

Bridging Research Credits And the Circular Economy

by Abbie Therrow, Dennis St. Martin, Monica Bambury,
and Kevin Benton

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Abbie Therrow is a manager in the corporate tax solutions group of Grant Thornton Advisors LLC, Dennis St. Martin is a senior manager in the firm's Washington National Tax office, Monica Bambury is a managing director in the corporate tax solutions group, and Kevin Benton is a managing director in the Washington National Tax office.

In this article, the authors examine the circular economy and how it aligns with section 41 research credit criteria, and they offer considerations for taxpayers seeking to qualify research activities and expenditures in this economic system.

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I. Introduction

In recent years, taxpayers have focused on aligning their historical innovation projects with environmental, social, and governance (ESG) reporting and on offsetting costs through tax credits.¹ The government offers federal income tax credits,² including the section 41 credit for increasing research activities, to strategically encourage the development of new or improved products and processes. While this is not a new opportunity, this article examines how activities that qualify for the research credit connect to a

more recently promoted ESG-related concept — the circular economy.

II. Background

The circular economy is an economic model in which entities and individuals value recovery activities instead of the traditional “take, make, and dispose.”³ It is therefore a key driver of sustainability⁴ and strategically changes how entities and individuals design, use, and reuse products. The core principles of the circular economy are to:

- reduce waste and pollution by designing products, materials, and infrastructure that will go back into the economy after use;
- circulate products and materials by maintaining, reusing, and refurbishing them; and
- regenerate nature by focusing on improving natural environments and building biodiversity.⁵

To the extent that these core principles are aligned with consumer beliefs, it allows taxpayers to focus their efforts on innovation to obtain a competitive edge in tie-breaker situations⁶ while building public trust as responsible corporate actors.⁷ The French economist and a recipient of the 2025 Nobel prize in economic sciences Philippe Aghion said it best:

³ See Department of Commerce, National Institute of Standards and Technology, “Circular Economy Product Design and Digital Thread” (last updated Mar. 26, 2025).

⁴ Amanda McGrath and Alexandra Jonker, “What Is a Circular Economy?” IBM (accessed Jan. 13, 2026).

⁵ “Circular Economy Principles,” Ellen MacArthur Foundation (Aug. 20, 2024).

⁶ Elizabeth Sloan and Marjorie Whittaker, “Perspectives for Corporate Directors Navigating ESG,” *Directorship Magazine* (Winter 2023).

⁷ Pinky Shodhan and Don Reiris, “Marrying ESG Initiatives to Business Tax Planning,” *The Tax Adviser* (Feb. 1, 2023).

¹ Victor Sturgis and Mike Gumbleton, “ESG and Taxation: A Necessary Part of a Company's Strategic Objectives,” *The Tax Adviser* (Oct. 6, 2022).

² Recent examples include credits provided through the CHIPS and Science Act of 2022 and the Inflation Reduction Act of 2022.

Consumers indeed have the power to influence corporate decisions. Thus, in countries where consumers are truly concerned about the environment . . . heightened competition will motivate firms⁸ to innovate to reduce the ratio between price and the environmental impact, which means they will pursue greener innovations to escape competition.⁹

Environmental effects have prompted taxpayers to rethink innovation, product development, and manufacturing processes. This shift has accelerated the advancement of certain scientific disciplines. For example:

Material science is at the forefront of the transition to a circular economy. Product innovations and recycling technologies have made significant strides in advancing circularity, allowing us to create a more sustainable and resilient future.¹⁰

By leveraging these and similar advanced scientific principles, taxpayers can undertake initiatives to extend product lifespans and improve products' performance and reliability.¹¹ Taxpayers may employ a product development life cycle approach that aligns with the principles of the circular economy, which include:

- *Ideation*: Gathering input from stakeholders, brainstorming concepts, and exploring different solutions to existing problems.
- *Research*: Gathering information to help determine if a product idea is viable and adheres to the principles of the circular economy (such as the environmental effects of materials, production methods, and disposal options).
- *Planning*: Defining a product's features and developing a project roadmap that outlines timelines, resources, and milestones.

- *Prototyping*: Creating tangible models or samples to test a product's functionality, design, and feasibility. Multiple iterations are commonly performed during this stage.
- *Sourcing*: Identifying ethical suppliers of materials and components that meet quality and cost requirements.
- *Costing*: Calculating total production expenses and pricing that aligns with customer expectations and taxpayer goals.
- *Commercialization*: Launching the product and incorporating circular economy principles during production, such as achieving product sustainability and packaging recyclability and reusability.¹²

Throughout this structured process, from concept to market-ready product, taxpayers may be faced with technical challenges when ensuring that a new or improved product is viable, functional, and aligned with market demand.¹³ Scaling up practices to match the volume of the linear economy is a hurdle that must be cleared, along with developing effective recycling and reuse technologies.¹⁴

Economists estimate that the circular economy could generate up to \$1.5 trillion in new revenue and economic value by 2030, which represents approximately 7 percent of U.S. GDP.¹⁵ Subject matter experts have approached similar forecasts with both optimism and pragmatism:

While the potential benefits are significant, the transition will require sustained effort, innovation, and collaboration across industries and sectors. . . . This is where the expertise of quality professionals, combined with innovative design thinking and supportive policy frameworks, will play a crucial role in shaping a more sustainable future.¹⁶

⁸ For purposes of this article, the term "firms" has the same meaning as "taxpayers."

