HFO-1234ze AS A BLOWING AGENT IN THE MANUFACTURE OF XPS FOAM BOARDSTOCK

Building construction sector.
Source: istockphoto.

Demonstration Projects on Alternative Technologies that Minimize Environmental Impacts

After the Montreal Protocol was adjusted in 2007 to accelerate the phase-out of HCFCs, Parties were encouraged to promote the development and the availability of alternatives to HCFCs that minimize environmental impacts, particularly for those specific applications where such alternatives are not presently available and applicable.

The decision of the Meeting of Parties to the Montreal Protocol (decision XIX/6, 2007) encourages Parties to promote the selection of alternatives to hydrochlorofluorocarbons (HCFCs) that minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations.

The Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol (Executive Committee) in its decision 55/43 has agreed on the importance of approving a limited number of projects in Article 5 countries to demonstrate emerging technologies in various industrial processes under local conditions.

Therefore, since 2007 the Executive Committee approved such demonstration projects in different sectors, mainly foam, refrigeration and air conditioning.

UNDP has been at the forefront of demonstration projects since 1992 and is implementing demonstration projects in all regions and all sectors. UNDP is assessing relatively new technological developments that have not or scarcely been used in developing countries. This task is conducted on behalf of and financed by the Multilateral Fund for the Implementation of the Montreal Protocol (MLF).

UNDP has been at the forefront of technology demonstration projects to replace ozone-depleting substances since 1992 and has been implementing demonstration projects in all regions and all sectors. UNDP is assessing relatively new technological developments that have not or scarcely been used in developing countries.

LOW CARBON TECHNOLOGY TRANSFER IN THE EXTRUDED POLYSTYRENE (XPS) FOAM SECTOR

Extruded polystyrene (XPS) foams can be categorized into sheet and boardstock. Sheet is mostly used for food applications and thermal insulation requirements are modest for these uses. For boardstock, however, which is mostly used for construction applications, good thermal insulation is critical. Therefore, while virtually all CFC use in sheet has been converted to hydrocarbons, boardstock has initially been converted to HCFCs and then later, where forced by regulations, to a mixture of options that all are less than desired from a performance point of view.

The manufacture of XPS boardstock has been traditionally a developed country market. Historically, there had been minor production in developing countries, but production capacity was developed in China and Turkey. In addition, there is production in Argentina, Egypt and Saudi Arabia, while Kuwait, Brazil and Mexico have started newer production lines. This increase in production required a close look at HCFC phaseout options in this foam sector.

Currently, in developed countries, the principal phaseout choices in XPS foams are HFC blends, CO_2 (LCD) and hydrocarbons. The significant variety in products required, for instance, to serve the North American market (thinner and wider products with different thermal resistance standards and different fire-test-response characteristics) require different solutions than in Europe and Japan, who have already phased out HCFCs with HFC-134a, HFC-152a and CO_2 in Europe and significant use of hydrocarbons in Japan. However, F-Gas regulation introduced in Europe will change the scenario in that region as HFC-134a will have to be phased out. With so many uncertainties in non-Article 5 countries, it is a challenge to provide guidance to them.

