Emission Reduction Measurement and Monitoring Methodology for the Conversion of Foam Blowing Agents from High-GWP Materials to Low-GWP Materials

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1.0 BACKGROUND AND APPLICABILITY

1.1 Summary Description of the Methodology

Certain sectors and technologies in the foam manufacturing industry use blowing agents (BAs) containing hydrofluorocarbons (HFCs), which have high-global warming potentials (GWPs). Alternative BAs with low-GWPs are available and can be substituted thereby reducing the associated greenhouse gas (GHG) emissions without impacting performance. This Methodology provides the quantification framework for the creation of carbon offset credits (offsets) from the resulting reduction in GHGs and is intended to be used as an incentive for the industry to make the transition.

The Methodology uses a performance standard approach for the inclusion of foam sectors. It is based on a robust data set and the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) methodology for avoidance of HFC emissions in foam manufacturing

Market information currently shows that the Rigid PUF and XPS sectors and associated technologies are eligible under the Methodology. Additional sectors and technologies may be added during future revisions of this Methodology.

1.2 Definitions and Acronyms

If not explicitly defined here, the current definitions in the latest version of the American Carbon Registry (ACR) Standard apply.

Table 2: Definitions

Term	Acronym (if applicable)	Definition
Baseline activity		The use of a high-GWP BA in the manufacture of foam.
Blowing agent	BA	The material used to propel foam mixture for its required use. BAs have a GWP that can range from low to high.
Building materials		Foam materials used in building construction.
Carbon dioxide equivalent	CO_2e	A standard unit of measure to express the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of global warming.
Carbon offset credits	Offsets	A carbon offset is a reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for or to offset an emission made elsewhere.

Term	Acronym (if applicable)	Definition
Continuous laminated boardstock		Foam panels generally used for applications like roofs. The majority of these panels are produced using Pentane, a BA which is not a qualifying low-GWP BA, as defined by this Methodology.
Eligible foam sector		Those sectors within foam manufacturing for which the demonstrable adoption rate of a low-GWP BA is sufficiently low compared that of high-GWP BAs used in that sector.
End of life	EOL	The emissions associated with the destruction of the foam. As opposed to the emissions associated with manufacturing and use.
Extruded polystyrene	XPS	Rigid foam insulation technology generally used to form boards.
Foam manufacturing		The process of combining a BA with a foam system to produce foam. The process may be conducted to produce a product either in a manufacturing facility or at a construction location for insulation, stabilization or other commercial functions.
Global warming potential	GWP	An index that attempts to integrate the overall climate impacts of a specific action (e.g., emissions of CH_4, NO_x or aerosols). It relates the impact of emissions of a gas to that of emission of an equivalent mass of CO_2.
Hydrocarbon	HC	An organic compound containing only hydrogens and carbons (eg, Pentane, C3H8).
Hydrofluorocarbon	HFC	A gaseous compound that contains carbon, fluorine, and hydrogen. Most common HFCs used in foam blowing are HFC-134a, HFC-152a, HFC-365mfc and HFC-245fa.
Low global warming potential material	Low-GWP material	A BA used for manufacturing of foam that has a GWP of less than 5.

Term	Acronym (if applicable)	Definition
Project activity		The use of a low-GWP BA instead of a high-GWP BA pursuant to this Methodology.
Polyurethane foam	PUF	Foam created through the mix of polyurethane and a BA.
Polyurethane spray foam	PU spray	PU spray involves a gun, nozzle or straw and forms a foam as the ingredient chemicals are blended together. It is frequently used in applications to improve or create insulating capacities into existing as well as new buildings. It is also used in other insulating situations where the insulating properties can be blown in or tailored to odd shapes. It also has other uses in the construction sector such as in stabilizing trenches.
Rigid polyurethane foam	Rigid PUF	Polyurethane foam generally used for insulation and building materials.

1.3 Applicability Conditions

Projects that avoid the emissions of HFC gases used in BAs during the production of foam are considered a “Project Activity” under this Methodology. This is done through BA product replacement of a high-GWP material with a low-GWP material.

In addition to satisfying the latest ACR program eligibility requirements as found in the *ACR Standard*, Project Activities must satisfy the following conditions for this Methodology to be applicable:

(a) The project is located in North America

(b) The project activity uses a low-GWP BA to replace a high-GWP BA, such as HFC-134a or HFC-245fa, that are used in the baseline activity. For purposes of this Methodology, a “low-GWP BA” is a material which has a GWP of less than 5 and which can lawfully be used as a BA in the production of foam.