⁹ Philippe Aghion, Céline Antonin, and Simon Bunel, *The Power of Creative Destruction: Economic Upheaval and the Wealth of Nations* 186-187 (2021).

¹⁰ Han Hendricks, "Material Science With Circular Economy as the Centerpiece," *Forbes*, Feb. 21, 2025.

¹¹ Atalay Atasü, Céline Dumas, and Luk N. Van Wassenhove, "The Circular Business Model," *Harv. Bus. Rev.* (July-Aug. 2021).

¹² International Institute for Management Development, "Integrating the 7 Stages of the Product Development Cycle in the Circular Economy" (last updated Feb. 2026).

¹³ *Id.*

¹⁴ Larissa Scherrer de Quadros, "The Circular Economy: Challenges and Opportunities in Implementation," Indeed Innovation's *The Mensch* newsletter (Aug. 26, 2024).

¹⁵ Saji Sam and Dylan Dickens, "The Circular Economy Can Unlock \$1.5 Trillion for U.S. Firms," Oliver Wyman LLC blog (Apr. 2024).

¹⁶ See de Quadros, *supra* note 14.

III. The Research Credit

One of the supportive policy frameworks in the United States, which economists have referred to as the lifeblood of innovation,¹⁷ is the activity-based research credit. While the rules regarding the research credit have changed since its introduction in 1981, the fundamental mechanism has been consistent over time:

Congress always has maintained an incremental tax credit structure because it has sought to encourage firms to increase their R&D spending beyond the level that they would do in the absence of any tax incentive.¹⁸

However, the research credit has not been without controversy regarding its effectiveness. In a report delivered to Congress, the Office of Technology Assessment (OTA)¹⁹ provided observations on how the research credit functioned in practice:

Anecdotal interview *evidence obtained by OTA indicates that some firms indeed “game” the rules* either in this manner or by adjusting or “relabeling” their R&E spending categories to meet IRS definitions of qualified research. . . . To the extent that it takes place, R&E relabeling is not unlike many other types of expenditure allocation judgments that taxpayers invariably have to make in the face of ambiguous definitions and other sources of uncertainty in the tax code. . . . Some analysts have argued that this is a relatively common activity, and that relabeling may account for a significant portion of the apparent increase in R&D spending induced by the tax credit.²⁰ [Emphasis added.]

The research credit, like the circular economy concept, is not exclusive to a specific industry but can apply to taxpayers in most, if not all, sectors. A recent Congressional Research Service report²¹ considered one challenge with directing the research credit to encourage taxpayers to undertake projects with higher social rates of return:

Firms will choose the investments with the highest after-tax private returns and not necessarily the highest social returns. . . . One option is to increase the credit for selected industries or investments; an example from current law is the orphan drug credit,²² designed to encourage the development of drugs for rare conditions. However, there is little evidence to guide choices of industries or investments.²³

Regardless of a taxpayer’s industry, economists have found that, in the aggregate, social returns for the research credit are significantly higher than private returns, with estimates of social returns being up to 20 times those of private returns.²⁴ However, all this requires taxpayers to address subjective and complex rules when claiming the research credit.

Taxpayers seeking to claim the research credit under section 41 must meet the general qualification criteria, including the four-part test for determining qualified research.²⁵ Taxpayers should be aware of technical issues that could arise regarding activities that are more common in the circular economy. For example:

- For a permitted purpose²⁶: Taxpayers must undertake a business component to create a new or improved function, performance, reliability, or quality, not solely to reduce costs or to meet environmental compliance requirements.

¹⁷ Gary Guenther, “Federal Research Tax Credit: Current Law and Policy Issues,” Congressional Research Service Report RL31181, at 1 (updated July 27, 2022).

¹⁸ Office of Technology Assessment, “The Effectiveness of Research and Experimental Tax Credits,” at 9 (Sept. 1995).

¹⁹ The OTA, which operated from 1972 to 1995, was responsible for providing congresspeople and congressional committees with objective and authoritative analysis of the complex scientific and technical issues of the late 20th century. For further details regarding the legacy of the OTA, see “The OTA Legacy” on Princeton University’s website.

²⁰ See OTA, *supra* note 18, at 11.

²¹ Jane G. Gravelle and Mark P. Keightley, “The Federal Research and Development (R&D) Tax Credit,” CRS Report R48848 (Feb. 6, 2026).

²² Section 45C.

²³ See Gravelle and Keightley, *supra* note 21, at 16.

²⁴ *Id.* at 1-2.

²⁵ Section 41(d).

