AT&T – GCP Concrete Management – Case Study

Description of the Enabling Technology	AT&T's connectivity enables the operation of internet-connected sensors which are utilised by Verifi to monitor concrete composition when in-transit. Having real-time measurement of concrete mixes allows customers to meet specification requirements accurately and efficiently, reducing unnecessarily added excess material. This has resulted in a reduced consumption of cement and related reductions in greenhouse gas emissions. The Verifi system provides the user with visibility on when the concrete composition is ready to leave the supply plant. It also ensures that the load arrives at the site with the correct slump and composition, such that it is immediately ready to pour. Both impacts mean that less time is spent with the delivery truck idling whilst the load composition is adjusted or re-mixed. The reduction in idling time and revolutions of the concrete mixer drum has meant that greenhouse gas emissions related to the truck fuel consumption have also decreased.
Impact Category	This case study focuses on the reduced cement used in concrete production and the carbon impact associated with these savings. The study also examines the reduction in diesel fuel consumption due to lower truck idling times and the carbon impact associated with these savings.
Materiality	The avoided usage of surplus cement means that emissions associated with the extraction of the raw minerals, processing and delivery of cement products is reduced. This reduction has the most material carbon impact, however, reduced combustion of diesel fuel in the engines of concrete transportation trucks also avoids greenhouse gas emissions.
Attribution of Impacts	The carbon savings detailed in this case study are a result of the implementation of Verifi amongst GCP's customers. Using Verifi, GCP's customers can reduce emissions associated with the production and delivery of their purchased goods. Both AT&T and GCP play a fundamental role in enabling the environmental benefits that are delivered.

Primary Effects	Commonly, producers of concrete use a higher proportion of cement than is required in concrete mixes. Concrete has minimum strength specifications that must be adhered to but, without visibility on the composition, producers often vastly 'overdesign' mixes. Verifi allows users to know exactly how much cement must be added to a mix to meet specification and, therefore, reduces surplus waste. Cement production is a highly carbon intensive process due to the need for a chemical reaction where limestone is heated to produce the lime used in cement. This reaction produces CO_2 as a waste product. Reducing cement usage, lowers the demand for production and, hence, the waste CO_2 produced. Verifi also enables the reduction of time spent idling by concrete mixer trucks. This is because the AT&T connectivity allows the user to monitor and regulate the composition of the concrete mix from when it is first received, through transit and up to delivery. As the correct composition can be met and maintained more quickly than if mixes were tested manually, the time during which the truck is using fuel, is decreased. Reduced time spent adjusting concrete loads means that there are also fewer rotations of the truck's mixing drum per delivery, another process which consumes truck fuel. Typical truck fuel is diesel, a fossil fuel which releases CO_2 when burnt in an internal combustion engine. The accuracy with which AT&T's connectivity enables Verifi to track the composition of each concrete load means that mixes are more likely to be maintained to the required standard. This means that fewer loads will arrive at delivery site and be rejected due to having unsatisfactory slump. Fewer rejected loads results in less concrete waste and, therefore, emissions savings associated with the lifecycle of concrete from raw material extraction to waste disposal. The carbon impact of a decrease in rejected loads was not included in this study.
Secondary Effects	No secondary effects were identified.

Rebound Effects	No rebound effects were identified.
Trade-Offs or Negative Effects	This technology does not appear to create other outsized or irreparable environmental or social impacts.
Carbon Burden from the Enabling Technology	The embodied carbon emissions of the internet-connected sensors, which will be minimal compared with the emissions reductions.
Scope	The scope of the study includes all of GCP's customers that have purchased Verifi to assist with concrete management.
Timeframe	The data in this case study calculates the AT&T enabled reduction in emissions associated with the concrete production of Verifi customers in 2021.
Functional Unit	The functional unit for the avoided GHG emissions is expressed as metric tons of CO_2e per cubic metre of concrete produced by Verifi customers.
Methodology	The GHG emissions reductions are the sum of the emissions reductions from: • reduced cement usage. • reduced idling time of concrete mixer delivery trucks. • reduced drum revolutions of the concrete mixer delivery trucks. Three case studies of Verifi implementation (across two different customers - one customer with a single instance of Verifi implementation and another customer with two instances of implementation) were used to calculate an average value of cement reduced per kilogram of concrete delivered. This was based on data provided for the total cement used and total concrete volume delivered per case study, each with an unmanaged

reference scenario compared against a Verifi-managed scenario. The difference in cement used per kilogram of concrete delivered between scenarios was calculated. The customers for which data was provided were stated as being more progressive, so the average value calculated was likely to be an overestimate of cement reduction for an average Verifi customer. Therefore, on advice from GCP, the calculated value of cement reduced per kilogram of concrete delivered was decreased to the lower end of the case study range of cement reduction per unit volume of concrete, giving a more conservative estimate. Emissions associated with the cement production and all upstream activities (mineral extraction, delivery, processing etc.) were calculated using US-specific emission factors from Ecoinvent database v3.8.

