&I, ISO 50001. (Summary not yet provided.)

Existing research: Research in this area is ongoing at the U.S. Department of Energy's (DOE) Advanced Manufacturing Office (AMO, formerly known as the Industrial Technologies Program or ITP; see http://www1.eere.energy.gov/ manufacturing/) and Northwest Energy Efficiency Alliance (NEEA, http://neea.org/).

Key research questions:

1. Questions not yet specified

RETA (CEV) not implemented formally, NEEA work with MED need to educate. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

ETOROC widespread adoption by providers (refrigeration operations training). (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

Energy awareness training focused on industrial energy use (PGE / NEEA industrial training). (Summary not yet provided.)

Existing research: None identified.

Key research questions:

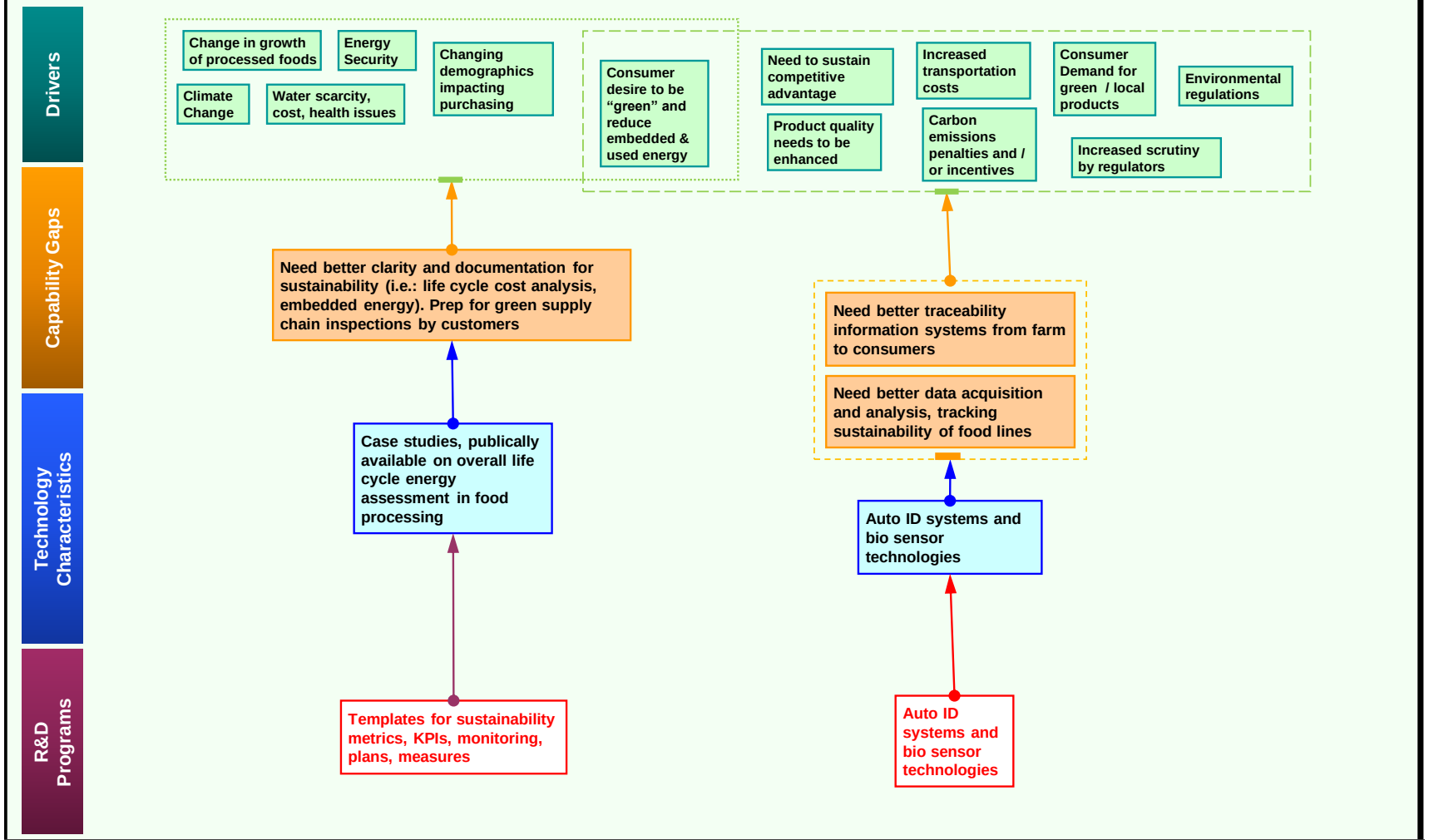
1. Questions not yet specified

Product/Service Area : **INDUSTRIAL FOOD PROCESSING**

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap: **Infrastructure (4 of 6)**