²⁶ Section 41(d)(3).

- To be technological in nature²⁷: Sustainability goals and technical concepts do not meet this criterion unless the goals relate to activities that rely on principles of the so-called hard sciences, such as physical or biological sciences, engineering, or computer science.²⁸
- Funded research exclusion: While the federal government has recently passed legislation to encourage elements of circularity,²⁹ such as the Infrastructure Investment and Jobs Act, taxpayers must be aware that any research to the extent that it is funded by any grant, contract, or otherwise by another person (or governmental entity) is excluded from the definition of qualified research.³⁰
- Other qualified research exclusions³¹: While routine environmental testing and compliance studies do not meet the definition of qualified research, these activities may constitute direct support of qualified research to the extent that they are performed in support of a process of experimentation to evaluate one or more alternatives to resolve technological uncertainty.

Taxpayers should also be aware that the regulations and IRS guidance provide examples of qualified research that coincide with the goals of the circular economy. These include:

- product development in response to government-mandated requirements;³²
- development of robotic equipment used in a taxpayer's manufacturing process;³³
- development of a new production process using a different production method;³⁴ and

- design of new efficient manufacturing equipment.³⁵

In addition to examples within the regulations, the 2005 audit techniques guide clarifies how the exclusions apply to the definition of qualified research:

Note that it is the *activity* which governs, not the intended end result. For example, the development of a new production process, which met all the tests for qualified research, would not be excluded simply because the activity was preceded by a management efficiency survey.³⁶ [Emphasis added.]

This provides taxpayers with an important distinction when evaluating if, and when, activities performed on a project³⁷ may be qualified.

IV. Case Law

Beyond the statutory and procedural framework, taxpayers should assess how the courts have applied the research credit rules to activities that align with but predate the circular economy initiative. Recent court cases are a significant source of insight because an examination team is more likely to rely on the reasoning they provide for research credit claims, given the subjective nature of section 41, compared with other federal income tax provisions.³⁸ While the following cases involved several technical issues, our focus is on the taxpayer activities that correspond to today's circular economy, demonstrating that those research activities have historically qualified for the research credit.

²⁷ Section 41(d)(1)(B)(i).

²⁸ Reg. section 1.41-4(a)(4).

²⁹ Circular Economy Coalition, "2024 Federal Circularity Audit and Report," at 2-3 (released Dec. 10, 2024).

³⁰ Section 41(d)(4)(H).

³¹ Section 41(d)(4).

³² Reg. section 1.41-4(a)(8), Example 4.

³³ Reg. section 1.41-4(c)(10), Example 7.

³⁴ Reg. section 1.174-2(a)(11), Example 10.

³⁵ See IRS, "SB/SE Research Credit Practice Aid" (undated).

³⁶ See IRS, "Audit Techniques Guide: Credit for Increasing Research Activities (i.e. Research Tax Credit) IRC Section 41 — Qualified Research Activities," section 5.c.4 (June 2005).

³⁷ The terms "projects" and "business components" are used interchangeably throughout this article. The technically correct term is "business components," as defined in section 41(d)(2)(B).

³⁸ Richard Bernstein, "How to Think About Preparation of R&D Tax Credit Documentation," *Accounting Today* (Dec. 16, 2025).

A. Union Carbide

In *Union Carbide*,³⁹ about \$8.4 million in research credits claimed by Union Carbide Corp. (UCC) for the 1994 and 1995 tax years were in dispute.⁴⁰ Referred to in IRS training materials as “the most complete discussion [of] R&E credit issues of any case,”⁴¹ *Union Carbide* highlights several technical issues, including a few that are still relevant to today’s circular economy.⁴²

UCC is a worldwide manufacturer and marketer of basic chemicals and plastics, as well as specialty and intermediate chemicals, and it conducts its operations at large-scale production facilities throughout the United States and abroad.⁴³ While UCC claimed research credits based on 106 projects conducted in six manufacturing plants, the company and the IRS agreed to examine only five of the largest projects at trial.⁴⁴

The IRS argued that UCC failed to meet the uncertainty test and the process of experimentation test because the projects were production activities.⁴⁵ In particular, the agency referred to the qualified research exclusions, including the research performed after commercial production,⁴⁶ data collection, and routine testing.⁴⁷ The IRS asserted that the activities performed by UCC were conducted after the business component was developed to the point that it was ready for commercial sale or

use, or that it met the basic functional and economic requirements for the component’s sale or use.⁴⁸

The Tax Court held that two of the five selected projects met the definition of qualified research⁴⁹ — the Amoco Chemical Corp. anticoking project and the UCAT-J project.⁵⁰ To demonstrate how activities related to the circular economy may qualify for the research credit, we examine the Amoco anticoking project below.