(c) The project activity does not use a hydrocarbon (HC) based substitute BA. While HC based BAs have a lower GWP than HFCs, they contribute to the formation of tropospheric ozone and pose unique safety issues when used as BAs.

(d) The project is within a foam sector (Rigid PUF or XPS) which has a low adoption rate of a low-GWP BA.

1.4 Crediting Periods

The crediting period shall be ten years. The Methodology's quantification approach is based upon a UNFCCC small system method which allows for a ten-year crediting period and which excluded any calculation of end of life (EOL) emissions. Because most of the emissions are during manufacturing, and in light of the *ex post* emission calculations, this method will deliver offsets, on average, after the vast majority of real reductions have occurred and as to which, the future reductions are also well known.

1.5 Periodic Reviews and Revisions

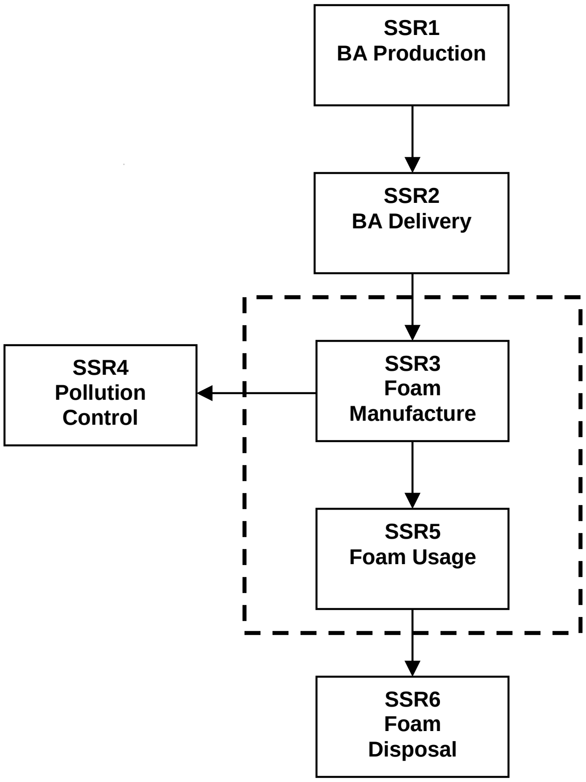
ACR may require revisions to this Methodology to ensure that monitoring, reporting, and verification systems adequately reflect changes in the project's activities. This Methodology may also be periodically updated to reflect regulatory changes, emission factor revisions, or expanded applicability criteria. Before beginning a project, the project proponent should ensure that they are using the latest version of the Methodology.

2.0 PROJECT BOUNDARIES

The project boundary is narrow and focuses on the specific manufacturing locations at which the foam is produced. In certain instances the low-GWP BA may be delivered pre-mixed, with a polyol, or with the isocyanate, to the manufacturing site. The BA may also be delivered in pure form to the manufacturing site, at which point it is then mixed or blended before producing the foam. The monitoring plan shall reflect the particular manner in which the BA is delivered and the foam manufacturing occurs.

2.1 Geographic Boundary

The project boundary is the physical and geographical site where foam manufacturing and/or foam usage takes place in the project. The project boundary for the project activity is illustrated below:



For manufacturing that is at a construction site involving the use of a BA to create foam, such as for PU spray, the project boundary includes the building location or site at which the construction activity is occurring.

Within the boundary, the only source of GHG emissions is from the use of the BA.   Table 5 shows some emission rates from the BA, both during the initial manufacturing process and during subsequent years of the crediting period.

The BA is entirely used within the boundary and there is no reservoir of remaining BA. Similarly, there is no sink.

Table 3 - Greenhouse gases

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method
1	BA Production	Fossil fuel emissions from the production of foam BAs.	CO_2	E	N/A
			CH_4	E	N/A
		HFC leaks during BA production.	HFCs	E	N/A
2	BA Delivery	HFC leaks of BA from delivery of BA.	HFCs	E	N/A
		Fossil fuel emissions from the delivery of BA.	CO_2	E	N/A
			CH_4	E	N/A
			N_20	E	N/A
3	Foam Manufacture	Emissions of HFCs from manufacture of foam materials in the baseline and project.	HFC	I	See Methodology
4	Pollution Control	Fossil fuel emissions from air pollution control equipment used in the baseline and project.	CO_2	E	N/A
			CH_4	E	N/A
			N20	E	N/A
5	Foam Usage	Emissions from the lifetime of foam in the baseline and project.	HFC	I	See Methodology
6	Foam Disposal	Fossil fuel emissions from the transport of foam to EOL.	CO_2	E	N/A
			CH_4	E	N/A
			N_20	E	N/A
		Emissions from the EOL (e.g., landfill) or destruction of foam material from a project.	HFC	E	N/A
			CO_2	E	N/A
			CH_4	E	N/A