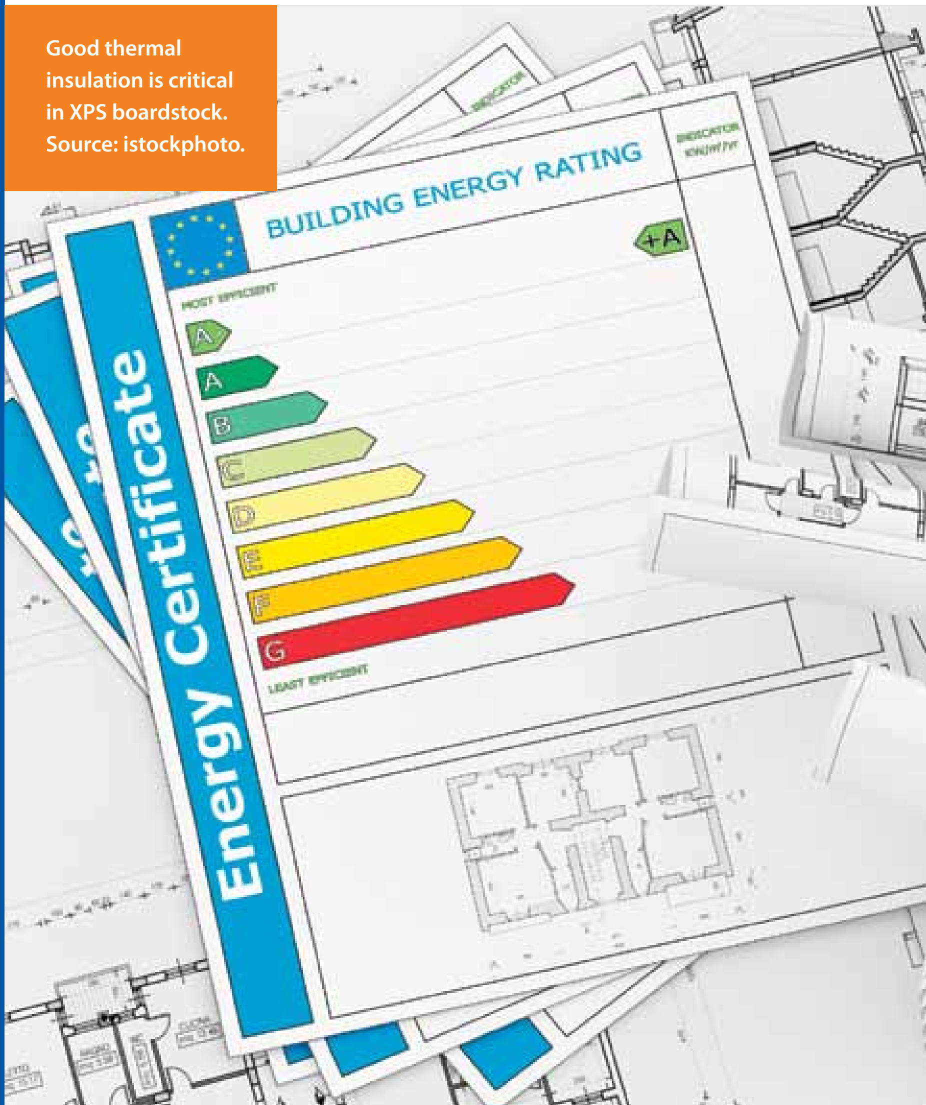
Blowing agent manufacturers are working diligently on a new generation of blowing agents that aim to combine zero ozone-depleting potential (ODP) and good thermal insulation properties with low global warming potential (GWP). However, for most options the horizon for industrialization in developed countries is 2-4 years. There is one exception - HFO-1234ze - the chemical which is already industrially applied in one component PU foam (OCF) manufacturers in Europe which were struck by a ban on the use of HFC-134a in July 2008 and needed a replacement urgently. The properties of the chemical as well as preliminary trials showed promise for its use in XPS boardstock but there has been no formal validation so far.

Validation of the use of HFO-1234ze as blowing agent in then manufacture of extruded polystyrene foam boardstock

The project TUR/FOA/60/DEM/96 entitled "Validation of the use of HFO-1234ze as Blowing Agent in the Manufacture of Extruded Polystyrene (XPS) Foam Boardstock" was approved at the 60th meeting of the Executive Committee.

Turkey hosts 12 local manufacturers of extruded polystyrene boardstock, most using a mixture of HCFC-142b/22 because of performance - good thermal insulation. These producers tested already several HCFC replacement options (with HFCs/DME) with mixed results and were interested to compare their evaluations with the testing of HFO-1234ze that may make the use of high-GWP HFCs unnecessary in future.

HFO-1234ze has no ODP. The chemical further offers negligible climate impact (low GWP) and promises improved insulation values compared with other HCFC replacements in extruded polystyrene (XPS) plank.



Good thermal insulation is critical in XPS boardstock. Source: istockphoto.

The objective of this project is to validate the use of a recently industrialized hydrofluoroolefin, HFO-1234ze, in the production of extruded polystyrene foam boardstock in Turkey.

Turkey is a Party to the Vienna Convention and the Montreal Protocol, and also ratified the London, Copenhagen, Montreal and Beijing amendments to the Protocol. The Government is proactive in reducing the reliance on HCFCs and agreed to take the lead in assessing this new alternative technology in the XPS foam sector.

Project implementation

The project has been divided into several implementation steps described below:

- Preparatory activities – which consisted of an implementation Inception Meeting which took place July 6, 2010 and during which the modifications and hardware needed for the trials, the qualities to be trialed, the related testing and the timing were discussed;
- Trial Preparations – under which a host company prepared the trial configuration as designed and installed the procured testing equipment;
- Procurement of Testing Equipment and Chemicals – which included an insulation tester, a closed cell counter and the HFO gas. For cost and processing reasons, HFO-1234ze has been blended by the supplier with DME. At a later stage DME has been directly injected as a co-blowing agent; and
- Trials/Testing – Before the trials, the host company installed an air powered booster pump to support the trials.

The planned initial tests started in 2011 and ended in January 2012.