UCC performed research activities to address furnace performance issues and improve efficiency and cost effectiveness of production processes through the reduction or elimination of coke⁵¹ buildup. In general, coke layers lead to higher energy consumption, which is also environmentally unfavorable.⁵²

The goal of the coke reduction program was to reduce the number of decokes per year by 50 percent and increase productivity by 4 to 4.5 percent per year. If successful, UCC estimated that this would reduce its decoking costs by \$2.4 million per year and increase revenue by as much as \$20 million. However, there was technical uncertainty regarding the anticoking technologies:

Many coke mitigation technologies have been proposed and developed in laboratories over the years, but none have succeeded commercially. Some failed to mitigate coke or even made it worse. UCC screened and commercially tested numerous anticoking technologies in the mid-1980s and later. During the credit years there was no known, generally accepted, commercial coke mitigation technology for pyrolysis furnaces. UCC considered at least four technologies

³⁹ *Union Carbide Corp. v. Commissioner*, T.C. Memo. 2009-50, *aff’d*, 697 F.3d 104 (2d Cir. 2012).

⁴⁰ *Union Carbide*, T.C. Memo. 2009-50, at 8.

⁴¹ See IRS, “SB/SE Research Credit Practice Aid,” *supra* note 35. The practice aid includes a training session titled “Significant R&E Case Summaries” by Kathy Dombrowski (senior counsel, SB/SE, San Diego), dated June 30, 2021.

⁴² *Union Carbide* addressed topics such as technical uncertainty, process of experimentation, qualified research exclusions, base period computations, the consistency rule, substantiation, and trial run supplies.

⁴³ *Union Carbide*, T.C. Memo. 2009-50, at 4-5.

⁴⁴ *Id.* at 3. Further, footnote 4 clarifies that the parties originally agreed on six projects to try before the Tax Court, but UCC withdrew a project before the trial.

⁴⁵ Section 41(d)(1)(A) and (C).

⁴⁶ Section 41(d)(4)(A).

⁴⁷ Section 41(d)(4)(D)(iv)-(v).

⁴⁸ Reg. section 1.41-4(c)(2).

⁴⁹ *Union Carbide*, T.C. Memo. 2009-50, at 1.

⁵⁰ We exclude a discussion of the UCAT-J project because it spans 46 pages in *Union Carbide*, T.C. Memo. 2009-50. In summary, through the UCAT-J project, UCC developed a more active or reusable catalyst that could produce more polymer from the same inputs, thereby reducing waste and extending catalyst life.

⁵¹ *Union Carbide*, T.C. Memo. 2009-50, at 20. Coke is a heavy, hard, and brittle form of carbon that gradually forms on the interior walls of cracking set coils during the cracking process.

⁵² Jia Zhang, Kevin M. Van Geem, and Reyniers M.F., “Coke Formation Simulation During Steam Cracking,” Laboratory for Chemical Technology (undated).

during the credit years but tested only technology developed by Amoco Chemical Corp. (Amoco) during that period.⁵³

UCC worked with Amoco to draft a plan that specified the number of test runs, the run lengths,⁵⁴ the method of injecting the inhibitor, and the data to record during four consecutive furnace cycles. This process included recording measurements during decokes, including phosphine,⁵⁵ furnace coil skin temperature, pressure drop across the coils, transfer line exchanger inlet pressure, and carbon monoxide.⁵⁶ Many of these data points were not normally measured.⁵⁷ Before performing the tests, UCC prepared a facility operational change review document that addressed the technical, quality, health, waste, and safety issues that must be considered to minimize risks involved with the change.⁵⁸

While initial test results indicated carbon monoxide in the cracking sets treated with the Amoco technology, further results from the other measurements were either inconclusive or indicated no difference between the treated and untreated cracking sets. UCC performed a second iteration of treating the cracking sets and observed that the test results were almost identical. In fact, UCC observed that the pretreatment contributed to excess coke in the transfer line exchanger cones.⁵⁹ Although the Tax Court noted that the testimony provided was contradictory, UCC asserted that it did not provide Amoco with the data it collected and analyzed.⁶⁰

UCC considered the Amoco anticoking project complete and never again evaluated the

technology. Through the course of the project, UCC learned about the operation of thiophosphates (the active ingredients in the Amoco technology), the relationship between sulfur and carbon monoxide levels, and the effects of anticoking technology on ceramic material of the transfer line exchanger cones. UCC used this information in its business going forward.⁶¹

The Amoco anticoking project demonstrates how activities that are quintessential to the circular economy (for example, reducing energy consumption, operational costs, and environmental effects) can constitute qualified research when taxpayers conduct nonroutine testing to evaluate alternatives and eliminate technical uncertainty — in particular, when the activities involve emerging technologies that, at the outset of the research and during experimentation, have proven to be technically challenging and ineffective in the taxpayer's industry.

B. Geosyntec

In *Geosyntec Consultants*,⁶² roughly \$1.7 million of research credits claimed by Geosyntec Consultants Inc. for projects undertaken during its 2002 to 2005 tax years were in dispute.⁶³

Founded in 1983, Geosyntec is a consulting and engineering firm specializing in environmental solutions.⁶⁴ While Geosyntec claimed research credits for 370 projects under contract with third parties for the relevant tax years, only six representative projects were examined at trial.⁶⁵ Each of the selected projects was primarily engaged in developing environmental solutions.