3.0 BASELINE DETERMINATION AND ADDITIONALITY

3.1 Baseline Determination

The baseline for a project activity is determined utilizing industry standards. The baseline represents the most commonly used BA for the sector.

Table 4 below lists the default baseline GWP factor to be used for each sector, which represents the continued use of HFC containing, high-GWP BA in foam manufacturing. Project proponents must show that their project is in an eligible foam sector and uses the standardized baseline BA outlined below.

Table 4 – GWP of Baseline BAs

Foam Sector	Blowing Agent	GWP
Rigid PUF – Continuous laminated boardstock	Pentane	11
Rigid PUF – PU spray	HFC-245fa	1030[1]
Rigid PUF – All other	HFC-134a	1430
XPS	HFC-134a	1430

The EPA SNAP program has new regulations to limit HFC usage in foam manufacturing starting in 2017. The regulations will not affect PU spray but will affect all others by no longer allowing the use of HFC-134a or HFC-245fa. Thus, until 2017, the baseline for those sectors using HFC-134a will remain. After 2017, a revised baseline may be established for these sectors via a Methodology revision.

3.2 Additionality Assessment

Emission reductions from the project must be additional, or deemed not to occur in the "business-as-usual" scenario. Assessment of the additionality of a project will be made based on passing the two tests cited below. These two tests require the project proponent to demonstrate that the project activity is surplus to regulations and reduces emissions below the level established in the Methodology.

1. Regulatory Surplus Test, and
2. Practice-Based Performance Standard

3.2.1 Regulatory Surplus Test

In order to pass the regulatory surplus test a project must not be mandated by existing laws, regulations, statutes, legal rulings, or other regulatory frameworks in effect as of the project start date that directly or indirectly affect the credited GHG emissions associated with a project. The project proponent must demonstrate that there is no existing regulation that mandates the project or effectively requires the GHG emission reductions associated with the replacement of high-GWP BAs with alternative low-GWP BAs.

The proposed SNAP 20 rule by U.S.EPA will prohibit the use of HFC-134a starting in January 2017, if the rule is adopted as proposed. Following that time, the default baseline will be determined by the GWP of the BA predominantly used by the relevant sectors in place of HFC-134a. However, this rule does not affect PU spray, as there was not a demonstrated replacement or alternative BA to HFC-245fa.

3.2.2 Practice-Based Performance Standard

In order for a project to qualify for offsets under this Methodology it must be demonstrated that the project's sector and technology has a low market adoption rate for low-GWP BAs. A market adoption

[1] *IPCC, Fourth Assessment Report (100 year)*

analysis, and hence the additionality demonstration under Applicability Condition 1.3(d), was conducted for the listed sectors. Review of the California Air Resources Board (CARB) commissioned “Caleb Report”, review of the American Chemistry Council’s Center for Polyurethanes “2012 End-Use Market Survey”, review of the EPA proposed SNAP rule, and conversations with various regulatory bodies and industry experts provided evidence that these sectors have low market adoption rates for low-GWP BAs (see Appendix B). Therefore, project activities within these sectors and technologies qualify for offset creation under this Methodology.

Additional sectors may be added through revisions to this Methodology.

4.0 QUANTIFICATION OF GHG EMISSION REDUCTIONS

Quantification of project emission reductions requires calculation of baseline emissions and project emissions, which are calculated from emission factors derived from the chemical composition of the BA material used in the foam production (Table 5).

The emissions of HFC from the BA used in foam manufacturing occurs at three phases of the product lifecycle, (i.e. manufacture, use, and EOL). The EOL emissions of the foam are excluded from calculation in this Methodology and hence the calculated emission reductions only take into account emissions during manufacture and use.