See "Technology Area Definitions" section



Driver: Capability Gap: | Commercially Available: Commercially Unavailable: | R&D Program Requirement: No Explicit Systems Integration / Explicit Systems Integration | Existing R&D Program or Project:

R&D Program Summaries

Templates for sustainability metrics, KPIs, monitoring, plans, measures. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

Auto ID systems and bio sensor technologies. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

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Product/Service Area :

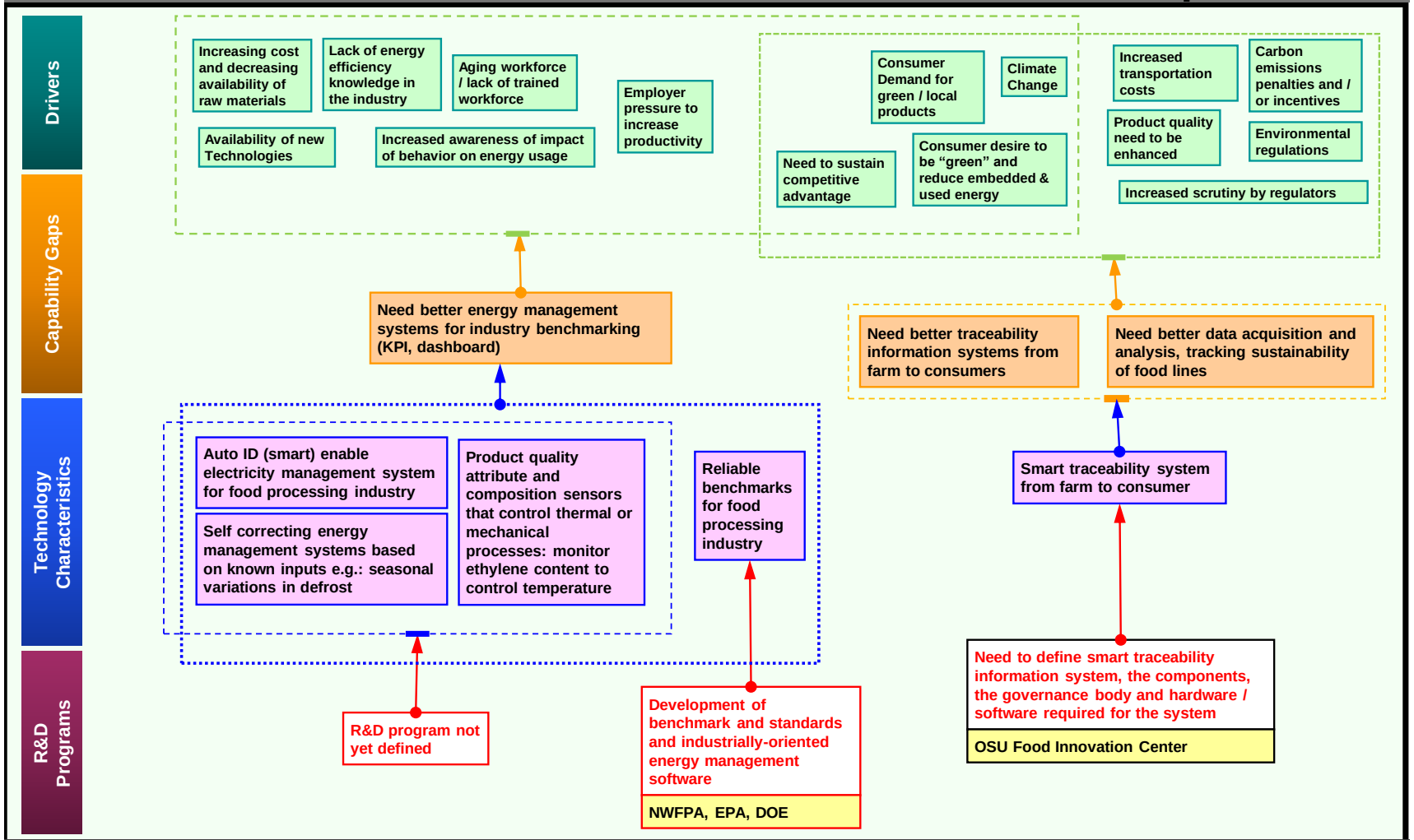
INDUSTRIAL FOOD PROCESSING

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap:

Infrastructure (5 of 6)

See "Technology Area Definitions" section



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Capability Gap:

Commercially Available:

Commercially Unavailable:

R&D Program Requirement: No Explicit Systems Integration | Explicit Systems Integration

Existing R&D Program or Project:

R&D Program Summaries

Development of benchmark and standards and industrially-oriented energy management software. (Summary not yet provided.)

Existing research: Research ongoing at the Northwest Food Processors Association (NWFPA, http://www.nwfpa.org/) and at the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) [is this EPA-DOE collaboration the ENERGY STAR program? See http://www.energystar.gov/ index.cfm?c=home.index).