The case focused on funding issues, but it shows that environmental-based projects, including novel remediation and decontamination approaches, can qualify for the research credit since the court did not disqualify the projects based on activity alone. Of the six

⁵³ *Union Carbide*, T.C. Memo. 2009-50, at 18.

⁵⁴ *Id.* at 21-22. The run lengths would be determined by furnace cycles, which is the amount of time the furnace would run between hot decokes (a process that feeds air and steam into the cracking sets at elevated temperatures) under normal operating conditions.

⁵⁵ *Id.* at 22. Phosphine is a toxic substance produced when materials containing phosphorous function as coke inhibitors. UCC identified that this is the only measurement not affected by coke formation.

⁵⁶ *Id.*

⁵⁷ *Id.* at 24.

⁵⁸ *Id.* at 22-23.

⁵⁹ *Id.* at 27.

⁶⁰ *Id.* at 25.

⁶¹ *Id.* at 28-29.

⁶² *Geosyntec Consultants Inc. v. United States*, No. 9:12-cv-80334 (S.D. Fla. 2013).

⁶³ *Id.* at 1-2.

⁶⁴ *Id.* at 13.

⁶⁵ *Id.* at 14-15.

projects examined, the court found that all three fixed-price contracts were eligible for the research credit⁶⁶: the fixed-price Asian rare-earth contract, the fixed-price Seal Beach bioremediation contract, and the fixed-price Saudi Arabia oiled coastline contract. The contracts demonstrate that environmental activities consistent with circular economy concepts can qualify for the research credit.

1. Fixed-price Asian rare-earth contract.

A Malaysia-based subsidiary of Geosyntec contracted with a Malaysian corporation to develop environmental solutions as part of an overarching effort to perform decommissioning and decontamination activities related to a former rare-earth mineral processing plant. The contract required the construction of a facility for the disposal of materials with radioactive contamination. As part of a subcontract with its Malaysia-based subsidiary, Geosyntec supported diverse activities, including design, construction, and project management efforts. Geosyntec said these environmental efforts constituted the first-ever radioactive cleanup and storage project of this type in Southeast Asia.⁶⁷ The novelty of the underlying activities bolstered the strength of the environmental activities that were performed by emphasizing their complexity and the fact that they were not merely routine. Further, the fact that the court did not disallow the project based on the activities demonstrates that the development of unique environment-related technology may qualify for the research credit.

2. Fixed-price Seal Beach bioremediation contract.

The U.S. Navy contracted Geosyntec to perform groundwater plume decontamination activities at a former NASA test facility. As part of the dual-phase contract, the company was tasked with evaluating alternative remedial approaches and developing plans and documentation related to the chosen approach.⁶⁸ The focus of the evaluation was researching bioremediation approaches, which, given the definition alone,

could provide for a more sustainable and environmentally friendly approach to decontamination.

3. Fixed-price Saudi Arabia oiled coastline contract.

The Saudi Arabian coastline suffered environmental damage from the first Gulf War in the form of petroleum contamination in the sediment. Under a multiphase project, Geosyntec was contracted to perform activities for the first two of seven phases related to assessing the extent of petroleum contamination and restoring an 800-kilometer section of coastline. As part of the first phase, the company was contracted to research the remediation of petroleum contamination and the restoration of the coastline. Geosyntec was responsible for evaluating remediation approaches and developing plans for conducting laboratory testing. As part of the second phase, the company was to collect sediment samples for testing, report the test results, and develop plans for large-scale field testing.⁶⁹ The project serves as another example of research activities performed by Geosyntec that align with circular economy principles by emphasizing remediation and restoration of environmental systems affected by pollution.

C. Siemer Milling

In *Siemer Milling*,⁷⁰ \$122,424 and \$116,246 in research credits were in dispute, claimed by Siemer Milling Co. for the tax years ended May 31, 2011, and May 31, 2012, respectively.⁷¹

Siemer was a miller and seller of wheat products.⁷² The company had engaged in research and claimed qualified research expenditures related to four projects in the 2011 tax year and five projects in the 2012 tax year.⁷³ Research efforts involved the development of new and improved processes for the production of wheat products. This included research to remove harsh chemicals

⁶⁶ *Id.* at 42.

⁶⁷ *Id.* at 15-16.

⁶⁸ *Id.* at 17-18.

⁶⁹ *Id.* at 18-19.

⁷⁰ *Siemer Milling Co. v. Commissioner*, T.C. Memo. 2019-37.

⁷¹ *Id.* at 11-12.

⁷² *Id.* at 1.

⁷³ *Id.* at 5.

and find natural alternatives for modified starches⁷⁴ and to reduce waste and improve yield.