Table 5 - Default Emission Factors

Foam Technology	Product Life in years	First year Loss (%)	Annual Loss (%)	Maximum Potential End-of-life loss (%)
XPS: HFC-134a	50	25	0.75	37.5
Rigid PUF - PU spray: HFC-245fa	50	15	1.5	10
Rigid PUF – All other (injected): HFC-134a	15	12.5	0.5	80
Rigid PUF – All other (discontinuous panel): HFC-134a	50	12.5	0.5	62.5
Rigid PUF – All other (continuous panel): HFC -134a	50	10	0.5	65
Rigid PUF – All other (appliance): HFC 134a	15	7	0.5	85.5
Rigid PUF – All other (integral skin): HFC 134a	12	95	2.5	0
Rigid PUF – Continuous laminated boardstock: Pentane	25	6	1	69
Source: Table 7.6 and Table 7.7, Page 7.37, Chapter 7: Emissions of fluorinated substitutes for Ozone depleting substances, Volume 3, Industrial Processes and Product Use, 2006 IPCC Guidelines for National Greenhouse Gas Inventories				

4.1 Baseline Emissions

The baseline emissions are calculated as the summation of the following:

- **Emissions during foam manufacturing**: These emissions are calculated as the total quantity of high-GWP BA that would have been used for foam manufacturing in absence of the project activity, multiplied by the first year loss rate, multiplied by the GWP of the high-GWP BA (see Table 4).
- **Emissions during foam usage**: These emissions are calculated starting in the second year as the total quantity of high-GWP BA that would have been stored in the material (i.e. HFC stored in the cells of the foam materials) in absence of the project activity, multiplied by the loss rate, multiplied by the GWP of the high-GWP BA, multiplied the number of years remaining in the project. Ten years is the maximum number of years which can be credited under this Methodology; further emission reductions and EOL emission reductions are not credited.

Equation #1

$$BE_{HFC} = \left\{ BU_{HFC_y} \times FYL_{HFC} + \sum_{n=2}^{y} BU_{HFC_{y+1-n}} \times AL_{HFC} \times (1 - FYL_{HFC}) \times (1 - AL_{HFC})^{(n-2)} \right\} \times GWP$$

Where:

BE_{HFC}	Baseline emissions (tonnes CO_2e)
BU_{HFC}	The quantity of high-GWP BA, in tonnes, which would have been used to produce the foam in the absence of the project activity
FYL_{HFC}	The first year loss rate of the low-GWP BA as obtained from the above Table 5 or material-specific data
AL_{HFC}	The annual loss rate of the low-GWP BA as obtained from the above Table 5 or material specific data
GWP_{HFC}	The GWP of the low-GWP BA from the above Table 4

BU_{HFC} is derived from the monitored quantity of foam manufactured or used and the HFC that would have been used in absence of the project activity.

4.2 Project Activity Emissions

- **Emissions during foam manufacturing using low-GWP material:** These emissions are calculated as the total quantity of low-GWP BA that is now used for the foam manufacturing, multiplied by the first year loss rate, multiplied by the GWP of the BA.
- **Emissions during foam usage with low-GWP material**: These emissions are calculated starting in the second year as the total quantity of low-GWP BA in the material (i.e. HFC stored in the cells of the foam materials), multiplied by the loss rate, multiplied by the GWP of the BA, multiplied by the number of years remaining in the project.

Equation #2

$$PE_{HFC} = \left\{ PU_{HFC_y} \times PFYL_{HFC} + \sum_{n=2}^{y} PU_{HFC_{y+1-n}} \times PAL_{HFC} \times (1 - PFYL_{HFC}) \times (1 - PAL_{HFC})^{(n-2)} \right\} \times PGWP_{HFC}$$

Where:

PE_{HFC}	Project activity emissions (tCO_2e)
PU_{HFC}	The quantity of low-GWP BA in tonnes, which was used to produce the foam
$PFYL_{HFC}$	The first year loss rate of the low-GWP BA as obtained from the above Table 5 or material-specific data
PAL_{HFC}	The annual loss rate of the low-GWP BA as obtained from the above Table 5 or material-

specific data

$PGWP_{HFC}$ The GWP of the low-GWP BA from the above Table 4

PE_{HFC} is derived from the monitored quantity of foam manufactured and used during the project activity.

4.3 Leakage

Activity-Shifting Leakage: If the equipment used previously for a high-GWP BA is transferred and used in another activity in which a high-GWP BA issued, leakage effects are to be considered. If the equipment is either used with the new project with the low-GWP material or low-GWP mixture, or is disabled, then leakage is to be disregarded. Records shall be kept and verified for the project.