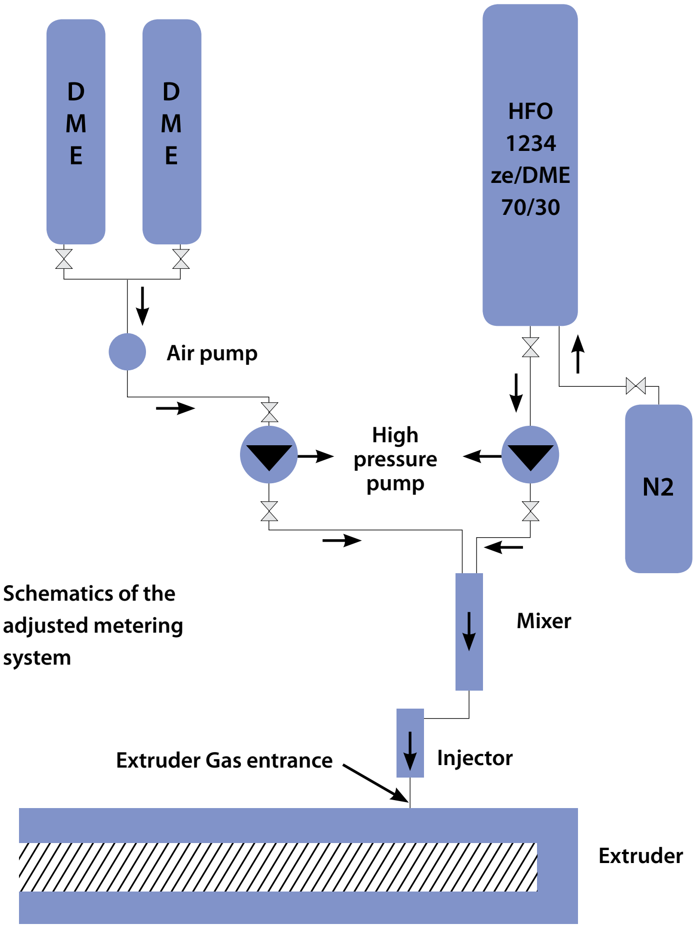
Preliminary results were received and the findings were summarized in an interim technology report submitted for consideration of the 67th Executive Committee meeting.

Interim project results

Based on the information presented in the report it was concluded that:

Health, Safety, Environment

- The use of HFO-1234ze does not create incremental health concerns;
- HFO-1234ze is inert, not flammable, and in itself does not require any related safety precautions;



Schematics of the adjusted metering system

- HFO-based blowing agent blends do not pose an environmental hazard based on current knowledge. Its atmospheric profile is benign, there is no ODP and its global warming potential is negligible.

System Processability

- Based on blowing potential at equimolecular comparison, HFO-1234ze requires almost the same mass as CFC-12 but 15% more than HCFC-142b and HFC-134a and 70% more than HFC-152a. The customary co-blowing with DME will flatten these differences to some extent;
- Shipment and storage of HFO-1234ze must take place in pressurized containers—which is the case for all other blowing agents as well and therefore no incremental burden;
- The shelf life for HFC-1234ze is at par with most other alternatives;
- Flammability of HFO-1234ze/DME 50/50 mixture requires process safeguards; however, the blend is not explosive.

Aerial view of Bursa, Turkey where project took place. Source: istockphoto

Foam Properties

- HFO-1234ze-based XPS foams match HCFC as well as HFC-based foams in insulation properties and structural properties;
- The resulting foam from the assessment trials will need surface and density optimization to be commercially acceptable;
- The amount of co-blowing agent appears critical for processing and cell structure. Alternatively, the equipment used for the trials could be a critical factor. Further trials will be needed;
- Based on the current trials, HFO-1234ze needs 50% co-blowing with DME to be acceptable in processing. If this can be reduced, it is to be expected that the insulation properties of HFO-1234ze will be superior to other HCFC alternatives and can match those of HCFC-142b/22.

In summary, the following list of recommendations has been developed on findings of the current technology review work:

1. HFO-1234ze can replace the HCFCs and/or high GWP HFCs in XPS plank while providing acceptable thermal insulation and structural properties;
2. To make this commercially acceptable optimization of density and surface will be required;
3. The conversion requires equal amounts of DME as co-blowing agent making the blend flammable therefore requiring adequate process safeguards;
4. There is potential to improve thermal insulation performance by reducing the relative amount of DME.

CONCLUSION

The current findings show that there is a need for further trials as this will help obtain better assessment of the feasibility of the technology for developing countries. UNDP recommends continuing this project as follows:

- **Duplicate the trials with HFO-1234ze/DME (50/50) on different equipment**
- **If these trials are successful, repeat with a 70/30 blend**
- **If this is also successful, then there is an equipment compatibility issue at hand with the extruders used in trials**
- **In that case, continue with an 80/20 blend. The outcome will allow prediction of expected insulation values through extrapolation and provide the manufacturer with a choice between the best insulation (highest amount of HFO) or best cost price (highest amount of DME).**

These tests are pending decision due to additional investments required.

Complete report can be downloaded at ***http://www.undp.org/content/undp/en/home/librarypage/environment-energy/ozone_and_climate/Demoprojectsreport.html***

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