The IRS argued that Siemer failed to meet its burden of showing that each selected project met the four-part test criteria. For example, the IRS argued that Siemer did not meet the technological information test because the taxpayer did not identify the scientific principles on which the research relied and no employees held job titles or degrees that aligned with scientific principles. Moreover, because no employees held the title of engineer or had an engineering degree, the IRS asserted that the activities could not have relied on principles of engineering.⁷⁵

Despite finding the IRS's arguments unpersuasive, the Tax Court held that none of the projects met all four of the qualification tests.⁷⁶ In particular, the court said Siemer lacked documentation to show how the projects met the four-part test criteria. Thus, taxpayers should not necessarily read the Tax Court's ruling in *Siemer Milling* as a determination that the projects themselves were inherently nonqualified. Rather, it is important that taxpayers clearly evaluate the activities in terms of the four-part test criteria and ensure that there is sufficient contemporaneous documentation available to support the qualified activities, including for projects undertaken to reduce waste, eliminate harsh additives, and other initiatives that correspond with the circular economy.

1. Flour heat treatment project.

Siemer undertook a multiyear research project to create processes for producing flour products without using chemicals like chlorine and to produce all-natural alternatives for modified starches. To develop these processes, Siemer evaluated alternative heating times and methods while assessing their effects on the product. For example, Siemer examined the effects of those different variables on bacteria and microbiological material levels.⁷⁷

The flour heat treatment project has parallels with circular economy concepts because the

taxpayer performed activities to develop new processes to reduce potentially harmful additives in food products.

2. Pulsewave project.

A Pulsewave machine uses resonance, shock waves, and vortex-generated shearing forces to break down particles in lieu of traditional milling approaches. In the 2011 tax year Siemer undertook efforts to optimize the performance of its Pulsewave equipment so that it could achieve a certain speed without facing equipment malfunction issues. Siemer also researched the effects of using the Pulsewave equipment to process different grains and flour. For example, Siemer evaluated the effect of the machine on alternative grain types at load sizes.

In the 2012 tax year Siemer researched the effect of the Pulsewave equipment on the flour product, including granulation. The company also researched the effects of the alternative equipment guidelines, such as speed, on the milling process. In doing so, Siemer evaluated the effects of those varying guidelines on the composition of the end products that used the flour.⁷⁸

The Pulsewave project also aligned with circular economy concepts through the optimization of milling processes, including reduced downtime and improved throughput, which could help improve yield and reduce waste.

V. Considerations

The selected projects from *Union Carbide*, *Geosyntec*, and *Siemer Milling* demonstrate how activities related to the circular economy can align with the research credit. Taxpayers that perform similar activities should consider the following guidelines when identifying qualified research, coordinating the research credit with ESG reporting, and optimizing "Industry 4.0" investments.

A. Identifying Qualified Research

While taxpayers may be aware that the definition of qualified research is broad, they may

⁷⁴ *Id.* at 6.

⁷⁵ *Id.* at 26-28.

⁷⁶ *Id.* at 32.

⁷⁷ *Id.* at 6.

⁷⁸ *Id.* at 6-8.

overlook activities more commonly associated with ESG reporting rather than the research credit, even though there is often significant overlap between the two. Unless otherwise disallowed,⁷⁹ taxpayers should evaluate if activities performed related to the circular economy could align with the development of a new or improved business component,⁸⁰ such as:

- Product development that involves:
 - biodegradable packaging instead of traditional packaging materials;
 - bioplastics from agricultural waste;
 - high-value components from upcycled waste; and
 - plant-based polymers instead of petroleum-based plastics.
- Process development that involves:
 - advanced composting using microbial engineering;
 - chemical processes to break down plastics into reuseable monomers;
 - closed-loop manufacturing processes and systems; and
 - smart waste segregation and recycling or reuse systems.
- Other development that involves:
 - advanced remanufacturing techniques for creating high-value components;
 - digital platforms to monitor and enhance product reuse and recycling;
 - energy recovery techniques from waste heat; and
 - predictive models to minimize waste and maximize reuse across supply chains.

Taxpayers should consider evaluating the activities performed, costs incurred, technical uncertainties, and other key facts when determining how to identify and structure a business component. To the extent that a project involves both a product and process development component, taxpayers must evaluate each as a separate business component.⁸¹ Further, there may generally be more inherent risks with

taxpayers claiming process development rather than product or technique development based on the existing guidance and case law.⁸²

Given the subjective and contentious nature of the research credit, retaining contemporaneous documentation is critical in substantiating technical positions during the audit and appeals process.⁸³ Depending on reporting requirements, ESG-related initiatives often have more structured documentation and measurable outcomes that can demonstrate the four-part test criteria for the research credit.

B. Coordinating the Research Credit With ESG Reporting

In creating closer alignment between the research credit and ESG-related initiatives, such as the circular economy, taxpayers can enhance their financial reporting to meet regulatory requirements or investor mandates while minimizing potential discrepancies by IRS examination teams. This is true regardless of whether the taxpayer is an SEC registrant. Below are examples of how research activities and the circular economy may correspond to each pillar of the ESG framework:

- Environmental:
 - effective resource management while lowering operating costs;
 - ethical sourcing and sustainable materials; and
 - reduction of emissions to support local ecosystems.
- Social:
 - broader diversity and increased perspectives for innovation;
 - higher employee compensation (and potentially qualified research expenditures); and
 - increased employee opportunities and retention.
- Governance:
 - closer alignment with the taxpayer's purpose and values;

⁷⁹ Section 41(d)(4) includes specific exceptions for the qualification of research activities.