Market-Shifting Leakage: The relative quantity of HFCs which are displaced are immaterial to the established global/domestic markets for goods and services. Market-shifting leakage is hence to be disregarded.

Equation #3

$$LE_{HFC} = \left\{ LU_{HFC_y} \times FYL_{HFC} + \sum_{n-2}^{y} LU_{HFC_{y+1-n}} \times AL_{HFC} \times (1 - FYL_{HFC}) \times (1 - AL_{HFC})^{(n-2)} \right. \times GWP$$

Where:

LE_{HFC} Leakage emissions (tonnes CO_2e)

LU_{HFC} The quantity of high-GWP BA, in tonnes, which would have been used to produce the foam

FYL_{HFC} The first year loss rate of the high-GWP BA as obtained from the above Table 5 or material-specific data

AL_{HFC} The annual loss of the high-GWP BA as obtained from the above Table 5 or material-specific data

GWP_{HFC} The GWP of the high-GWP BA from the above Table 4

4.4 Project Emission Reductions

The emission reductions achieved as a result of switching to a low-GWP material are calculated as the difference between the baseline emissions and the project activity emissions, as a result of using a low-GWP BA. Annual losses beyond year ten and EOL emissions shall not be calculated.

Equation #4

$$ER = BE_{HFC} - PE_{HFC} - PL_{HFC}$$

Where:

$\boldsymbol{ER}$	Project emission reductions (tonnes CO_2e)
$\boldsymbol{BE_{HFC}}$	Baseline emissions (tonnes CO_2e)
$\boldsymbol{PE_{HFC}}$	Project activity emissions (tonnes CO_2e)
$\boldsymbol{PL_{HFC}}$	Project activity leakage (tonnes CO_2e)

5.0 MONITORING AND DATA COLLECTION

Each project shall include a monitoring, reporting and verification plan sufficient to meet the requirements of the ACR Standard. The plan shall collect all data required to be monitored and in a manner which meets the requirements for accuracy and precision of this Methodology.

5.1 Description of the Monitoring Plan

The project proponent must prepare a monitoring plan describing (for each separately) the following: a) project implementation, b) technical description of the monitoring task, c) data to be monitored and collected, d) overview of data collection procedure, e) frequency of the monitoring, f) quality control and quality assurance procedure, g) data archiving, and h) organization and responsibilities of the parties involved in all the above.

The rationale of monitoring project implementation is to document all project activities implemented by the project (including leakage prevention measures) that could cause an increase in GHG emissions compared to the baseline scenario.

5.2 Data Collection and Parameters to be Monitored

The process for monitoring the project's emission reduction parameters includes:

- Identifying and logging the equipment to be modified or replaced as a result of the project
- Recordkeeping of historical BA usage
- Recordkeeping of project-related BA usage
- Maintenance of any documentation showing GWP of project-related BA used

5.2.1 Parameters Monitored

Parameter	BU_{HFC}
Units	Tonnes
Description	Quantity of high-GWP BA that would have been used in absence of project activity.
Relevant Section	4.1
Relevant Equation(s)	1
Source of Data	Operating Records
Measurement Frequency	Determined and recorded once

Parameter	FYL_{HFC}
Units	tCO_2e
Description	First year loss of high-GWP BA that would have been emitted in absence of project activity.
Relevant Section	4.0, 4.1, and 4.3
Relevant Equation(s)	1 and 3
Source of Data	Operating Records and Calculated
Measurement Frequency	Determined, calculated and recorded once

Parameter	AL_{HFC}
Units	tCO_2e
Description	Annual loss of high-GWP BA that would have been emitted in absence of project activity.
Relevant Section	4.0, 4.1 and 4.3
Relevant Equation(s)	1 and 3
Source of Data	Operating Records and Calculated
Measurement Frequency	Determined, calculated and recorded once

Parameter	PU_{HFC}
Units	Tonnes
Description	Quantity of low-GWP BA used in project
Relevant Section	4.0 and 4.2
Relevant Equation(s)	2
Source of Data	Operating Records
Measurement Frequency	Determined and recorded once

Parameter	$PFYL_{HFC}$
Units	tCO_2e
Description	First year loss of the low-GWP BA used in the project
Relevant Section	4.0 and 4.2
Relevant Equation(s)	2

Source of Data	Operating Records and Calculated
Measurement Frequency	Determined, calculated and recorded once