Datasets containing records on idling time and drum revolutions were provided for approximately 30 Verifi customers for the scenario before usage of Verifi and for the scenario after Verifi implementation. The difference between the average time spent idling between loading completion and truck leaving the plant was calculated for each scenario. The average idling time saved due to Verifi was multiplied by a factor for diesel consumption per hour for a typical delivery truck to calculate the volume diesel saved. The emissions associated with this diesel reduction were calculated using 2021 emission factor for average biofuel blend diesel.

The average number of concrete mixer drum revolutions between truck arrival at site and start of concrete discharge was also calculated for each scenario. A value for volume of truck fuel consumption per drum revolution was provided by GCP and this was used to calculate associated diesel and emissions saved in the same way as with the idling time reduction calculations.

The emissions reduction (for both cement and diesel reductions) directly attributable to the use of Verifi was calculated by multiplying the calculated emission change by a percentage multiplier representative of the fraction of time during which Verifi was active and the savings could hence be attributed to use of the solution.

Key Assumptions	The average value of cement reduced for a typical Verifi customer is assumed to be 10 kg per cubic meter of concrete delivered (see methodology for reasoning). It is assumed that the average cement composition is 25% Portland cement and 75% pozzolana and fly ash (15-40%), based on the percentage of deliveries of each type. Both types of cement correspond to US emission factors within the Ecoinvent database, encompassing all activity upstream of cement production at a cement mill. The fuel type of all concrete delivery trucks is assumed to be diesel, corresponding to the BEIS 2021 emission factor for 'Diesel (average biofuel blend)'. It is assumed that the average fuel consumption of a delivery truck whilst at idle is 0.84 US Gallons per minute, based on the value reported by Argonne National Laboratory for a delivery unloaded heavy truck (to be conservative in the estimate of amount of truck fuel saved, the truck was assumed to be unloaded although loading actually varies through operation). In reality, delivery trucks were of different types, but data was not available at this resolution. Using different fuel consumption rates for different truck types would increase the accuracy of the results. It is assumed that the average fuel consumption of a delivery truck is 0.01 litres per drum revolution based on GCP guidance. An 'uptime' report was provided by GCP, measuring the proportion of time during December 2022 when the Verifi solution was active for each customer. The December 2022 uptime percentages were used as proxies for the customers' uptime percentages throughout 2021. The uptime percentages for each customer were used to calculate weighted averages for the proportion of each emissions source reduction (i.e. cement or diesel reduction) for each customer which could be attributable to the influence of Verifi due to the solution being active. The assumption here is that any reduction in emissions that has occurred between before and after implementation of Verifi occurred uniformly through time (a conservative approach to estimating the direct impact of Verifi on reducing emissions).

<table>
<tr><td>Exclusions</td><td>Verifi can also enable other components of a typical concrete mix to be reduced. Other factors that have been excluded from this study due to the lack of available data include:

• reduced water (replaced by Admix solution).
• reduced Admix solution (replaced by sand).
• reduced number of rejected concrete loads.

Excluded due to materiality:

• Embodied emissions associated with the production of internet-connected sensors used in the Verifi solution.</td></tr>
<tr><td>Data Sources</td><td>Ecoinvent v3.8 – emission factors for:

• US, cement production, Portland.
• US, cement production, pozzolana and fly ash 15-40%.

BEIS 2021 – emission factors for:

• Diesel (average biofuel blend).

Argonne National Laboratory. Vehicle Idle Reduction Savings Worksheet. https://www.anl.gov/sites/www/files/2018-02/idling_worksheet.pdf

• US Gallons per minute, diesel, delivery truck.

Values advised by GCP:

• Concrete produced by Verifi customers – 2021.
• Typical case study cement reduction.
• Fuel consumption per truck drum revolution.

All other datasets comprise of anonymised GCP customer data.</td></tr>
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Carbon Abatement Factor	Annual GHG savings of 4.72 kg CO_2e per cubic metre of concrete produced by Verifi customers. This comprises: • 4.61 kg CO_2e per cubic metre of concrete produced from reduced cement usage. • 0.03 kg CO_2e per cubic metre of concrete produced from reduced drum revolutions of the concrete mixer delivery trucks. • 0.07 kg CO_2e per cubic metre of concrete produced from reduced idling time of concrete mixer delivery trucks. In 2021, using the total amount of concrete produced by Verifi customers, this equates to 107,294 tCO_2e of emissions savings from the use of Verifi.