⁸⁰ Section 41(d)(2)(B).

⁸¹ Section 41(d)(2)(C) and reg. section 1.41-4(b).

⁸² For example, see *Union Carbide*, T.C. Memo. 2009-50, *aff'd*, 697 F.3d 104.

⁸³ Mary Zimmer et al., "Embracing the Nexus Concept for the Research Credit," *Tax Notes Federal*, July 14, 2025, p. 217.

- enhanced innovation-centric culture; and
- greater cross-disciplinary collaboration on research and development projects.

Tax departments can play a key role in planning and implementing ESG initiatives because the initiatives often overlap with tax strategies.⁸⁴ Taxpayers should thus consider integrating ESG reporting and income tax compliance teams. This strategic coordination can also ensure accuracy, completeness, and consistency with data and reporting for these and other related initiatives.

C. Optimizing Industry 4.0 Investments

Another recent development related to the circular economy is what is known as the Fourth Industrial Revolution, or Industry 4.0.⁸⁵ While there are almost one hundred definitions of Industry 4.0 and related concepts,⁸⁶ there have been efforts to establish a defining concept for it. For example, the two largest standards bodies — the International Organization for Standardization and the International Electrotechnical Commission — formed a joint working group called JWG21 that defines Industry 4.0 as:

Manufacturing that improves its performance aspects⁸⁷ with integrated and intelligent use of processes and resources in cyber, physical, and human spheres to create and deliver products and services, which also collaborates with other domains within enterprises' value chains. In addition to manufacturing, other enterprise domains can include engineering, logistics, marketing,

procurement, sales, or any other domains identified by the enterprise.⁸⁸

The strategic adoption and development of Industry 4.0 initiatives, which rely on science, innovation, and technology,⁸⁹ can enable taxpayers to achieve the goals of the circular economy while potentially qualifying for the research credit. For example, the primary areas that taxpayers can focus their manufacturing efforts on to promote the circular economy through the development and use of Industry 4.0 technologies include:

- *Production process optimization*: Collecting data in real time, implementing lean manufacturing principles, leveraging automation and robotics, and using predictive maintenance approaches to reduce waste and create customer value.
- *Product customization*: Collecting customer data using artificial intelligence and smart technology to gain insights into designing and manufacturing products that meet customer technical needs while reducing waste and warehouse costs.
- *Supply chain transparency*: Tracking and monitoring products and materials using blockchain technology, smart sensors, and big data analytics to reduce waste, improve resource efficiency, and identify opportunities to recycle and repurpose materials.
- *Business model innovation*: Leveraging innovative technologies to pursue resource efficiency, extend product lifespan, and enhance multiple product life cycles of reuse, remanufacturing, and recycling.⁹⁰

⁸⁴ Natalie Runyon, "How Corporate Tax Departments Can Contribute to Their Companies' ESG Strategies," Thomson Reuters, Dec. 2, 2022.

⁸⁵ See Department of Commerce: National Institute of Standards and Technology, "Topic: Industry 4.0." "Industry 4.0" is a term coined in Germany, popularly used in Europe, and equivalent to "smart manufacturing" in the United States. For discussion purposes, we will use these terms interchangeably.

⁸⁶ Giovanna Culot et al., "Behind the Definition of Industry 4.0: Analysis and Open Questions," *Int'l J. Production Econ.* 226 (Aug. 2020).

⁸⁷ Performance aspects include agility, efficiency, safety, security, sustainability, and any other performance indicators identified by the enterprise.

⁸⁸ Jeff Winter, "Introduction: The Birth of Industry 4.0 and Smart Manufacturing," *InTech Magazine*, Aug. 2022.

⁸⁹ Franck Journoud, Jess Wysocky, and Connor Rabb, "Re: Request for Information: Accelerating the American Scientific Enterprise (Docket No. OSTP-TECH-2025-0100)," National Association of Manufacturers, at 2 (Dec. 26, 2025).

⁹⁰ Virginia Dolci et al., "Integrating Industry 4.0 and Circular Economy: A Conceptual Framework for Sustainable Manufacturing," 232 *Procedia Computer Science* 1711, 1715-1716 (2024).