Parameter	PAL_{HFC}
Units	tCO_2e
Description	Annual loss of low-GWP BA used in project
Relevant Section	4.0 and 4.2
Relevant Equation(s)	2
Source of Data	Operating Records and Calculated
Measurement Frequency	Determined, calculated and recorded once

Parameter	*Equipment Maintenance*
Units	NA
Description	Identify and log the maintenance records of the equipment to be modified or replaced
Relevant Section	5.2
Relevant Equation(s)	NA
Source of Data	Operating Records
Measurement Frequency	As maintenance is performed

APPENDIX A: FOAM BLOWING INDUSTRY BACKGROUND

This Methodology is targeted at the reduction of HFCs in the foam manufacturing industry. Specifically, it addresses the use of HFC-intensive foam BAs in the industry. The EPA reports that HFC usage globally has been steadily increasing. The reporting to the United Nations Framework Convention on Climate Change (UNFCCC) demonstrates that HFC emissions have increased 250% since 1990 and use in the U.S. alone has grown about 20% since 2006.

The quantity of HFCs emitted in 2011 in the U.S. was 128,985,000 mtCO_2e. Foam BAs are used in the manufacturing of items like refrigerators, buildings, automobiles, furniture, packaging, and in a variety of construction applications. A BA is used to propel liquid plastic resin to produce the foam that is used in these materials. The majority of foam BAs have an HFC as their main chemical agent, therefore, it is the BA that produces the CO_2e emissions through the use of chemicals with a high-GWP.

Table 6 – Examples of Foam Technologies

Foam Technology	Description	Example End Uses
XPS	XPS foam board is essentially foam that is liquified then molded and compressed into Styrofoam.	Foam for food and product packaging (eg, coffee cups), marine and insulation products
PU spray	Spray foam is a two part polyurethane application that when combined forms a solid foam insulation. Spray foam is one of the most versatile forms of insulation available. It can seal a home from air and moisture intrusion, strengthen building structure and provide thermal, air and vapor barriers.	Roof, wall, and sealant insulation for commercial, agricultural, and residential structures, including trenchbreakers (use of spray foam to stabilize trench excavations for placing pipes in soil)
PU injected (pour in place)	A manufacturing process for producing parts by injecting material into a mold. Material for the part is fed into a heated barrel, mixed, and forced into a mold cavity, where it cools and hardens to the configuration of the cavity.	Domestic and commercial refrigeration, freezers, and cold-chain products including cold store panels and refrigerated transport
PU discontinuous panel	Also known as “sandwich panels”. The panels have a polyurethane core and are produced individually.	Roofs, walls and partitions

Foam Technology	Description	Example End Uses
PU continuous panel	Similar to discontinuous panels except that continuous panels are produced in a line and then cut to size. The majority of continuous panels are produced with Pentane.	Roofing insulation

APPENDIX B: BASIS FOR SECTORS AND TECHNOLOGY FOR METHODOLOGY

In developing the Methodology, information about the foam industry was gathered and reviewed. This information included, but was not limited to, the Caleb Report, conversations with ARB staff with respect to the findings of that report, conversations with investigators working on behalf of U.S. EPA with respect to the foam market conditions, the 2012 CPI End-Use Market Survey, a review of the recent proposal by U.S.EPA to prohibit certain HFCs under the proposed SNAP 20 rule, and industry knowledge.

In order to continue its efforts to reduce GHG emissions from the manufacture and use of foam, CARB commissioned the Caleb Report. That report included detailed research and scores of interviews with market participants with respect to what foams were being generated and used, and what then would be disposed both presently, and into the future. While focused on California, the Caleb Report is a strong representative sample of the North American foam markets.

Further, EPA's proposed SNAP rule was also referenced. The PU spray category is the only category for which U.S.EPA is proposing to allow HFC-245fa, and another high-GWP material, Formacel TI, to continue to be used after January 2017. However, EPA is proposing to prohibit HFC-245fa and HFC-134a in each of the other listed sectors. Given the continued growth in the PU spray category, emissions of high-GWP BAs can be expected to continue because of continued market demand and because EPA is not proposing to limit the use of HFC-245fa or Formacel TI in the PU spray category.