Key research questions:

1. Questions not yet specified

Need to define smart traceability information system, the components, the governance body and hardware/software required for the system. (Summary not yet provided.)

Existing research: Research is ongoing at the Oregon State University (OSU) Food Innovation Center (http://fic.oregonstate.edu/).

Key research questions:

1. Questions not yet specified

R&D program not defined. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

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Product/Service Area :

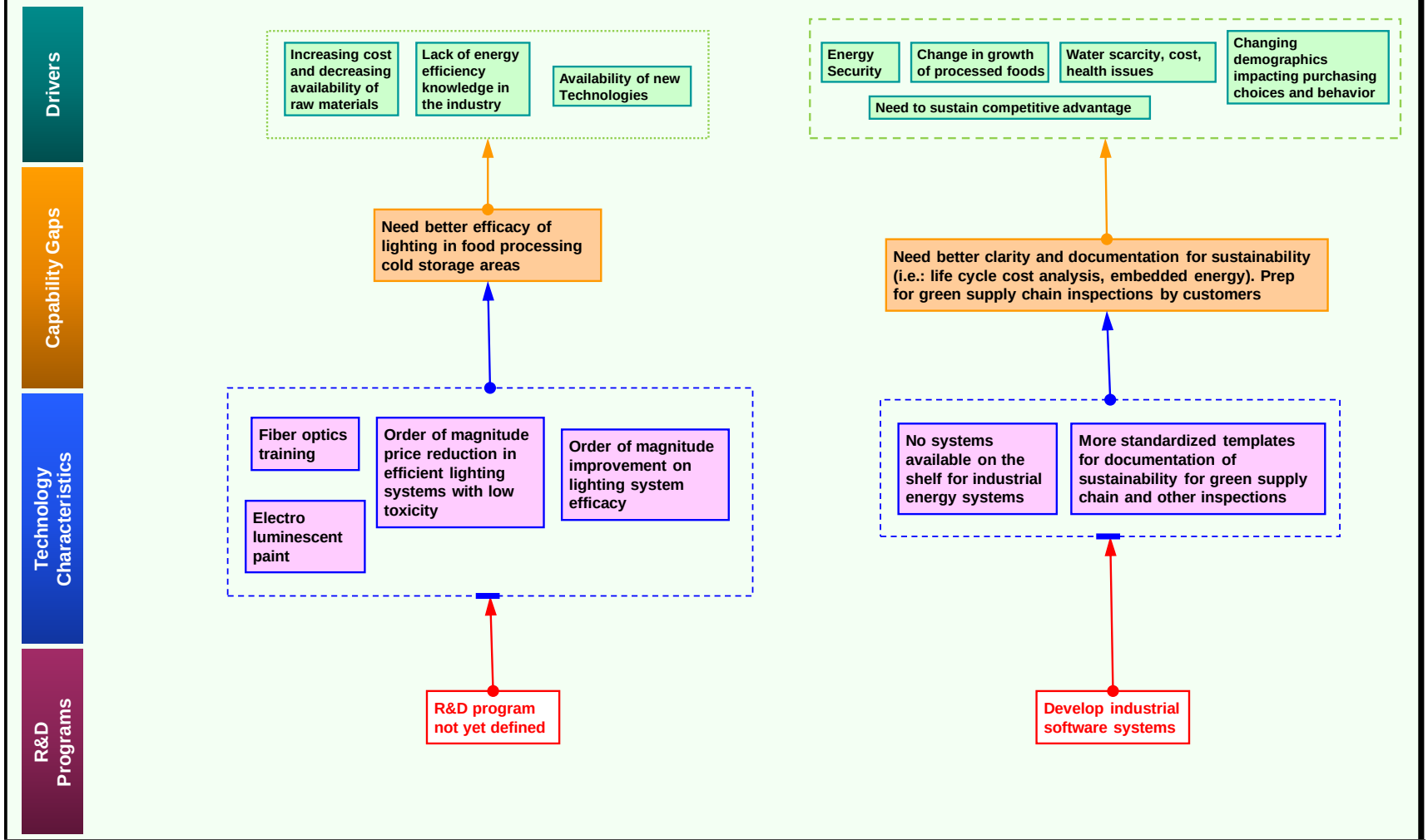
INDUSTRIAL FOOD PROCESSING

National Energy Efficiency Technology Roadmap Portfolio

Technology Roadmap:

Infrastructure (6 of 6)

See "Technology Area Definitions" section



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Capability Gap:

Commercially Available:

Commercially Unavailable:

R&D Program Requirement: No Explicit Systems Integration | Explicit Systems Integration

Existing R&D Program or Project:

R&D Program Summaries

Develop industrial software systems. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

R&D program not defined. (Summary not yet provided.)

Existing research: None identified.

Key research questions:

1. Questions not yet specified

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