Further, manufacturers are creating technological environments devoted to innovation, separate from solution development, to evaluate production environments.⁹¹

Because of recent legislation, taxpayers have undertaken a renewed focus on Industry 4.0 initiatives during the second half of 2025:

The passage of the One Big Beautiful Bill Act (OBBBA)⁹² has ushered in a new era for American manufacturing. . . . As manufacturers recalibrate their strategies in response to the OBBBA's sweeping tax incentives, the sector is experiencing a renaissance of investment, innovation and strategic expansion. Across sectors, the OBBBA can be a catalyst for modernization to Industry 4.0.⁹³

Looking forward, taxpayers in the manufacturing sector anticipate that they will continue to invest in smart manufacturing throughout 2026. A recent survey of 600 manufacturing executives found that:

The majority (80 percent) plan to invest 20 percent or more of their improvement budgets in smart manufacturing initiatives, with a focus on foundational tools and technologies. These include automation hardware, data analytics, sensors, and cloud computing. According to the survey results, they largely view *smart manufacturing as the primary driver of competitiveness over the next three years*, thanks to benefits such as improved production output, increased employee productivity, and unlocked capacity.⁹⁴ [Emphasis added.]

These efforts will present taxpayers with significant opportunities to claim research credits to offset their federal income tax liability and potentially recover costs through other tax

planning strategies. But taxpayers will need to address challenges that the IRS continues to raise, even considering the recent headcount reductions within the agency, when claiming the research credit.

VI. Conclusion

While circular economy initiatives may give rise to research credit opportunities, we cannot overemphasize the importance of contemporaneous documentation to substantiate the qualified research activities and expenditures. Other professional service providers have made similar statements based on their observations:

The IRS continues to focus on areas with significant financial impact and complex facts, particularly R&D credits. . . . These areas remain attractive exam targets because even with staff reductions, the potential for substantial adjustments and revenue recovery is high. . . . It's crucial to have strong documentation and well-reasoned positions supporting R&D credit claims. That includes traceability between research initiatives and the research expenses claimed, and technical documentation to substantiate the testimony of researchers.⁹⁵

Moreover, taxpayers have noticed, in certain circumstances, a change in the examination experience with the research credit compared with prior years. For example:

Taxpayers may find that they face a higher burden of proof, as some exam teams are showing less willingness to rely on inferences to connect project activities to the process of experimentation. Exam teams are increasingly requiring more direct substantiation, such as documentation that proves every aspect of the research process for a particular project, or individuals with a comprehensive understanding of entire research projects.⁹⁶

⁹¹ Kelly Schindler, Seth Chaikin, and Greg S. Davis, "It's Time. Upgrade for Growth in Manufacturing," Grant Thornton (Aug. 18, 2025).

⁹² P.L. 119-21.

⁹³ Schindler, "OBBBA Can Be a Catalyst for Industry 4.0," Grant Thornton (Sept. 17, 2025).

⁹⁴ Steve Shepley et al., "2026 Manufacturing Industry Outlook," Deloitte Research Center for Energy & Industrials (Nov. 13, 2025).

⁹⁵ Hogan Humphries, Alexander Fox, and Greg Sweigart, "IRS Keeps Focus on R&D Tax Credit Even as Agency Staff Shrinks," *Bloomberg Law*, Jan. 5, 2026.

⁹⁶ *Id.*

This shows how producing thorough documentation is one of the most pervasive challenges (and opportunities) that taxpayers face when analyzing the technical positions discussed above and, in general, defending a research credit claim. As it relates to the circular economy, taxpayers should consider how contemporaneous documentation can help explain the underlying technology, the roles of non-core development teams involved in research, and how nonroutine testing and data assisted in evaluating alternatives and eliminating technical uncertainty.

In a recent case involving one of the largest fully integrated poultry companies in the United States⁹⁷ that incurred qualified expenditures in the performance of research trial runs, the Tax Court posed an intriguing question:

The primary dispute is whether [the taxpayer] conducted research trials during the research years or whether the alleged research trials are merely post hoc distortions of routine data collection into the model of section 41 qualified research.

⁹⁷ *George v. Commissioner*, T.C. Memo. 2026-10.

Forget the proverbial chicken or the egg;
today we are called to answer which came first,
the research or the research credit study?⁹⁸
[Emphasis added.]

Taxpayers can better position themselves to answer this question, and similar questions, by using real-time documentation strategies to meet the burden of proof and demonstrate that they are entitled to claim the research credit. This will provide some degree of certainty as taxpayers undertake innovative (yet often unpredictable) projects to advance their business, the circular economy, and other strategic initiatives.⁹⁹ ■

⁹⁸ *Id.* at 2.

⁹⁹ The foregoing information is general in nature and is based on authorities that are subject to change. It is not, and should not be construed as, accounting, legal, tax, or professional advice provided by Grant Thornton Advisors LLC. This material may not be applicable to, or suitable for, the reader's specific circumstances or needs and may require consideration of tax and nontax factors not described herein. Contact your tax professional before taking any action based upon this information. Changes in tax laws or other factors could affect, on a prospective or retroactive basis, the information contained herein; Grant Thornton Advisors LLC assumes no obligation to inform the reader of any such changes. This article represents the authors' views only and does not necessarily represent the views or professional advice of Grant Thornton Advisors LLC. Grant Thornton Advisors LLC and its subsidiary entities are not licensed CPA firms.