With respect to HFC-134a, which is proposed to be banned, the market is projected to move to another relatively high HFC, HFC-152a. The offset opportunities of replacing HFC-152a are substantial. HFC-152a has a GWP of 124, an order of magnitude lower than HFC-134a. However, it does not qualify as a low-GWP material as defined in this Methodology. Additionally, HFC-152a emits at three times the rate of HFC-134a. The entire amount of HFC-152a will be emitted in the first three years of the product use. By comparison, HFC-134a has 37.5% of the BA remaining at end of life. Thus, the offset potential is still quite large. The use of HFC-152a is likely to increase as a result of the SNAP 20 proposal. Should this projection prove accurate, the baseline for the sectors currently using HFC-134a could feasibly be revised to the use of HFC-152a in a future revision to this Methodology.

With respect to Pentane, which is predominantly used in the continuous laminated boardstock sector, the GWP of Pentane is relatively low, a GWP of 11. However, it does not qualify as a low-GWP material as defined in this Methodology because it has a GWP of greater than 5. Additionally, Pentane is a volatile organic HC and HCs are excluded from this Methodology.

In addition, we have been able to compare sales of low-GWP BAs to industry totals by sectors. Each of the sectors approved by this methodology has a low market share for low-GWP materials based on information provided to ACR. It is expected that more low-GWP materials will be entering the market and that the existence of this Methodology will advance the shift in industrial practices towards low-GWP BAs.

Table 7 – Low-GWP Market Share [2 3 4 5 6]

Foam Sector	U.S. System Sales 2012 (lbs)	Low-GWP Market Share (based on available data)
XPS	> 200,000,000	<1%
Rigid Foam	1.704 billion	<2%

This Methodology is not intended to apply to HC based BAs. While HC based BAs have a lower GWP than HFCs, they contribute to formation of tropospheric ozone. Nearly all of the HC BAs also have a GWP above 5. HCs also pose unique safety issues as a BA and, for that reason, are not used in the US in manufacturing operations for the sectors in this Methodology.

[2] *High-GWP systems are generally around 7% BA. Low-GWP systems are generally around 4% BA.*

[3] *"2012 End-Use Market Survey on the Polyurethanes Industry in the United States, Canada, & Mexico"; American Chemistry Council, Center for the Polyurethanes Industry;*

[4] *Global Chemical Consultants report by Greg Geaman*

[5] *XPS Trend Report (Kunststoffe International), pgs. 17 – 21, 12/2011.*

[6] *Owens Corning Investor report, pgs. 36 – 40, 12/2011 & Markets and Markets ; Building Thermal Insulation by Materials*

APPENDIX C: SAMPLE LOW-GWP MATERIALS

The following is a table of some known low-GWP materials that have a GWP of less than 5. This is not an exhaustive list as there are many products on the market that could meet the low-GWP definition of this Methodology. These GWP values are based on reported GWP levels, principally as recognized by EPA or other authoritative regulatory bodies and are provided as illustrative of the low-GWP alternatives.

Low-GWP Alternatives[7]

Low-GWP Alternative	GWP
Water	1
Formic Acid	<5
Methyl Formate	<5
Methylene Chloride	<5
Acetone	0.5
2-chloropropane	<5
Exxsol	<5
Ammonia	0
Ecomate	<1
Dimethyl ether	1
Methyl Bromide	0.7
HFO1234ZE	1
Methyl Chloroform	5

[7] *Hydrocarbons such as pentane, propane, isobutene, propylene, hexane and heptane are not included.*

APPENDIX D: REFERENCES AND OTHER INFORMATION

- "A Review of The CPI End-Use Market Survey 2012," PU Magazine, Vol. 10, No. 5 – October/November 2013
- "2012 End-Use Market Survey on the Polyurethanes Industry in the United States, Canada, & Mexico"; American Chemistry Council, Center for the Polyurethanes Industry.
- ACR Guidance on Monitoring Recordkeeping and Verification
- "2010 End Use Market Survey on Polyurethanes Industry in the US, Canada & Mexico", American Chemistry Council, Center for the Polyurethanes Industry.
- AB-32 Climate Change Scoping Plan, 2008
- Global Chemical Consultants Report by Greg Geaman, 2015
- AB-32 First Update to the Climate Change Scoping Plan, 2014
- CARB Regulation, Article 5: "California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms to Allow for the Use of Compliance Instruments Issues by Linked Jurisdictions"
- CARB "Compliance Offset Protocol Ozone Depleting Substances Projects", Adopted October 20, 2011
- CDM Methodology III.N, Version 03, "Avoidance of HFC Emissions in Poly Urethane Foam (PUF) Manufacturing"
- Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol
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